

SECTION 26 05 05

GENERAL PROVISIONS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals shown, specified, and required to complete the electrical Work, which includes:
 - a. Providing conduits, inserts and other electrical items to be embedded in concrete, built into walls, partitions, ceilings, and panels provided by others.
 2. Temporary Utilities: CONTRACTOR shall provide temporary power and lighting in accordance with Section 01 51 13, Temporary Electricity, and Section 01 51 26, Temporary Lighting.
 3. Demolition: Electrical demolition shall be in accordance with Section 02 41 00, Demolition.
 4. Utility Companies:
 - a. Electric Utility Company: Perform the Work in connection with the electric service and utility metering in accordance with requirements of NYSEG.
- B. Coordination:
1. Review installation procedures and schedules under other contracts and coordinate with other contractors the installation of electrical items to be installed with or within formwork, walls, partitions, ceilings, and panels constructed by other contractors.
 - a. Furnish as required to other contractors detailed drawings or sketches of the locations of conduits and other built-in items.
 - b. Coordinate with other contractors regarding progress of construction where conduits and built-in items are will be installed. Install conduits and built-in items in manner that does not delay work of other contractors.
 2. Coordination and Intent of Electrical Drawings:
 - a. Dimensions on Drawings related to equipment are based on equipment of certain manufacturers. Verify the dimensions of equipment furnished to space available at the Site and allocated to the equipment.
 - b. Drawings show the principal elements of the electrical Work, and are not intended as detailed working drawings for the electrical Work. Drawings supplement and complement the Specifications and other Contract Documents relative to principal features of electrical systems.
 - c. Equipment and devices provided under this Contract and other contracts shall be properly connected and interconnected with other equipment and devices for successful operation of complete systems, whether or not all connections and interconnections are specifically mentioned or shown in the Contract Documents.
 - d. Drawings are provided for CONTRACTOR's guidance in fulfilling the

intent of the Contract Documents CONTRACTOR shall comply with Laws and Regulations, including safety and electrical codes, and provide materials, equipment, appurtenances, and specialty items necessary for complete and operable systems.

3. Obtain from OWNER record drawings required to execute the Work.
4. Field Coordination:
 - a. Provide materials, equipment, and services to interface with existing circuits. Field-verify system and equipment requirements prior to modifying existing systems.
 - b. Coordinate the interface of equipment with OWNER's personnel and field conditions.
 - c. Field-compare existing starter and panel control circuit terminations from record documents with existing circuits.
 - d. Field-trace existing circuits as required to interface the equipment provided.
 - e. Field-identify terminations for starters and panel controls for follow function for re-connection.

C. Related Sections:

1. Section 02 41 00, Demolition.
2. Section 03 30 00, Cast-in-Place Concrete.
3. Section 05 05 33, Anchor Systems.
4. Section 09 91 00, Painting.
5. Section 31 23 05, Excavation and Fill.
6. Section 40 61 13, Process Control Systems General Provisions.

D. Work Included in This Contract but Specified Elsewhere:

1. Concrete for pads, manholes, ductbanks, and conduit encasement shall comply with Section 03 30 00, Cast-in-Place Concrete.
2. Anchorage systems shall comply with Section 05 05 33, Anchor Systems.
3. Shop painting and surface preparation shall comply with Section 09 91 00, Painting, unless otherwise specified in Division 26 Sections.
4. Excavation and filling associated with buried electrical Work shall comply with Section 31 23 05, Excavation and Fill.

E. Area Classifications:

1. Materials, equipment, and incidentals shall be suitable for the area classification(s) shown, specified, and required.
2. Wet or Corrosive Locations: Comply with NEC and NEMA requirements for corrosive locations. Enclosures in corrosive locations shall conform to NEMA 4X requirements unless specified otherwise.
3. Hazardous Locations: Comply with NEC requirements for the Class and Division designated.
4. Dusty Locations: Indoor areas not designated as hazardous, corrosive, or wet are dusty locations. Comply with NEC and NEMA 12 requirements unless specified otherwise.

1.2 QUALITY ASSURANCE

A. Qualifications:

1. Wiring Coordinator:

- a. Retain services of a wiring coordinator who shall prepare complete point-to-point interconnection wiring diagrams. Diagrams shall identify all external interconnecting wiring associated with new or modified existing equipment.
- b. Qualifications: Wiring coordinator shall be experienced in developing diagrams of the type required and shall have served in a similar wiring coordinator role on a completed project of similar size and complexity to the Project.
 - 1) Submit qualifications and approach for the Project not later than the pre-submittal conference required in Section 40 61 13, Process Control Systems General Provisions.
 - 2) Submit to ENGINEER the items indicated below not less than three weeks prior to the pre-submittal conference required in Section 40 61 13, Process Control Systems General Provisions:
 - a) List of projects where the wiring coordinator developed point-to-point wiring diagrams.
 - b) Samples of diagrams developed for the listed projects.
 - c) Example wiring diagram proposed for the Project with a preliminary list of drawings to be produced.
 - d) Plan of how information will be obtained and documented.
- c. Responsibilities:
 - 1) Develop diagrams for performing the Work and to document terminations. Prepare diagrams in accordance with this Section and the example wiring diagram accepted by ENGINEER. Diagrams are in addition to loop diagrams required in Section 40 61 13, Process Control Systems General Provisions.
 - 2) Use information obtained from approved Shop Drawings and approved CONTRACTOR's other submittals, record drawings, and field inspections as required to complete the diagrams.
 - 3) Attend pre-submittal conference required under Section 40 61 13, Process Control Systems General Provisions, and periodic coordination and progress meetings required in Section 01 31 16, Project Coordination; Section 01 31 19.23, Progress Meetings; and Section 40 61 13, Process Control Systems General Provisions.

B. Component Supply and Compatibility:

1. Materials and equipment similar to each other shall be from the same manufacturer for uniformity.

C. Regulatory Requirements:

1. Permits: Refer to the General Conditions, Supplementary Conditions, and other parts of the Contract Documents for responsibilities relative to obtaining and paying for permits, licenses, and inspection fees.

2. Codes: Refer to the Architectural Drawings for indication of applicable codes.

1.3 SUBMITTALS

A. General:

1. To the extent practical, submit Shop Drawings and other CONTRACTOR submittals for each Specification Section into the smallest number of submittals possible. Do not furnish partial submittals.
2. Review of equipment submittals does not relieve CONTRACTOR of responsibility for providing complete and successfully operating systems.

B. Action Submittals: Submit the following:

1. Shop Drawings:
 - a. Internal wiring diagram and drawings indicating all connections to components and numbered terminals for external connections.
 - b. Dimensioned plan, section, elevations, and panel layouts showing means for mounting, conduit connection, and grounding.
 - c. List of components including manufacturer's name and catalog number (or part number) for each.
 - d. Point-to point interconnection wiring diagrams.
2. Product Data:
 - a. Manufacturer's name and product designation or catalog number.
 - b. Electrical ratings.
 - c. Manufacturer's technical data and specifications.
 - d. Manufacturer's indication of compliance with applicable reference standards.
 - e. Painting and coating systems proposed.
3. Test Procedures: Proposed testing procedures and testing limitations for source quality control testing and field quality control testing.

C. Informational Submittals: Submit the following:

1. Manufacturer's Instructions:
 - a. Installation data and instructions.
 - b. Instructions for handling, starting-up, and troubleshooting.
2. Source Quality Control Submittals: Results for required shop testing.
3. Field Quality Control Submittals: Results for required field testing.
4. Qualifications:
 - a. Electrical Subcontractor.
 - b. Wiring coordinator, including information required of wiring coordinator in Paragraph 1.2.A of this Section.

D. Closeout Submittals: Submit the following:

1. Record Documentation:
 - a. System Record Drawings: Include the following:
 - 1) One-line wiring diagram of the electrical distribution system.
 - 2) Actual, in-place conduit and cable layouts with schedule of conduit sizes and number, and size of conductors.

- 3) Layouts of the power and lighting arrangements and the grounding system.
- 4) Control schematic diagrams, with terminal numbers and control devices identified, for all equipment.
- b. Point-to-Point Interconnection Wiring Diagram Drawings: Include the following:
 - 1) External wiring for each piece of equipment, panel, instrument, and other devices and wiring to control stations, lighting panels, and motor controllers.
 - 2) Numbered terminal block identification for each wire termination.
 - 3) Identification of the assigned wire numbers for all interconnections.
 - 4) Identification of wiring by the conduit tag in which the wire is installed.
 - 5) Terminal, junction, and pull boxes through which wiring is routed.
 - 6) Identification of equipment and the submittal transmittal number for equipment from which wiring requirements and termination information was obtained.
- c. Record documents shall indicate final equipment and field installation information.

PART 2 - PRODUCTS

- A. Performance Criteria:
 1. Electrical equipment shall be capable of operating successfully at full-rated load, without failure, with ambient outside air temperature of 0 degrees F to 104 degrees F and an elevation of 900 feet above mean sea level.
 2. Unless specified otherwise, electrical equipment shall have ratings based on 75 degrees C terminations.
- B. Testing Laboratory Labels: Electrical material and equipment shall bear the label of Underwriters' Laboratories, Inc. or other nationally recognized, independent testing laboratory, where standards have been established and label service applies.
- C. Equipment Mats
 1. Provide rubber insulating mats placed on the floor in front of all free-standing electrical equipment.
 2. Mats shall extend the entire length of the equipment.
 3. Mats shall be in accordance with ASTM specifications with dielectric strength of 30,000 volts minimum, 1/4-inch-thick, 36 inches wide with corrugated surface.
 4. Furnish and install a non-conductive compound rubber floor mat extending the full length and placed in front and in back of each free-standing piece of electrical distribution equipment.
 5. Mats shall be in accordance with ASTM D178 specification, Type II, Class 2.
 6. Mats shall have the following ratings:
 - a. Voltage phase to phase 17,000 V RMS
 - b. AC Proof Test Voltage 20,000 V RMS

- c. DC Proof Test Voltage 30,000 V Average
- 7. Type II mats shall be ozone, flame and oil resistant.
- 8. Install mats in one continuous piece. Where equipment faces each other, and is less than 6-ft apart, provide one width of mat.
- 9. Mats shall be stored without distortion, free from direct sunlight or sources of ozone and at a temperature not to exceed 95 degrees F.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which Work will be performed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. General:
 - 1. Install materials and equipment in accordance with the Contract Documents, Laws and Regulations, approved (and accepted, as applicable) Shop Drawings and other CONTRACTOR submittals, and manufacturer's recommendations.
 - 2. Provide tools and equipment required to trace circuits necessary for proper execution of the Work.
 - 3. Define and identify all wiring, circuit terminations, and equipment to be modified to ensure proper interface of components. The Contract Price includes all costs associated with field services specified for a complete and functional system.
- B. Staging, Sequencing, and Coordination with Existing Facilities:
 - 1. Schedule, sequence, and install materials and equipment in accordance with Section 01 14 16, Coordination with Owner's Operations
 - 2. Perform the Work in a manner that will not interfere with the existing equipment and facilities or cause interruption of the functions of the Site, unless specified otherwise or otherwise allowed by OWNER.
 - 3. When operation of existing facilities and Site is disrupted due to CONTRACTOR's operations, comply with Section 01 14 16, Coordination with Owner's Operations, unless otherwise allowed by OWNER.
 - 4. Where the Work ties in with existing installations, take precautions and provide safeguards in connecting the Work to existing operating circuits to prevent interruption to existing circuits. Connection of Work to existing circuits shall be performed in the presence of OWNER and ENGINEER.
 - 5. Interruptions of existing circuits, not addressed in Section 01 14 16, Coordination with Owner's Operations, shall be coordinated with the OWNER who will determine the length of time a circuit may be de-energized to maintain the OWNER's processes in dependable and safe operation.

3.3 FIELD QUALITY CONTROL

- A. Field Quality Control – General:
 - 1. Perform field quality control for electrical Work in accordance with the Contract Documents.

- B. Site Tests:
 - 1. Prior to requesting certificate of Substantial Completion, demonstrate to ENGINEER that electrical systems and electrically-operated equipment installed or modified under the Contract operates in accordance with the Contract Documents and operates as required
 - 2. Perform the following operational tests on electrical systems:
 - a. Operate power circuits to verify proper operation and connection to electrical systems materials and equipment, including mechanical key-interlocks for circuit breakers.
 - b. Remove and re-apply power supply to automatic transfer equipment to verify operation. Activate standby power systems to verify their automatic start-up, proper de-energization, and cool down upon resumption of normal power supply.
 - c. Operate control circuits, including pushbuttons, indicating lights, and similar devices, to verify proper connection and function. Operate all devices, such as pressure switches, flow switches, and similar devices, to verify that shutdowns and control sequences operate as required.
 - d. Operate lighting systems and receptacle devices to verify proper operation and connections.
 - 3. Prepare and submit report on the equipment demonstration and operating field quality control tests. Report shall include complete information on the tests performed and results.

- C. Manufacturer's Services:
 - 1. Furnish at the Site qualified, factory-trained representative(s) of equipment manufacturers for the services indicated in the Contract Documents.

++ END OF SECTION ++

SECTION 26 05 13

MEDIUM VOLTAGE CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install medium voltage cable.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. AEIC CS8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46 kV.
2. ANSI C2, National Electrical Safety Code.
3. ANSI/NETA ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems
4. ASTM B3, Specification for Soft or Annealed Copper Wire
5. ASTM B8, Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft.
6. ASTM B33, Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.
7. ICEA S-93-639, 5-46 KV Shielded Power Cables for use in the Transmission and Distribution of Electric Energy.
8. IEEE 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5kv through 765kv.
9. IEEE 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500 000 V
10. UL 1072, Medium-Voltage Power Cables.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Independent Testing Agency:
 - a. Retain services of an independent testing agency for field quality control testing of installed medium voltage cables.
 - b. Testing agency shall have experience inspecting and testing cables of the type specified and shall be a member company of NETA.
 - c. Test Equipment, Calibration, and Reporting: Test equipment, instrument calibration, and test reports shall be in accordance with ANSI/NETA ATS.

B. Regulatory Requirements:

1. Tests by Independent Agencies: Cable shall bear the label of Underwriters Laboratories, Inc.

2. Utilities:
 - a. Perform Work in connection with utility service in conformance with requirements of NYSEG. Refer to NYSEG SP-1099 Specification for Customer Electric Service 2.4KV to 34.5KV for additional requirements.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 1. Shop Drawings:
 - a. Literature identifying the methods and materials proposed for making splices and terminations. Submittal shall consist of manufacturer literature evidencing compatibility of conductor insulation, shield, and jacket of cable with splicing or terminating materials, and methods proposed for use.
 - b. Listing of locations where splices are proposed.
 2. Product Data:
 - a. Manufacturer's literature and technical information indicating compliance with the Contract Documents.
 3. Subsequent to Engineer's approval of the Product Data and Shop Drawings Submit a package for approval by NYSEG.
- B. Informational Submittals: Submit the following:
 1. Certificates:
 - a. Certification from cable Supplier that cable installation is in accordance with cable manufacturer's recommendations.
 2. Design Data: Cable pulling calculations from cable Supplier confirming that cable tensions will not be exceeded during installation.
 3. Source Quality Control Submittals: Submit results of factory tests. Include testing procedures utilized.
 4. Field Quality Control Submittals: Submit results of field quality control testing. Include testing procedures utilized.
 5. Qualifications Statements:
 - a. Qualifications of splicing and termination personnel
 - b. Independent testing agency.
- C. Closeout Submittals: Submit the following:
 1. Record Documentation:
 - a. Include on record documents actual location and routing of medium voltage cable installations in accordance with Section 01 78 39, Project Record Documents.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General:
 1. Cable provided under this Section shall be rated for insulation level of 133 percent at 15 KV.

2. Cable insulation shall be thermosetting rubber-based suitable for normal installation indoors or outdoors, in conduit, in air, and intermittent or continuous submergence in water.
3. Cable shall be single conductor bearing UL label "MV 105" and comply with or exceed applicable ICEA and AEIC standards.

B. Manufacturers: Provide products of one of the following:

1. Kerite Company.
2. The Okonite Company.
3. General Cable Corporation.
4. Southwire.
5. Or equal.

C. Materials:

1. Conductor: Conductors shall be soft or annealed uncoated or tinned coated copper with concentric-lay Class B round stranding in accordance with ASTM B8, and ASTM B3 or ASTM B33.
2. Insulation System: Cable insulation system shall include two separate screen layers, primary insulation and shield.
 - a. Conductor screen shall consist of extruded inner layer of non-conducting energy suppression or semi-conducting material. Conductor screen shall be in intimate contact with outer surface of conductor.
 - b. Primary insulation shall be high quality ozone-resistant ethylene-propylene rubber based compound. Insulation system shall be suitable for use at conductor temperatures not exceeding 90 degrees C for normal operation, 130 degrees C for emergency overload conditions, and 250 degrees C for short circuit conditions. Minimum and maximum thickness of insulation system shall be 210/220 mils for 15 kV system.
 - c. Insulation screen shall be outer layer of thermosetting semi-conducting material. Insulation screen shall be in intimate contact with outer insulation surface.
 - d. Insulation shield shall be a five-mil copper tape applied helically with minimum 12.5 percent overlap.
3. Jacket: Continuous jacket of moisture, heat, oil resistant black polyvinyl chloride shall be applied over insulation and shielding system. Minimum thickness of jacket shall be in accordance with ICEA.

D. Cable Connectors:

1. Connectors shall be copper, tin-plated, long-barrel compression type. Suitable for voltage applications up to 35 KV.
2. For sizes 250 MCM and larger, connectors shall be two-hole mount type with provisions for two bolts for joining to apparatus terminal.
3. Manufacturers: Provide products of one of the following:
 - a. FCI-Burndy.
 - b. T&B Connectors.
 - c. Or equal.

- E. Cable Terminations:
1. Cable terminations shall comply with Class 1 requirements of IEEE 48.
 2. Terminations shall be molded elastomer, wet-process porcelain or heat-shrinkable types with grounding provisions for cable shielding.
 3. Manufacturers: Provide products of one of the following:
 - a. Elastimold.
 - b. G&W Electric Company.
 - c. Raychem Corporation.
 - d. 3M Company.
 - e. Or equal.
- F. Cable Splices:
1. Make cable splices using standard splice kits that reinstate cable's insulation and jacket and continue metallic shielding through entire cable joint.
 2. Splices shall be premolded, conventional tape or heat-shrinkable type.
 3. Manufacturers: Provide products of one of the following:
 - a. Elastimold.
 - b. G&W Electric Company.
 - c. Raychem Corporation.
 - d. 3M Company.
 - e. Or equal.
- G. Pulling Compound:
1. Provide pulling compound to facilitate wiring pulling. Compound shall be UL-listed, waxed or water based type. Compound shall be compatible with all jacket types.
 2. Pulling tension coefficient of friction shall not exceed 0.35.
 3. Use winter-grade compound for outdoor, low-temperature installations.
 4. Manufacturers: Provide products of one of the following:
 - a. Ideal Industries.
 - b. Greenlee.
 - c. Or equal.
- H. Fireproofing Tape for Cables in Manholes, Handholes, and Boxes:
1. Tape shall be 30-mils thick of self-extinguishing material that does not support combustion. Tape shall not deteriorate when subjected to water, salt, sewage, or fungus
 2. Secure tape with glass cloth tape.
- I. Color code cables by applying general purpose, flame-retardant tape, wrapped in overlapping turns covering an area of at least two inches. Colors shall be as follows:
1. Grounded Neutral: White.
 2. Phase A: Brown.
 3. Phase B: Orange.
 4. Phase C: Yellow.

2.2 SOURCE QUALITY CONTROL

- A. Factory Testing:
 - 1. Cables shall be factory tested in accordance with testing standards of ICEA and UL.
 - 2. Conductors shall comply with electrical resistance requirements of ICEA.
 - 3. Perform insulation resistance test in accordance with ICEA. Each cable shall have an insulation resistance not less than that corresponding to insulation resistance constant of 20,000 megohms-1000 feet at 15.6 degrees C.
 - 4. Perform high voltage AC test in accordance with ICEA.
 - 5. Measure and record shield resistance from end to end on completed cable.
 - 6. Corona Test: Each reel of completed shielded power cable shall be partial discharge tested in accordance with ICEA.
 - 7. Record cable physical measurements.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cables complete with proper terminations at both ends. Check for proper phase sequence and proper motor rotation.
- B. Splice and terminate medium voltage cables in accordance with cable manufacturer's recommendations.
 - 1. Use experienced personnel familiar with materials and procedures to be employed.
 - 2. Make splices watertight for below-grade installations, and submersible in manholes and handholes.
- C. Pulling:
 - 1. Use insulating types of pulling compounds containing no mineral oil.
 - 2. Pulling tension shall be within limits recommended by cable manufacturer.
 - 3. Use dynamometer when mechanical means are used.
 - 4. Cut off section subject to mechanical means.
- D. Bending Radius: Limit to twelve times cable overall diameter.
- E. Slack: Provide maximum slack at terminal points and in manholes.
- F. Wrap cables located within manholes, handholes, and boxes with fireproofing tape for cable's entire length for each individual cable. Secure fireproofing tape with glass cloth tape. Fireproof cables in accordance with cable manufacturer's recommendations, and cover cables with tape extending at least one inch into each duct.
- G. Identification: Identify conductors by circuit number and phase at each terminal or splice location.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform acceptance testing of medium voltage cable system. Each cable circuit shall be inspected and tested on an individual, per-phase basis. Testing and inspection shall be performed by independent testing agency.
2. Visual and Mechanical Inspection: Inspect each power cable installation in accordance with ANSI/NETA ATS. Inspect each splice and termination.
3. Electrical Tests: Perform electrical testing of each power cable in accordance with ANSI/NETA ATS and manufacturer's recommended testing procedures. Testing shall include:
 - a. Shield continuity test.
 - b. DC or AC high potential test.
 - c. Adhere to following procedures before performing over-potential tests:
 - 1) Disconnect all equipment, including but not limited to: transformers, switches, motors, circuit breakers, and surge arrestors from cable circuit to prevent test interruptions due to flashovers or trip-outs resulting from excessive leakage current.
 - 2) Establish adequate clearance between circuit test ends and grounded objects and to other equipment not under test.
 - 3) Ground all circuit conductors not being tested, all cables shields, and nearby equipment.
 - 4) Clean insulation surfaces.
 - 5) Keep cable ends dry.
 - d. Apply high-potential slowly in eight to ten equal steps to 80 percent of manufacturer's test value. Record leakage current at each test voltage and plot resulting curve on graph paper.
 - e. Stop the test if leakage current increases excessively or if a "knee" appears in the curve before reaching maximum test voltage.
 - f. Upon reaching specified maximum test voltage, maintain voltage for 15 minutes, record leakage current at 30 seconds, one minute, and at one-minute intervals thereafter. Plot leakage current versus time on the same graph as step voltage curve.
 - g. Reduce conductor test potential to zero and measure residual voltage at discrete intervals.
 - h. Apply grounds for a time period adequate to drain all insulation stored charge.
 - i. Repair or replace and retest new cable that fails tests.
 - j. Test curves shall be signed by the individual performing tests and submitted to ENGINEER.

B. Cable Tension Field Quality Control: Testing and Supplier Services:

1. Provide services at the Site during cable installation to ensure that cable tensions are not exceeded. Provide cable splicing when tension exceeds cable manufacturer's recommendations.
2. Provide services of cable manufacturer's representative to prepare cable pulling calculations. Manufacturer's representative shall inspect, monitor, and assist in cable installation, and shall certify that cables have been correctly installed.

3. Required field services include:
 - a. Document, with assistance of manufacturer's representative, actual ductbank installation parameters needed to prepare cable pulling calculations.
 - b. Prepare pulling calculations in advance of cable installation.
 - c. Monitor actual pulling tensions during installation to ensure that recommended tensions are not exceeded.
 - d. Certify jointly with manufacturer's representative that cable installation is in accordance with cable manufacturer's recommendations.
4. Provide equipment, coordinate, and identify information necessary to ensure proper installation of cables. Contract Price shall include all costs associated with equipment, coordination, and identification of all information necessary for complete, functional system.

+ + END OF SECTION + +

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals shown, specified, and required to furnish and install low-voltage conductors and cabling.
 - 2. Types of cabling required include:
 - a. Insulated cable for installation in raceways.
- B. Related Sections:
 - 1. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. ANSI/NETA ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
 - 2. ASTM B3, Specification for Soft or Annealed Copper Wire.
 - 3. ASTM B8, Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft.
 - 4. ASTM D3485, Specification for Smooth-Wall Coilable Polyethylene (PE) Conduit (Duct) for Preassembled Wire and Cable.
 - 5. ASTM F2160, Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD).
 - 6. NEMA TC 7, Smooth Wall Coilable Electrical Polyethylene Conduit.
 - 7. UL 44, Thermoset-Insulated Wires and Cables.
 - 8. UL 1277, Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
 - 1. NEC Article 300, Wiring Methods.
 - 2. NEC Article 310, Conductors for General Wiring.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Product Data:
 - a. Manufacturer's literature, specifications, and engineering data for low volt insulated cable proposed for use.

- B. Informational Submittals: Submit the following:
 - 1. Field Quality Control Submittals:
 - a. Written results of field insulation resistance tests.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Insulated Cable In Raceways:
 - 1. Application: Use for circuits located indoors and outdoors.
 - 2. Manufacturers: Provide products of one of the following:
 - a. Southwire.
 - b. The Okonite Company.
 - c. American Insulated Wire
 - d. General Cable
 - e. Or equal.
 - 3. Material: Single conductor copper cable complying with ASTM B3 and ASTM B8 with flame-retardant, moisture- and heat-resistant insulation rated for 90 degrees C in dry or wet locations, listed by UL as Type XHHW-2 or RHW-2 complying with UL 44.
 - a. Cables No.8 AWG and larger routed in underground shall be Type RHW-2.
 - 4. Wire Sizes: Not smaller than No. 12 AWG for power and lighting and No. 14 AWG for 120-volt control circuits.
 - 5. Stranding: 600-volt cable shall be stranded, except that solid cable, No. 10 and smaller may be used for lighting circuits.
- B. Cable for Installation in Trays:
 - 1. Manufacturers: Provide products of one of the following:
 - a. Southwire.
 - b. The Okonite Company.
 - c. General Cable.
 - d. Or equal.
 - 2. Material: Factory-assembled single- or multi-conductor control, signal, or power cable that bears UL label Type TC and are specifically approved for installation in cable trays. Overall jacket shall be sunlight-resistant PVC. Cable shall be rated for 90 degrees C wet or dry, complying with UL 44 and UL 1277.
- C. Cable Connectors, Solderless Type:
 - 1. Products and Manufacturers: Provide products of one of the following:
 - a. T&B Sta-Kon.
 - b. Burndy Hylug.
 - c. Or equal.
 - 2. For wire sizes No. 4 AWG and above, use either compression type or bolted type with silver-plated contact faces.
 - 3. For wire sizes up to and including No. 6 AWG, use compression type. Alarm and control wire shall be terminated using forked type connectors at terminal

- boards.
4. For wire sizes No. 250 KCMIL and larger, use connectors with at least two cable clamping elements or compression indents and provision for at least two bolts for joining to apparatus terminal.
 5. Properly size connectors to fit fastening device and wire size. Connectors shall be rated for 90 degree C, 600 volts.

D. Cable Splices:

1. Products and Manufacturers:
 - a. Compression-Type Splices: Provide one of the following:
 - 1) Burndy Hylink.
 - 2) T&B Color-Keyed Compression Connectors.
 - 3) Or equal.
 - b. Spring Connectors: Provide one of the following:
 - 1) Buchanan B-Cap.
 - 2) T&B Wire Connector.
 - 3) Or equal.
2. For wire sizes No. 8 AWG and larger, splices shall be made up with compression type copper splice fittings. Splices shall be taped and covered with materials recommended by cable manufacturer to provide insulation equal to that on conductors.
3. For wire sizes No. 10 AWG and smaller, splices may be made up with pre-insulated spring connectors.
4. For wet locations, splices shall be waterproof. Compression type splices shall be waterproofed by sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring thermosetting resin into mold that surrounds the joined conductor. Spring connector splices shall be waterproofed with sealant filler.
5. Splices shall be suitably sized for cable, rated 90 degrees C, and 600 volts.

E. Wire and Cable Markers:

1. Provide wire and cable markers in accordance with Section 26 05 53, Identification for Electrical Systems.

2.2 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Factory-test wire and cable in accordance with UL standards

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Pulling:

1. Use insulating types of pulling compounds containing no mineral oil.

2. Pulling tension shall be within limits recommended by wire and cable manufacturer.
 3. Use dynamometer where mechanical means are used.
 4. Cut off section subject to mechanical means.
- C. Bending Radius: Limit to minimum of six times cable overall diameter.
- D. Slack: Provide maximum slack at all terminal points.
- E. Splices:
1. Where possible, install cable continuous, without splice, from termination to termination.
 2. Where required, splice as shown and also where required for cable installation. Splices below grade, in manholes, handholes, and wet locations shall be waterproof.
 3. Splices are not allowed in conduits.
- F. Identification:
1. Identify conductors in accordance with Section 26 05 53, Identification for Electrical Systems.
 2. Identify power conductors by circuit number and phase at each terminal or splice location.
 3. Identify control and status wiring using numeral tagging system.
- G. Color-code power cables as follows:
1. No. 8 AWG and Smaller: Provide colored conductors.
 2. No. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, wrapped in overlapping turns to cover an area of at least two inches.
 3. Colors: Match color scheme in use at the Site. If the Site does not have an existing color scheme, use the following colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue

System	Conductor	Color
480Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	Gray Brown Orange Yellow

3.2 FIELD QUALITY CONTROL

A. Site Tests:

1. Test each electrical circuit after permanent cables are in place, to demonstrate that circuit and equipment are connected properly and will perform satisfactorily, free from improper grounds and short circuits.
2. Individually test 600-volt cable mechanical connections after installation and before they are put in service, with calibrated torque wrench. Values shall be in accordance with manufacturer's recommendations.
3. Individually test 600-volt cables for insulation resistance between phases and from each phase to ground. Test after cables are installed and before they are put in service, with Megger for one minute at voltage rating recommended by cable manufacturer or in accordance with ANSI/NETA ATS recommendations.
4. Insulation resistance for each conductor shall not be less than value recommended by cable manufacturer. Cables not meeting recommended value or that fail when tested under full load conditions shall be replaced with a new cable for full length.
5. Where existing cables are spliced to cables provided under the Project, test existing cables prior to splicing. Test cables at 1,000 vdc for one minute. Entire spliced cable installation shall be re-tested after splice is completed. Existing cable that fails or has value less than two megohms shall be brought to attention of ENGINEER and splicing shall not proceed until condition is acceptable.

++ END OF SECTION ++

SECTION 26 05 23

INSTRUMENTATION AND COMMUNICATION CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals shown, specified, and required to furnish and install instrumentation and communication cables.
 - 2. Types of cables include the following:
 - a. Shielded instrumentation cables.
 - b. Telephone cables.
 - c. Data communication cables.

- B. Related Sections:
 - 1. Section 26 05 33.13, Rigid Conduits.
 - 2. Section 26 05 53, Identification for Electrical Systems.
 - 3. Section 40 66 33, Fiber Optic Communication Cable and Appurtenances

1.2 TERMINOLOGY

- A. The following words or terms are not defined but, when used in this Section, have the following meaning:
 - 1. "CPE" means chlorinated polyethylene.
 - 2. "FEP" means fluorinated ethylene-propylene.
 - 3. "XLPE" means cross-linked polyethylene.

1.3 REFERENCES

- A. Standards referenced in this Section are:
 - 1. ASTM A510, Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
 - 2. ASTM B633, Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
 - 3. ANSI/TIA/EIA-568, Commercial Building Telecommunications Cabling (requirements and restrictions of Technical Service Bulletins (TSBs) apply.)
 - 4. TIA/EIA-485, Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems (known as RS-485).
 - 5. UL 13, Power-Limited Circuit Cables.
 - 6. UL 1581, Electrical Wires, Cables and Flexible Cords.
 - 7. UL VW-1, Vertical Wire Flame Test.
 - 8. UL 910, Safety Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. NEC 725, Class 1, Class 2, and Class 3 Remote-Control, Signaling and Power-Limited Circuits.
 - 2. NEC 727, Instrumentation Tray Cable.
 - 3. NEC 800, Communications Circuits.

1.5 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Product Data: Manufacturer's technical information for instrumentation cables and communications cables proposed.
- B. Informational Submittals: Submit the following:
 - 1. Field Quality Control Submittals: Written report of results of field quality control testing specified in this Section.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General:
 - 1. Cables shall bear the UL label.
- B. Single Shielded Pair Instrument Cables:
 - 1. Manufacturers: Provide products of one of the following:
 - a. Belden Company.
 - b. Okonite Company.
 - c. Dekoron Wire and Cable Company.
 - d. Or equal.
 - 2. Tinned copper, XLPE-insulated, stranded conductors, not less than no. 16 AWG, twisted pair, with overall shield, stranded tinned no. 18 AWG copper drain wire and overall PVC or CPE jacket. Rated for not less than 300 volts and complying with UL 1581.
- C. Multi-Paired Shielded Instrument Cables:
 - 1. Manufacturers: Provide products of one of the following:
 - a. Belden Company.
 - b. Okonite Company.
 - c. Dekoron Wire and Cable Company.
 - d. Or equal.
 - 2. Tinned copper, XLPE-insulated stranded conductors, not less than no. 16 AWG, twisted pairs with shield over each pair, stranded tinned no. 18 AWG copper drain wire, and overall PVC or CPE outer jacket. Rated for not less than 300 volts and complying with either UL 1581 or UL 13.

- D. Multi-Conductor Shielded Instrument Cables:
1. Manufacturers: Provide products of one of the following:
 - a. Belden Company.
 - b. Okonite Company.
 - c. Dekoron Wire and Cable Company.
 - d. Or equal.
 2. Tinned copper, XLPE-insulated stranded conductors, not less than no. 16 AWG, stranded tinned no. 18 AWG copper drain wire, with overall 100 percent foil shield and overall PVC or CPE jacket. Rated for not less than 300 volts.
- E. Multi-Conductor Shielded High-Temperature Instrument Cables:
1. Manufacturers: Provide products of one of the following:
 - a. Belden Company.
 - b. Okonite Company.
 - c. Dekoron Wire and Cable Company.
 - d. Or equal.
 2. Silver-plated copper, extruded Teflon insulation, stranded conductors, not less than no. 16 AWG, with overall 90 percent silver-plated copper braid shield and overall Teflon tape-wrapped jacket. Rated for not less than 300 volts and complying with UL VW-1.
- F. Category 6 Ethernet, Data Highway Cables.
1. Manufacturers: Provide products of one of the following:
 - a. Belden Company.
 - b. Or equal.
 2. Cable shall be category 6 Ethernet type, four-pair, UL rated and complying with NEMA and ANSI TIA/EIA-568 requirements.
 3. Conductors shall be solid copper with FEP insulation with PVC overall jacket.
 4. Cable characteristics impedance shall be 100 plus or minus 15 ohms.
 5. Cable DC resistance shall be 7 ohms maximum with unbalance of 2.5% maximum.
 6. Cable mutual capacitance shall be 5.6nF per 100 meters maximum with pair to pair capacitance unbalance of 100pF per 100 meters maximum.
- G. Fiber Optic Cables
1. Provide fiber optic cables in accordance with 40 66 33 - Fiber Optic Communication Cable and Appurtenances.
- H. Cable Terminals:
1. Manufacturers: Provide products of one of the following:
 - a. T&B Sta-Kon.
 - b. Burndy Insulug.
 - c. Or equal.
 2. Fork type copper compression terminals with nylon insulation for termination of cable at terminal blocks.

- I. Patch Cords:
 - 1. Patch cords are used for connecting patch panel to hub, or wall jack to equipment.
 - 2. Manufacturer: Provide products of one of the following:
 - a. Bertek.
 - b. Belden.
 - c. Mohawk
 - d. Or equal.
 - 3. Cables shall consist of no. 24 AWG, thermoplastic-insulated, stranded conductors formed into four individually-twisted pairs and enclosed by thermoplastic jacket.
 - 4. Cables shall be riser-rated.
 - 5. Rated for Category 6 use.
 - 6. Cables shall incorporate integral strain relief into the connector at each end. Connectors shall be RJ45 plugs.
 - 7. Provide the following patch cords:
 - a. One 10-foot cable per wall jack installed.
 - b. One 3-foot cable per every two wall jacks installed.
 - c. One 5 foot cable per every two wall jacks installed.

- J. Connecting Hardware for Unshielded Twisted Pair (UTP) Cables:
 - 1. Hardware used to terminate UTP cable shall comply with ANSI/TIA/EIA-568, Part 10.4.
 - 2. Connecting hardware shall be compatible with wiring specified in the Contract Documents.
 - 3. Rated for Category 6 use.
 - 4. Connecting hardware shall utilize 110-type terminal blocks to coordinate with patch panels and termination blocks specified the Contract Documents.
 - 5. Telecommunications Outlets/Connectors:
 - a. Manufacturers: Provide products of one of the following:
 - 1) Hubbell.
 - 2) Or equal.
 - b. Outlets and connectors shall utilize RJ45 (eight-pin modular) plug/receptacle configuration.
 - c. Outlets and connectors shall utilize T568B pin/pair assignments, and be coordinated with wire type (solid or stranded conductor).
 - d. Outlets shall be flush-mount type or surface-mount type, as indicated on the Drawings.

- K. Patch Panels:
 - 1. Manufacturers: Provide products of one of the following:
 - a. Black Box.
 - b. Or equal.
 - 2. Patch panels shall utilize RJ45 (eight-pin modular) plug/receptacle configuration, and utilize T568B pin/pair assignments for receptacles.
 - 3. Coordinate patch panel terminations with wire type (solid or stranded conductor).

4. Patch panels shall be wall-mount type or rack-mount type, as indicated on the Drawings.
5. Listed as Category 6.
6. Provide quantity of ports not less than the quantity of wall jacks installed in the building/area served, plus 50 percent additional as spares.

L. Cable Support Hardware:

1. Wire Basket:

a. Materials and Finishes:

- 1) Yellow Zinc Dichromate: Straight sections shall be steel complying with ASTM A510, and shall be electro-plated yellow zinc dichromate in accordance with ASTM B633 Type SC2.

b. Straight section longitudinal wires shall be straight, without bends.

c. Wire basket runway shall be made of high-strength steel wires and formed into a standard two-inch by four-inch wire mesh pattern with intersecting wires welded together. Wire ends along runway sides (flanges) shall be rounded.

d. Wire basket sizes shall comply with the following:

- 1) Straight sections shall be furnished in standard lengths of nine feet ten inches.
- 2) Wire basket shall have one-inch usable loading depth by 6 inches wide.
- 3) Wire basket shall have two-inch usable loading depth by 6 inches wide.
- 4) Wire basket shall have four-inch usable loading depth by 6 inches wide.
 - a) Fittings shall be field-formed as required.
 - b) Splicing assemblies shall be bolted type with serrated flange locknuts. Hardware shall be either yellow zinc dichromate in accordance with ASTM B633 Type SC2, or AISI Type 304 stainless steel.
 - c) Wire basket runway supports shall be center-support hangers, trapeze hangers, or wall brackets, manufactured by Cooper B-Line, or equal.
 - d) Trapeze hangers or center-support hangers shall be supported by 1/4-inch or 3/8-inch diameter rods.
 - e) Provide special accessories as required to protect, support, and install wire basket runway system.

2. Conduit:

- a. Where conduit is shown or indicated on the Drawings, comply with Section 26 05 33.13, Rigid Conduits.

M. RS-485 Full Duplex Cables:

1. Products and Manufacturers:

- a. Non-Plenum-Rated RS-485 Full Duplex Cables: Provide one of the following:
 - 1) Belden 9842.

- 2) Or equal.
- b. Plenum-Rated RS-485 Full Duplex Cables: Provide one of the following:
 - 1) Belden 82842.
 - 2) Or equal.
2. Cables shall consist of four tinned copper stranded, no. 24 AWG conductors, polyethylene-insulated and twisted into two pairs, 100-percent aluminum-polyester shield, 90-percent tinned copper braided shield, no. 24 AWG tinned copper drain wire, and overall PVC jacket.
3. Cables shall comply with TIA/EIA RS-485.
4. When plenum rating is required, cables insulation shall be foam FEP and jacket shall be low-smoke PVC, in lieu of insulation and jacket materials otherwise specified in this Section for RS-485 full duplex cables.
5. When portion of cable run is not contained in conduit or appropriate enclosure, cables shall be plenum- or riser-listed and marked in accordance with NEC 800.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which materials and equipment will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. General:
 1. Install cables complete with proper terminations at both ends.
 2. Install in conduit separate from power cables, unless shown or indicated otherwise.
 3. Ground shield on shielded cables at one end only and as recommended by instrument manufacturer.
 4. Identify conductors in accordance with Section 26 05 53, Identification for Electrical Systems.
 5. Install and terminate Supplier-furnished cable in accordance with equipment manufacturer requirements and cable manufacturer's recommendations.
 6. Install in accordance with Laws and Regulations, including NEC.

3.3 FIELD QUALITY CONTROL

- A. Site Tests:
 1. Test shielded instrumentation cable shields with ohmmeter for continuity along full length of cables, and for shield continuity to ground.
 2. Connect shielded instrumentation cables to calibrated 4 to 20 mA dc signal transmitter and receiver. Test at 4 and 20 mA transmitter settings.
 3. Replace with new cables the full length of cables that fail test.

4. Test equipment shall be provided by CONTRACTOR.
5. For testing of communications cables, test equipment used shall comply with the following:
 - a. Equipment shall consist of a “master” and a “remote” unit.
 - b. Test of all aspects of cables shall be automatic and initiated with a single command. Test over entire frequency range. Test unit shall be capable of accepting cable identification tag for reporting. Test unit shall return “pass/fail” status for cables and, if “fail”, shall indicate reason for failure.
 - c. Test unit shall be capable of storing all test results internally and printing the results later.
 - d. For unshielded twisted pair cables, test unit shall be specifically designed and manufactured to certify cabling relative to Category 6 compliant.

+ + END OF SECTION + +

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install complete grounding for electrical systems, structures, and equipment.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. ANSI/NETA ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
2. ASTM B8, Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft.
3. UL 467, Grounding and Bonding Equipment.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Field Acceptance Testing Firm: Retain services of independent testing firm to perform acceptance field testing of grounding system. Testing firm shall have experience in testing grounding systems and shall be a member company of NETA.

B. Regulatory Requirements

1. National Electrical Code, (NEC).
 - a. NEC Article 250, Grounding and Bonding.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
 - a. Listing of grounding connector types identifying where each will be used.
 - b. Layouts of each structure's ground grid.
 - c. Test point construction details.
2. Product Data:
 - a. Manufacturer's technical information for grounding materials proposed for use.
3. Testing Plans:
 - a. Ground resistance test procedure.

- B. Informational Submittals: Submit the following:
 - 1. Field Quality Control Submittals
 - a. Results of ground resistance tests at each test point.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Bare Ground Cable:
 - 1. Manufacturers: Provide products of one of the following:
 - a. Cablec Corporation.
 - b. General Cable Corporation.
 - c. Southwire Cable Company.
 - d. Or equal.
 - 2. Material: Soft-drawn, bare copper stranded cable complying with ASTM B8. No. 4/0 AWG minimum size unless otherwise shown or indicated on the Drawings.

- B. Ground Rods:
 - 1. Manufacturers: Provide products of one of the following:
 - a. Copperweld, Bimetallics Division.
 - b. ITT Blackburn Company.
 - c. Or equal.
 - 2. Material: Copper-clad rigid steel rods, 3/4-inch diameter, ten feet long.

- C. Grounding Connectors:
 - 1. Products and Manufacturers: Provide one of the following:
 - a. Pressure Connectors:
 - 1) O.Z./Gedney, Division of General Signal Corporation.
 - 2) Burndy Corporation.
 - 3) Or equal.
 - b. Welded Connections:
 - 1) Cadweld by Erico Products, Incorporated.
 - 2) Therm-O-Weld by Burndy Corporation.
 - 3) Or equal.
 - 2. Material: Pressure connectors shall be copper alloy castings, designed and fabricated specifically for items to be connected and assembled with Durium or silicone bronze bolts, nuts, and washers. Welded connections shall be by exothermic process utilizing molds, cartridges, and hardware designed specifically for connection to be made.

- D. Grounding Additive:
 - 1. Grounding additive, in its set form, shall have resistivity of not more than 20 ohm-cm.
 - 2. Product and Manufacturer:
 - a. Ground Enhancement Material (GEM) by Erico
 - b. Or equal.

3. Grounding additive shall be permanent and maintenance-free, without requiring recharging with salts or chemicals that may be corrosive, and shall maintain its earth resistance with time.
4. Grounding additive shall set up firmly and not dissolve or decompose or otherwise pollute soil or groundwater.
5. Grounding additive shall be suitable for installation in dry form or in slurry form.
6. Grounding additive shall not depend on continuous presence of water to maintain its conductivity.

E. Ground Test Well

1. Provide heavy-duty test well suitable for heavy-duty traffic.
2. Manufacturer
 - a. Advanced Lightning Technology
 - b. Or equal.
3. Diameter and Material: 12.75-inch outside diameter, Concrete.
4. Depth: Two feet.
5. Cover: Provide test well with cast iron cover marked, "Ground" with cast iron ring to support lid.

F. Ground system components shall comply with UL 467.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions for the Work and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with Work until unsatisfactory conditions are corrected.

3.2 STRUCTURE GROUND SYSTEM

- A. Provide ground grids as shown and indicated on the Drawings.
- B. Provide No. 4/0 bare copper cable around exterior perimeter of structures at not less than 2.5 feet below grade, unless otherwise shown or indicated on the Contract Documents.
- C. For structures with steel columns, provide No. 4/0 ground cable from grid to each column around perimeter of structure. Connect cable to steel with exothermic welds.
- D. Connect grids to continuous underground water pipe system, when practical.
- E. Connect grid to underground ductbanks at each building.
- F. For new structures with concrete foundation or footings, connect structure's reinforcing steel or other concrete-encased electrode to grounding grid.

- G. Provide accessible test points for measuring the ground resistance of each grid.
- H. Weld all buried connections except for test points.

3.3 EQUIPMENT GROUNDING

- A. Ground electrical equipment in compliance with Laws and Regulations and the Contract Documents.
- B. Equipment grounding conductors shall be bare stranded copper cable of adequate size installed in metal conduit where required for mechanical protection. Ground conductors, pulled into conduits with non-grounded conductors, shall be insulated. Insulation shall be green.
- C. Control panels grounding conductors shall be bare stranded copper cable of adequate size to ground grid from AC ground bus, and an insulated stranded copper cable of adequate size to ground grid from DC ground bus.
- D. Connect ground conductors to conduit with copper clamps, straps, or with grounding bushings.
- E. Connect to piping by welding or brazing. Use copper bonding jumpers on gasketed joints.
- F. Connect to equipment by means of lug compressed on cable end. Bolt lug to equipment frame using holes or terminals provided on equipment specifically for grounding. Do not use hold-down bolts. Where grounding provisions are not included, drill suitable holes in locations recommended by equipment manufacturer or designated by ENGINEER.
- G. Connect to motors by bolting directly to motor frames, not to soleplates or supporting structures.
- H. Connect to service water piping by means of copper clamps. Use copper bonding jumpers on gasketed joints.
- I. Scrape bolted surfaces clean and coat with conductive oxide-resistant compound.

3.4 FIELD QUALITY CONTROL

- A. Site Tests:
 - 1. Test completed grounding systems for resistance to ground using an electrical three-terminal ground resistance tester. Test all grounded cables and metal parts for continuity of connection. ENGINEER and OWNER will witness the testing.
 - 2. Grounding system maximum resistance shall not exceed five ohms under normally dry conditions when measured by resistance tester. Resistance values above five ohms shall be brought to ENGINEER's attention. Provide additional ground rods as required to attain a resistance to ground of less than five ohms

for each ground grid. Add grounding additive installing additional ground rods to increase their effectiveness.

3. Acceptance Testing:
 - a. Perform acceptance testing of grounding system. Testing shall be performed by testing firm in accordance with ANSI/NETA ATS.
 - b. Test Equipment, Calibration and Reporting: Test equipment, instrument calibration, and test reports shall comply with ANSI/NETA ATS.

++ END OF SECTION ++

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install hangers and supports for electrical systemns.
2. Area Classifications: Materials shall by suitable for the area classification(s) shown or indicated on the Drawings, and specified in Section 26 05 05, General Provisions for Electrical Systems.

B. Related Sections:

1. Section 05 05 33, Anchor Systems.
2. Section 26 05 05, General Provisions for Electrical Systems.
3. Section 26 05 33.13, Rigid Conduits.

1.2 REFERENCES

A. Standards referenced in this section are:

1. ASTM A123/A123M, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
2. ASTM A1011/A1011M, Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
3. ASTM E84, Test Method For Surface Burning Characteristics of Building Materials

1.3 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
 - a. Detailed installation drawings showing dimensions and compatibility with proposed layout.
2. Product Data:
 - a. Manufacturer's name, product designation, and catalog number of each material item proposed for use.
 - b. Manufacturer's specifications including material, dimensional and weight data, and load capacity for each supporting system component proposed for use.
 - c. Pictorial views and corresponding identifying text of each component proposed for installation.
 - d. Documentation that confirms product compatibility with Laws and Regulations.

- B. Informational Submittals: Submit the following:
 - 1. Certifications:
 - a. Submit certifications required under this Section.
 - 2. Manufacturer's Instructions:
 - a. Manufacturer's installation instructions, including recommended tightening torque values for all nuts and bolts.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Provide products of one of the following:
 - 1. B-Line.
 - 2. Kindorf.
 - 3. Unistrut
 - 4. Or equal.

2.2 MATERIALS

- A. Strut, Fittings, and Accessories:
 - 1. General
 - a. Unless otherwise shown or indicated, strut shall be 1-5/8 inches by 1-5/8 inches. Double struts shall be two pieces of the same strut, welded back-to-back at the factory.
 - b. Attachment holes, when required, shall be factory-punched on hole centers approximately equal to the cross-sectional width and shall be 9/16-inch diameter.
 - c. Fittings, braces, brackets, hardware, and accessories shall be Type 316 stainless steel.
 - d. Strut nuts shall be spring captured Type 316 stainless steel.
 - e. Square and round washers shall be Type 316 stainless steel.
 - 2. Strut materials shall be suitable for area classifications indicated in Section 26 05 05, General Provisions for Electrical Systems, and shown or indicated on the Drawings.
 - a. Dusty Locations:
 - 1) Strut shall be 12-gage carbon steel, hot-dip galvanized after fabrication, complying with ASTM A123/A123M.
 - b. Wet Locations:
 - 1) Strut shall be 12-gage Type 316 stainless steel.
 - c. Corrosive and Hazardous Locations:
 - 1) Strut shall be 12-gage Type 316 stainless steel.
 - d. Chemical Storage Rooms or Chlorine Evaporator room:
 - 1) Strut shall be fiberglass-reinforced plastic (FRP) complying with ASTM E84.
 - 2) Fabricate materials either by pultrusion or extrusion process.
 - 3) Fasteners and fittings shall have a surface veil over 100 percent of the surface to protect against UV degradation.

- 4) Manufacture fasteners and fittings from long glass fiber-reinforced polyurethane or vinyl-ester resins.
 - 5) Thread rods shall be made from fiber-reinforced vinyl-ester resin.
- B. Hanger Rods:
1. Material:
 - a. Dry Locations: All-thread, zinc-coated
 - b. Wet, Corrosive, or Hazardous Areas: Stainless steel.
 2. Size: Not less than 3/8-inch diameter, unless otherwise shown on the Drawings or specified.
- C. Beam Clamps for Attaching Threaded Rods or Bolts to Beam Flanges for Hanging Struts or Conduit Hangers:
1. Beam clamps shall be stainless steel equipped with stainless steel square-head set screw, and shall include threaded hole sized for attaching the all-thread rod or threaded bolt.
- D. Miscellaneous Hardware:
1. Bolts, screws, and washers shall be stainless steel.
 2. Hex Nuts: Shall be stainless steel and include nylon inserts.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Provide hangers and supports for electrical systems with necessary channels, fittings, brackets, and related hardware for mounting and supporting materials and equipment. Provide anchor systems, concrete inserts, and associated hardware for proper support of electrical systems.
- B. Install equipment and devices on hangers and supports as shown on the Drawings, as specified, and as required.
- C. Install hangers and supports level, true, free of rack, and parallel and perpendicular to building walls and floors, so that the hangers and supports are installed in a neat, professional, workmanlike manner.
- D. Holes in suspended ceilings for rods for hangers and supports and other equipment shall be provided adjacent to bars, where possible, to facilitate removal of ceiling panels.
- E. Coordinate installation of hangers and supports with equipment, cabinets, consoles,

panels, enclosures, boxes, conduit, cable tray, wireway, busway, cablebus, piping, ductwork, lighting fixtures, and other systems and equipment. Locate hangers and supports clear of interferences and access ways.

F. Anchor Bolts, Expansion Anchors, and Concrete Inserts: Shall be in accordance with Section 05 05 33, Anchor Systems, and requirements of this Section.

G. Mounting of Conduit:

1. Provide space of not less than 1/4-inch between conduit surfaces and abutting or near surfaces except struts, cable trays, steel beams, and columns.
2. Fasten conduit to struts, cable trays, steel beams, and columns using specified clamps and straps as shown, specified, and required.
3. Devices shall be compatible with size of conduit and type of support. Following installation, size identification shall be visible and legible.
4. Install conduit supports and fasteners in accordance with Section, 26 05 33.13, Rigid Conduits.

H. Supports for Cabinets, Consoles, Panels, Enclosures, and Boxes:

1. Freestanding: Unless otherwise specified or shown on the Drawings, provide supports for floor-mounted equipment, cabinets, consoles, panels, enclosures, and boxes. Such supports shall be 4 inch high concrete equipment base with a 45 degree chamfered edge. Base shall extend four inches beyond outside dimensions of equipment on all sides.
2. Wall-Mounted:
 - a. Provide space not less than 1/4-inch between cabinets, consoles, panels, enclosures, and boxes and the surface on which each is mounted. Provide non-metallic or stainless steel spacers as required.
 - b. Do not mount equipment, enclosures, panels, and boxes directly to beams or columns. Mount struts to beams or columns using beam clamps, and mount equipment, enclosures, panels, and boxes to the struts.
3. Floor Stand Rack:
 - a. Where equipment, cabinets, consoles, panels, enclosures, and boxes cannot be wall-mounted, provide an independent floor stand rack.
 - b. Floor stand rack shall consist of struts, plates, brackets, connection fittings, braces, accessories, and hardware assembled in a rigid framework suitable for mounting of intended materials and equipment.
 - c. Equip floor stand racks with brackets and bases for rigidly-mounting the framework to the ceiling or floor, as applicable; or equip floor stand racks with beam clamps, angle plates, washers, and bolts for fastening to beam flanges, as applicable.
 - d. When equipment, cabinets, consoles, panels, enclosures, and boxes weigh more than 100 pounds:
 - 1) Main vertical supports of floor stand rack assemblies shall be back-to-back struts.
 - 2) Bracing, clamping and anchoring of each floor stand rack shall be sufficient to ensure rigidity of the floor stand rack with the intended equipment, enclosures, conduit, cable tray, busway, cablebus, and wireway installed. Floor stand racks shall not be deflected more than

1/8-inch by a 100-pound force applied at any point on the floor stand rack in any direction.

- I. Drilling into beams or columns is not allowed unless authorized by ENGINEER.
- J. Tighten nuts and bolts to the manufacturer's recommended torque values.
- K. Field Cutting:
 - 1. Cut edges of strut and hanger rod shall have rounded corners, edges beveled, and burrs removed. If field cutting the strut is required, use clean, sharp, dedicated tools. Remove oil, shavings, and other residue of cuttings prior to installation.
 - 2. Coatings: To prevent corrosion:
 - a. Coat cut edges with epoxy-base touchup paint.
 - b. Coat cut edges with zinc-rich paint.

++ END OF SECTION ++

SECTION 26 05 33.13

RIGID CONDUITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals shown, specified, and required to furnish and install conduit and fittings to form complete, coordinated and grounded raceway systems.
2. When specific, detailed conduit routings for various systems within buildings and other areas are not be shown on the Drawings, CONTRACTOR shall establish routings based on single-line, riser, and interconnection diagrams and other information on the Drawings. CONTRACTOR shall provide for the proper installation of conduits in each system.
3. Conduit types and the installation methods shall comply with the following, unless otherwise shown or indicated in the Contract Documents:
 - a. Use steel conduit rigid steel for exposed indoor conduit runs in non-corrosive areas.
 - b. Use PVC-coated rigid steel conduit for exposed interior or exterior conduit runs in hazardous, wet, and corrosive locations.
 - c. Use PVC-coated rigid steel conduit for individual conduits direct-buried in the ground.
 - d. Use Schedule 40 PVC or steel conduit for concrete-encased duct bank runs.
 - e. Use steel or Schedule 40 PVC conduit for conduit runs embedded in structural concrete slabs.
 - f. Use steel conduit for plant monitoring and control (PMCS) systems, system control and data acquisition (SCADA) systems, and communication systems, regardless of the installation. Conduit shall be PVC-coated rigid steel in hazardous, wet, and corrosive locations.
 - g. Provide nonmetallic conduits and fitting in Lake St Influent Facility Chemical Storage Room and Solid Handling Building Chlorine Evaporator Room.

B. Coordination:

1. Conduit runs shown are diagrammatic. Coordinate conduit installation with piping, ductwork, light fixtures, and other systems and equipment and locate to avoid interferences.
2. For conduits to be embedded in concrete slabs, confirm adequate slab thickness and coordinate location of conduits with placement of reinforcing steel, waterstops, expansion joints, and other features of the concrete slab.

C. Related Sections:

1. Section 31 23 05, Excavation and Fill.
2. Section 32 12 16, Asphalt Concrete Paving.

3. Section 05 05 33, Anchor Systems.
4. Section 26 05 29, Hangers and Supports for Electrical Systems.
5. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

- A. Standards referenced in this Section are:
1. ANSI C80.1, Standard for Rigid Electrical Steel Conduit (ERSC).
 2. ANSI/NEMA FB1, Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable.
 3. NEMA TC2, Electrical Polyvinyl Chloride (PVC) Conduit.
 4. NEMA TC3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 5. NEMA TC14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 6. UL 6, Electrical Rigid Metal Conduit – Steel.
 7. UL 514B, Conduit, Tubing, and Cable Fittings.
 8. UL 651, Safety Schedule 40 and 80 Rigid PVC Conduit and Fittings.
 9. UL 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.
 10. UL 1242, Electrical Intermediate Metal Conduit – Steel.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
1. NEC Article 342, Intermediate Metal Conduit
 2. NEC Article 344, Rigid Metal Conduit.
 3. NEC Article 352, Rigid Nonmetallic Conduit.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
1. Shop Drawings:
 - a. Assembly details of conduit racks and other conduit support systems.
 - b. Layout drawings showing proposed routing of exposed conduits, conduits embedded in structural concrete, and conduits directly buried in the ground. Shop Drawings shall show locations of pull and junction boxes and penetrations in walls and floors. Shop Drawings of embedded conduits shall include cross-sections showing thickness of concrete slabs and locations of conduits relative to reinforcing steel, waterstops, and other features of the slab.
 2. Product Data:
 - a. Manufacturer's catalog cuts and product data for conduit, fittings, and appurtenances.
- B. Informational Submittals: Submit the following:
1. Manufacturer's Instructions:
 - a. When requested by ENGINEER, provide copies of manufacturer's recommendations for handling and installing products.

2. Site Quality Control Submittals:
 - a. When requested by ENGINEER, provide copies of results of specified Site quality control testing.
- C. Closeout Submittals: Submit the following:
 1. Record Drawings:
 - a. Show actual routing of exposed and concealed conduit runs in record documents in accordance with Section 01 78 39, Project Record Documents.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Rigid Steel Conduit, Elbows, and Couplings:
 1. Manufacturers: Provide products of one of the following:
 - a. Allied Tube and Conduit.
 - b. Wheatland Tube Company.
 - c. Western Tube and Conduit Corporation.
 - d. Or equal.
 2. Material: Rigid, heavy-wall, mild steel, hot-dip galvanized, smooth interior, tapered threads and carefully reamed ends; 3/4-inch NPS minimum size.
- B. PVC-coated Rigid Steel Conduit, Elbows, and Couplings:
 1. Manufacturers: Provide products of one of the following:
 - a. Robroy Industries.
 - b. Perma-Cote Industries.
 - c. OCAL, Inc.
 - d. Or equal.
 2. Material: Rigid, heavy-wall, mild steel, hot-dip galvanized, smooth urethane interior coating, tapered threads, carefully reamed ends, 3/4-inch NPS minimum size with factory exterior coating of 40-mil thick PVC.
 3. Color: Color of coating shall be the same on all conduit and fittings.
- C. Metallic Conduit Fittings, and Outlet Bodies:
 1. Manufacturers: Provide products of one of the following:
 - a. Crouse-Hinds Company.
 - b. Appleton Electric Company.
 - c. Or equal.
 2. Material and Construction: Cast gray iron alloy, cast malleable iron bodies and covers consistent with conduit material. Units shall be threaded type with five full threads. Materials shall comply with ANSI/NEMA FB1 and be listed by UL. Do not use "LB" fittings. Use type "LBD" fittings where use of fittings is unavoidable.
 3. Use: Conduits shall be gasketed and watertight in hazardous, wet, and corrosive locations.

- D. PVC-coated Conduit Fittings, and Outlet Bodies:
1. Manufacturers: Provide products of one of the following:
 - a. Robroy Industries.
 - b. Perma-Cote Industries.
 - c. OCAL, Inc.
 - d. Or equal.
 2. Material and Construction: Cast gray iron alloy, cast malleable iron bodies and covers with factory coating of 40-mil thick PVC and smooth urethane interior coating. Units shall be threaded type with five full threads. Material shall comply with ANSI/NEMA FB1 and be listed by UL. Do not use "LB" fittings. Use type "LBD" fittings where use of fittings is unavoidable.
 3. Use: Provide PVC-coated conduit fittings and outlet bodies in hazardous, wet, and corrosive locations. Fitting material shall be consistent with conduit material.
- E. Non-metallic Conduit and Fittings:
1. PVC Plastic Conduit:
 - a. Manufacturers: Provide products of one of the following:
 - 1) Amoco Chemicals Corp.
 - 2) Carlon Electrical Products.
 - 3) Or equal.
 - b. Material: Schedule 40 PVC, rated for 90 degrees C, complying with NEMA TC3 and UL 514B and 651.
 - c. Fittings: Form elbows, bodies, terminations, expansions, and fasteners of same material and manufacturer as base conduit. Provide cement by same manufacturer as base conduit.
- F. Conduit Hubs:
1. Manufacturers: Provide products one of the following.
 - a. Myers Electrical Products Company.
 - b. Or equal.
 2. Material: Threaded conduit hub, vibration-proof, weatherproof, with captive O-ring seal, zinc metal with insulated throat and bonding screw.
 3. Use: Provide for all conduit terminations to boxes, cabinets, and other enclosures in areas designated as wet locations.
- G. PVC-coated Conduit Hubs:
1. Manufacturers: Provide products one of the following:
 - a. Robroy Industries.
 - b. Perma-Cote Industries.
 - c. OCAL, Inc.
 - d. Or equal.
 2. Material: Threaded conduit hub, vibration-proof, weatherproof, with captive O-ring seal, zinc metal with insulated throat and bonding screw, and factory coating of 40-mil thick PVC and smooth urethane interior coating.
 3. Use: Provide for PVC-coated steel conduit terminations to boxes, cabinets, and other enclosures in areas designated as corrosive location.

- H. Conduit Bushings and Locknuts:
1. Manufacturers: Provide products one of the following:
 - a. O-Z/Gedney.
 - b. Appleton Electric Company.
 - c. Or equal.
 2. Insulated Bushings: Malleable iron body with plastic liner. Threaded type with steel clamping screw. Provide with bronze grounding lug, as required.
 3. Locknuts: Steel for sizes 3/4-inch through two-inch diameter and malleable iron for sizes 2.5-inch through four-inch diameter.
 4. Use: Provide for all conduit terminations to boxes, cabinets and other enclosures except threaded type in areas designated as dusty locations.
- I. Thruwall Seals
1. For new construction through exterior subsurface walls and exterior concrete walls.
 - a. Manufacturer: Provide one of the following:
 - 1) Type WSK and WSCS by O-Z/Gedney.
 - 2) Or equal.
 2. For new construction passing through concrete floors and floor slabs.
 - a. Manufacturer: Provide one of the following:
 - 1) Type FSK and FSCS floor seals by O-Z/Gedney.
 - 2) Or equal.
 3. For conduits passing through new exterior masonry block walls or through core-drilled holes in existing exterior subsurface walls, exterior concrete walls, floor slabs, and roof slabs, and for conduits passing through existing interior concrete walls or floors and interior masonry block walls.
 - a. Manufacturer: Provide one of the following:
 - 1) Type CSMI sealing bushing at the inside of the structure and Type CSMC sealing bushing at the outside of the structure by O-Z/Gedney.
 - 2) Or equal.

2.2 ACCESSORIES

- A. Fasteners: To the extent possible, fastener material shall be consistent with conduit material. For PVC-coated rigid steel conduit runs, fasteners shall have factory applied PVC coating or be stainless steel. Fasten raceway systems to supporting structures using the following:
1. To Wood: Wood screws.
 2. To Hollow Masonry Units: Toggle bolts, in accordance with Section 05 05 33, Anchor Systems.
 3. To Brick Masonry: Expansion bolts by Price, or equal.
 4. To Concrete: Anchors in accordance with Section 05 05 33, Anchor Systems.
 5. To Steel: Beam clamps in accordance with Section 26 05 29, Hangers and Supports for Electrical Systems.
- B. Duct Sealing Compound
1. Soft, fibrous, slightly tacky, non-hardening sealing compound.
 2. Remains workable at all temperatures.

3. Manufacturer:
 - a. Type DUX by O-Z/Gedney.
 - b. Or equal.

2.3 IDENTIFICATION

- A. Conduit Labels:
 1. Provide conduit labels in accordance with Section 26 05 53, Identification for Electrical Systems.
- B. Warning Tape:
 1. Provide warning tape in accordance with Section 26 05 53, Identification for Electrical Systems.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be performed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install in accordance with Laws and Regulations.
- B. Supports:
 1. Rigidly support conduits by clamps, hangers, or Unistrut-type channels. Conduit supports and accessories shall be in accordance with Section 26 05 29, Hangers and Supports for Electrical Systems.
 2. Support single conduits by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the support surface. Support multiple runs of conduits on trapeze type hangers.
- C. Fastenings: Fasten raceway systems rigidly and neatly to supporting structures using specified materials.
- D. Exposed Conduit:
 1. Install parallel or perpendicular to structural members or walls.
 2. Where possible, run in groups. Provide conduit racks of suitable width, length, and height, arranged to suit field conditions. Provide support every ten feet, minimum.
 3. Install on structural members in protected locations.
 4. Locate clear of interferences.
 5. Provide six inches of clearance from hot fluid lines and 1/4-inch from walls.
 6. Install vertical runs plumb. Unsecured drop length shall not exceed 12 feet.

- E. Conduit Embedded in Structural Concrete:
1. Run embedded conduit in structural concrete in center of slabs and walls and above waterstops. Conduit connections shall be made watertight.
 2. Before placing concrete, arrange for observation of conduit installation by RPR or ENGINEER and make necessary conduit location measurements and provide required information on record documents.
 3. Confirm that concrete thickness is sufficient for embedding the quantity of conduits intended. Unless specifically shown or indicated otherwise, embedded conduits shall be in accordance with the following criteria:
 - a. Minimum concrete thickness shall be as follows:
 - 1) For concrete 16 inches thick and less, minimum concrete thickness shall be 11.5 inches plus the depth of largest conduit assembly. Conduit assembly depth shall be from the top of uppermost conduit to bottom of lowest conduit.
 - 2) For concrete greater than 16 inches thick, minimum concrete thickness shall be 13.5 inches plus depth of largest conduit assembly.
 - 3) For concrete at foundation slabs, provide an one inch additional to minimum concrete thicknesses specified.
 - b. Conduit spacing shall be as follows:
 - 1) Two adjacent conduits shall be separated by center-to-center distance of three times the outer diameter of larger conduit
 - 2) When conduits cross at a point, conduits may be in direct contact and angle of cross shall be 45 degrees or greater. Conduits may also cross within the vertical spacing of multi-conduit layer assembly.
 - 3) When conduits cross structural expansion joint, two adjacent conduits shall be separated by center-to-center distance of three times the outer diameter of conduit fitting of the larger conduit
- F. Underground Conduits:
1. Install individual, underground conduits minimum of 20 inches below grade, unless otherwise shown or indicated.
 2. Perform excavation, bedding, backfilling, and surface restoration, including pavement replacement where required, in accordance with Section 31 23 05, Excavation and Fill, and Section 32 12 16, Asphalt Concrete Paving.
 3. Install warning tape 12 inches below finished grade over buried conduits.
- G. Empty Conduits:
1. Install nylon pull wire in each empty conduit and cap conduits not terminating in boxes with permanent fittings designed for the purpose.
- H. Field Bends: No indentations. Diameter of conduit shall not vary more than 15 percent at bends.
- H. Joints:
1. Apply conductive compound to joints before assembly.
 2. Make up joints tight and ground thoroughly.
 3. Use standard tapered pipe threads for conduit and fittings.

4. Cut conduit ends square and ream to prevent damaging wire and cable.
5. Use full threaded couplings. Split couplings are not allowed.
6. Use strap wrenches and vises to install conduit. Replace conduit with wrench marks.
7. Apply zinc-rich paint to exposed threads and other areas of galvanized conduit system where base metal is exposed.

I. Terminations:

1. Install insulated bushings on conduits entering boxes or cabinets, except when threaded hubs are used.
2. Provide locknuts on both inside and outside of enclosure, except when threaded hubs are used.
3. Use of bushings in lieu of locknuts is not allowed.
4. Install conduit hubs on conduits entering boxes or cabinets in wet and corrosive areas.

J. Moisture Protection:

1. Plug or cap conduit ends at time of installation to prevent entrance of moisture and foreign materials.
2. Underground and embedded conduit connections shall be watertight.
3. Thruwall Seals and Conduit Sealing Bushings: Install for conduits passing through concrete slabs, floors, walls, or concrete block walls.
4. Drainage: Conduit runs shall be fully drainable. Where possible install conduit runs to drain to one end and away from building. Avoid pockets or depressions in conduit runs.
5. Seal conduit openings within control and instrumentation panels and distribution equipment with duct sealing compound to provide watertight seal.

K. Corrosion Protection:

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

- coupling/fittings between the PVC-coated rigid steel elbow and rigid steel conduit for transition between the two conduit types.
- e. For conduits stubbing up and extending to boxes, cabinets, and other enclosures above the concrete curb or equipment base in corrosive areas, continue conduit system with PVC-coated rigid steel conduit
2. Dissimilar Metals:
 - a. Prevent occurrence of electrolytic action between dissimilar metals.
 - b. Do not use copper products in connection with aluminum, and do not use aluminum in locations subject to drainage of copper compounds on bare aluminum.
 - c. Back paint aluminum in contact with masonry or concrete with two coats of aluminum-pigmented bituminous paint.
- L. Reused Existing Conduits:
1. Pull rag swab through conduits to remove water and to clean conduit prior to installing new cable.
 2. Repeat swabbing until all foreign material is removed.
 3. Pull mandrel through conduit, if necessary, to remove obstructions.
- M. Core drill for individual conduits passing through existing concrete slabs and walls. Notify ENGINEER in writing in advance of core drilling. Prior to core drilling, drill sufficient number of small exploratory holes to establish that the area to be core drilled is free of existing embedded conduits. Seal spaces around conduit as indicated in Paragraph 3.2.K.3 of this Section.
- N. Non-metallic Conduit:
1. Install in accordance with manufacturer's recommendations.
 2. Provide manufacturer's recommended adhesives or sealants for watertight connections.
 3. Provide expansion fittings for expansion and contraction to compensate for temperature variations. Fittings shall be watertight and suitable for direct burial.
 4. Transition to PVC-coated rigid steel conduit before making turn up to enclosures.
- O. PVC-coated Rigid Steel Conduit:
1. Install in accordance with manufacturer's recommendations.
 2. Install with manufacturer's installation tools to avoid damage to PVC coating.
 3. Repair damaged PVC coating with manufacturer's recommended touch-up compound.
- P. Identify conduits, including spares, in accordance with Section 26 05 53, Identification for Electrical Systems.

3.3 FIELD QUALITY CONTROL

A. Site Tests:

1. Test conduits by pulling through each conduit a cylindrical mandrel with length not less than two pipe inside diameters, having an outside diameter equal to 90 percent of conduit's inside diameter.
2. Maintain a record, by number, of all conduits successfully tested.
3. Repair or replace conduits that do not successfully pass testing, and re-test.

++ END OF SECTION ++

SECTION 26 05 33.16

FLEXIBLE CONDUITS

PART 1 – GENERAL

1.1 DESCRIPTION

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

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. UL 360, Liquid-Tight Flexible Steel Conduit.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
 - 1. NEC Article 350, Liquid-Tight Flexible Metal Conduit.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Product Data:
 - a. Manufacturer's literature and technical information for flexible conduit and fittings proposed for use.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Flexible Conduit (Non-hazardous Areas and Class 1, Division 2, Hazardous Areas):
 - 1. Material: Flexible galvanized steel core with smooth, abrasion-resistant, liquid-tight, polyvinyl chloride cover. Continuous copper ground built in for sizes 3/4-inch through 1.25-inch. Material shall be UL-listed.
 - 2. Products and Manufacturers: Provide one of the following:
 - a. Anaconda Sealtite Type UA by Anamet Electrical, Inc.
 - b. Licutite Type L.A. by Electric-Flex Company.
 - c. Or equal.
- B. Flexible Conduit (Class 1, Group D, Division 1, Hazardous Areas):
 - 1. Material: Flexible brass inner core with bronze outer braid and protective neoprene plastic coating. Steel, brass, or bronze end fittings. Minimum of 12 inches long.

2. Products and Manufacturers: Provide one of the following:
 - a. Type ECGJH or ECLK by Crouse Hinds Company.
 - b. Type EXGJH or EXLK by Appleton Electric Company.
 - c. Or equal.
- B. Flexible Conduit Fittings:
 1. Material and Construction: Malleable iron with cadmium finish. Fittings shall adapt the conduit to standard threaded connections, shall have an inside diameter not less than that of the corresponding standard conduit size and shall be UL listed.
 2. Manufacturers: Provide products of one of the following:
 - a. Crouse-Hinds Company.
 - b. Appleton Electric Company.
 - c. Or equal.
 3. Use: Provide on flexible conduit in non-hazardous and Class 1, Division 2 hazardous areas.
- C. PVC-Coated Conduit Fittings:
 1. Material and Construction: Malleable iron with standard finish and 40-mil PVC exterior coating. Fittings shall adapt the conduit to standard threaded connections, and shall have an inside diameter not less than that of the corresponding standard conduit size.
 2. Manufacturers: Provide products of one of the following:
 - a. Robroy Industries.
 - b. Permacote Industries.
 - c. OCAL, Inc.
 - d. Or equal.
 3. Use: Provide on flexible conduit in areas designated as corrosive locations.

PART 3 – EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install at motors, unit heaters, transformers, field instruments, and equipment subject to vibration or require movement for maintenance purposes. Provide necessary reducer where equipment furnished cannot accept 3/4-inch diameter flexible conduit. Limit flexible conduit length to three feet maximum.
- B. Install in conformance with the Laws and Regulations.

++ END OF SECTION ++

SECTION 26 05 33.23

SEALED FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install conduit sealing fittings with sealing fiber and sealing compound.

1.2 REFERENCES

- A. Standards referenced in this Section are:
1. UL 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations, Class 1, Groups A, B, C and D and Class II, Groups E, F and G.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
1. NEC Article 500, Hazardous (Classified) Locations.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
1. Shop Drawings:
 - a. Listing of locations where fittings are to be used.
 2. Product Data:
 - a. Manufacturer's literature and technical information for sealing fittings, sealing fiber, and sealing compound proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Manufacturers: Provide products of one of the following:
1. Crouse Hinds Company.
 2. Appleton Electric Company.
 3. Or equal.
- B. Materials and Construction:
1. Cast gray iron alloy, or cast malleable iron, bodies with zinc electroplate and lacquer or enamel finish.
 2. Ample opening with threaded closure for access to conduit hub for making dam.
 3. In corrosive locations, fittings shall include factory-applied 40-mil PVC coating.

- 4. Construct fitting to allow 40 percent cross-sectional fill.
- C. Sealing fiber for forming the dam within the hub and sealing compound shall be suitable for use with fittings furnished, and shall be products of fitting manufacturer.
- D. Sealing fitting, fiber, and sealing compound shall conform to UL 886.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install for hazardous locations as required by Laws and Regulations and as shown.
- B. Provide fittings for proper use relative to mounting position.
- C. Use oversized fittings with reducing bushings when necessary to maintain cable fill requirements of the conduit system.

++ END OF SECTION ++

SECTION 26 05 33.26

EXPANSION/DEFLECTION FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

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

1.2 REFERENCES

- A. Standards referenced in this Section are:
1. UL 514B, Conduit, Tubing, and Cable Fittings.
 2. UL 467, Grounding and Bonding Equipment.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
1. NEC Article 300, Wiring Methods.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
1. Shop Drawings:
 - a. Listing of locations where fittings are required.
 2. Product Data:
 - a. Manufacturer's literature and technical information for expansion and deflection fittings proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

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

- B. Cast gray iron alloy or bronze end couplings, malleable iron, or hot-dipped galvanized body, stainless steel clamps and tinned copper braid bonding jumper. Fitting shall be watertight, corrosion-resistant, UL-listed, and compatible with the conduit system.
- C. Features:
 - 1. Expansion/Deflection Fittings:
 - a. Axial expansion or contraction up to 3/4-inch.
 - b. Angular misalignment up to 30 degrees.
 - c. Parallel misalignment up to 3/4-inch.
 - 2. Expansion Fittings:
 - a. Expansion/Contraction: Eight-inch total movement.
- D. Expansion/Deflection fittings shall comply with UL 514B and UL 467.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be performed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install fittings in accordance with Laws and Regulations.
- B. Provide expansion fittings on exposed conduit runs crossing structural expansion joints and where necessary to compensate for thermal expansion and contraction. Provide expansion fittings on exposed conduit runs exceeding 200 feet.
- C. Provide expansion/deflection fittings on embedded conduit runs crossing structural expansion joints. Provide fittings above waterstops.
- D. Unless specifically shown or indicated otherwise, when crossing structural expansion joints larger than one inch, provide expansion fitting together with expansion/ deflection fitting. Install fittings on each conduit run in accordance with manufacturer's recommendations to accommodate additional movement necessary.
- E. Provide expansion/deflection fittings for underground conduit runs at penetrations of buildings, outdoor concrete equipment pads, and substations. Provide above grade expansion/deflection fittings where underground conduit runs transition to exposed runs at structures/buildings exterior.

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

+ + END OF SECTION + +

SECTION 26 05 33.33

PULL, JUNCTION, AND TERMINAL BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

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

- B. Related Sections:
 - 1. Section 26 05 05, General Provisions for Electrical Systems.
 - 2. Section 26 05 29, Hangers and Supports for Electrical Systems.
 - 3. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

- A. Standards referenced in this Section are.
 - 1. UL 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. NEC Article 314, Outlet, Device, Pull and Junction Boxes; Conduit Bodies; Fittings; and Handhole Enclosures.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Product Data:
 - a. Manufacturer's technical information for pull, junction, and terminal boxes proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Pull, Junction, and Terminal Boxes:
 - 1. General – Applicable to All Boxes:
 - a. Description and Performance Criteria:
 - 1) Provide pull, junction, and terminal boxes rated at not less than NEMA 12. Boxes shall be appropriate for each location in accordance with NEMA requirements and as required for area classifications specified in Section 26 05 05, General Provisions for Electrical Systems.

- b. Manufacturers: Provide products of one of the following:
 - 1) Appleton Electric Company.
 - 2) Crouse-Hinds Company.
 - 3) Hoffman Engineering Company.
 - 4) Or equal.
 - c. Materials: Pull boxes embedded in concrete slabs shall be cast iron.
 - d. Terminal strips and terminal blocks in terminal boxes shall be mounted on terminal box sub-panels.
 - e. Identification: Boxes shall be identified in accordance with Section 26 05 53, Identification for Electrical Systems.
2. Materials and Construction – Dusty Locations:
- a. Material: Welded and galvanized sheet steel of USS gage.
 - b. Gasket: Oil-resistant gasket.
 - c. Access: Lift-off hinges and quick-release latches.
 - d. Material Thickness:
 - 1) Boxes with dimension two feet and smaller shall be 14-gage.
 - 2) Boxes with dimension between two and three feet shall be 12 gage.
 - 3) Boxes with dimension of three feet or more in any direction shall be 10-gage.
3. Materials and Construction - Wet, Corrosive, or Hazardous Locations:
- a. Rating:
 - 1) Pull boxes in wet, corrosive, or outdoor areas shall be NEMA 4X.
 - 2) Boxes for areas classified as hazardous locations, where required by NEC, shall be explosion-proof and comply with UL 886.
 - b. Material:
 - 1) Cast gray iron alloy with hot-dip galvanized finish, or cast malleable iron bodies and covers.
 - 2) Large boxes not generally available in cast iron construction shall be copper-free aluminum alloy or Type 316 stainless steel, as required by location.
 - 3) In corrosive locations, where the conduit system is PVC-coated, boxes shall be cast metal with factory-applied 40-mil PVC coating or Type 316 stainless steel.
 - c. Gasket:
 - 1) Provide neoprene gaskets for wet and corrosive locations.
 - 2) Gaskets shall be an approved type designed for the purpose. Improvised gaskets are not acceptable.
 - d. Access: Stainless steel cover bolts.
 - e. Features:
 - 1) External mounting lugs.
 - 2) Drilled and tapped conduit holes.
 - 3) Boxes where conduits enter building or structure below grade shall have 1/4-inch drain hole at bottom of the box.
 - 4) Provide threaded connections for explosion proof boxes.

- B. Terminal Blocks:
1. Manufacturers: Provide one of the following:
 - a. Allen-Bradley Company
 - b. General Electric Company
 - c. Or equal.
 2. Material and Construction:
 - a. NEMA-rated nylon modular terminal blocks.
 - b. 600-volt rated.
 - c. Control and alarm circuit terminals shall be screwed type with permanently affixed numeric identifiers beside each connection.
 - d. Power terminals shall be copper and rated for the circuit ampacity.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Mount boxes so that sufficient access and working space is provided and maintain clearance of not less than 1/4-inch from walls.
- B. Securely fasten boxes to walls or other structural surfaces on which boxes are mounted. Provide independent supports that comply with Section 26 05 29, Hangers and Supports for Electrical Systems, where boxes will not be mounted on walls or other structural surface.
- C. Install pull boxes where shown or indicated, and provide pull boxes where one or more of the following conditions exist:
 1. Conduit runs containing more than three 90-degree bends.
 2. Conduit runs exceeding 200 feet in length.
- D. Provide removable, flame-retardant, insulating cable supports in boxes with any dimension exceeding three feet.
- E. Field-apply PVC touch-up to scratched PVC boxes damaged during installation. Touch-up work shall be in accordance with manufacturer's recommendations and instructions.
- F. Size junction, pull, and terminal boxes in accordance with NEC Article 314 and other Laws and Regulations.
- G. Provide terminal blocks in boxes where shown and where cable terminations or splices are required.

++ END OF SECTION ++

SECTION 26 05 33.36

OUTLET BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install outlet boxes for mounting wiring devices and lighting fixtures.
- B. Related Sections:
1. Section 26 05 05, General Provisions for Electrical Systems.
 2. Section 26 05 29, Hangers and Supports for Electrical Systems.
 3. Section 26 05 53, Identification for Electrical Systems.
 4. Section 26 27 26.13, Low-Voltage Receptacles.
 5. Section 26 27 26.23, Snap Switches.

1.2 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
1. NEC Article 314, Outlet, Device, Pull and Junction Boxes; Fittings; and Handhole Enclosures.
 2. NEC Article 501, Class I locations.
 3. UL 514A, Metallic Outlet Boxes.
 4. UL 514B, Fittings for Conduit and Outlet Boxes.

1.3 SUBMITTALS

- A. Action Submittals: Submit the following:
1. Product Data:
 - a. Manufacturer's technical information for outlet boxes proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Device Boxes:
1. Manufacturers: Provide products of one of the following:
 - a. Crouse-Hinds Company.
 - b. Appleton Electric Company.
 - c. Or equal.
 2. Material:
 - a. In Wet Locations: Cast gray iron alloy or cast malleable iron with zinc electroplate finish, bodies consistent with conduit material.

- b. In Dusty Locations: Zinc-coated sheet steel bodies consistent with conduit material.
 - c. Where conduit is installed concealed, boxes shall include suitable extension rings and covers, as required.
 - d. Where used with PVC-coated conduit system, boxes shall include factory applied 40-mil-thick PVC coating.
 - e. Cast boxes shall be hub-type and include external mounting lugs.
 - f. Metallic outlet boxes shall comply with UL 514A.
 - g. Fittings for outlet boxes shall comply with UL 514B.
3. NEMA rating of box shall be as required for area classifications specified in Section 26 05 05, General Provisions for Electrical Systems.
 4. Cover Plates:
 - a. Type 302 stainless steel alloy for indoor finished areas.
 - b. Plates in corrosive locations shall include factory-applied 40-mil PVC coating.
 - c. Stainless steel screws and hardware.
 - d. For receptacle and switch cover plates, comply with Section 26 27 26.13, Low-Voltage Receptacles, and Section 26 27 26.23, Snap Switches.

B. Flexible Fixture Hangers:

1. For Class I, Division 1 Hazardous Areas:
 - a. Product and Manufacturers: Provide one of the following:
 - 1) Type EFH by Crouse-Hinds.
 - 2) Or equal
 - b. Materials:
 - 1) Iron alloy with electro-galvanizing and aluminum acrylic paint.
 - 2) Products shall have brass bellows and stainless steel spring.
 - 3) Product shall be capable of 15 degree swing from perpendicular in all directions.
 - 4) Product shall allow fixtures to be pendant-hung in accordance with NEC Article 501.130(A)
2. For Class I, Division 2 Hazardous Areas:
 - a. Product and Manufacturers: Provide one of the following:
 - 1) Type AHG by Crouse-Hinds.
 - 2) Or equal
 - b. Materials:
 - 1) Malleable iron top section and removable malleable iron bottom fixture support assembly with electro-galvanizing and aluminum acrylic paint.
 - 2) Include vapor-tight cushion to support fixture stem.
 - 3) Provide neoprene diaphragm to exclude moisture and dirt from conduit system.
 - 4) Provide with manufacturer's neoprene gasket between fixture hanger and box.
 - 5) Product shall be capable of eight-degree swing from perpendicular in all directions, before and after coating.

- 6) Product shall allow fixtures to be pendant-hung in accordance with NEC Article 501.130 (B).

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Fasten boxes rigidly and neatly to supporting structures.
- B. Securely fasten equipment to walls or other surfaces on which materials or equipment is mounted. Provide independent supports complying with Section 26 05 29, Hangers and Supports for Electrical Systems, where boxes are not mounted on walls or other surface capable of supporting the materials or equipment.
- C. For units mounted on masonry or concrete walls, provide suitable 1/2-inch spacers to prevent mounting back of box directly against wall.
- D. Leave no open conduit holes in boxes. Close unused openings with capped bushings.
- E. Label each circuit in boxes and identify each circuit in accordance with Section 26 05 53, Identification for Electrical Systems.
- F. Install outlet boxes in accordance with NEC Article 314.

++ END OF SECTION ++

SECTION 26 05 43.13

UNDERGROUND DUCTBANKS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install underground ductbanks.

- B. Coordination:
 - 1. Ductbank routing on the Drawings is diagrammatic. Coordinate installation with piping and other Underground Facilities and locate ductbanks clear of interferences.
 - 2. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before underground ductbank Work.
 - 3. Notify other contractors in advance of installing underground ductbanks to provide other contractors with sufficient time for installing items included in their contracts that will be installed with or before underground ductbank Work.

- C. Related Sections:
 - 1. Section 03 20 00, Concrete Reinforcing.
 - 2. Section 03 30 00, Cast-in-Place Concrete.
 - 3. Section 26 05 26, Grounding and Bonding for Electrical Systems.
 - 4. Section 26 05 33.13, Rigid Conduits.
 - 5. Section 26 05 33.26, Expansion/Deflection Fittings.
 - 6. Section 26 05 53, Identification for Electrical Systems.
 - 7. Section 31 23 05, Excavation and Fill.

1.2 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Layouts showing proposed routing of ductbanks and locations of manholes, handholes, and areas of reinforcement.
 - b. Profiles of ductbanks showing crossings with piping and other Underground Facilities.
 - c. Typical cross sections for each ductbank.

- B. Informational Submittals: Submit the following:
 - 1. Special Procedure Submittals:
 - a. Installation procedures.
 - 2. Field Quality Control Submittals:
 - a. Field test report.

- C. Closeout Submittals: Submit the following:
 - 1. Record Drawings:
 - a. Include actual routing of underground ductbank runs on record documents in accordance with Section 01 78 39, Project Record Documents.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Duct: Provide conduit and fittings in accordance with Section 26 05 33.13, Rigid Conduits. Conduit types shall be as follows:
 - 1. Schedule 40 PVC conduits for the following types of circuits
 - a. Medium and Low voltage power circuits.
 - b. Fiber Cables
 - 2. Galvanized rigid steel conduits for the following types of circuits:
 - a. Low voltage status, analog, and communication.
- B. Backfill: Provide backfill, including select backfill, in accordance with Section 31 23 05, Excavation and Fill .
- C. Reinforcing: Provide Ductbank reinforcing in accordance with Section 03 20 00, Concrete Reinforcing.
- D. Concrete: Provide ductbank concrete in accordance with Section 03 30 00, Cast-in-Place Concrete.
- E. Grounding: Provide ground cable in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.
- F. Conduit Spacers: Conduit spacers shall be nonmetallic, interlocking type to maintain spacing between conduits. Provide spacers suitable for all conduit types used in multiple sizes.
- G. Foam Duct Sealant:
 - 1. Products and Manufacturers: Provide one of the following:
 - a. Polywater FST Foam Duct Sealant
 - b. Or equal.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Excavation and Backfilling:
 - 1. Provide excavation and backfilling for ductbank installation in accordance with Section 31 23 05, Excavation and Fill.
 - 2. Do not backfill with material containing large rock, paving materials, cinders, large or sharply angular substances, corrosive material, or other materials that can damage or contribute to corrosion of ducts or cables, or prevent adequate compaction of backfill.

- B. Ductbank Layout:
 - 1. Top of ductbank concrete shall be a minimum of 2.5 feet below grade, unless shown or indicated otherwise on the Drawings.
 - 2. Slope ductbank runs for drainage toward manholes and away from buildings with slope of approximately three inches vertical per 100 feet of run.

- C. Ductbank Assembly:
 - 1. Assemble ductbanks using non-magnetic saddles, spacers, and separators. Position separators to provide minimum three-inch concrete separation between outer surfaces of each conduit. Provide side forms for each ductbank.
 - 2. Make bends with sweeps of not less than four-foot radius or five-degree angle couplings.

- D. Concrete Placing:
 - 1. Provide minimum four-inch concrete covering on each side, top, and bottom of concrete envelopes around conduits. Concrete covering shall be as shown or indicated on the Drawings.
 - 2. Provide red dye in concrete for easy identification during subsequent excavation; all concrete in entire ductbank, including top and bottom, shall be dyed.
 - 3. Firmly fix conduits in place during concrete placing. Carefully place and vibrate concrete to fill spaces between conduits.

- E. Conduit Transitions:
 - 1. Conduit installations shall be watertight throughout entire length of ductbank.
 - 2. Transition from non-metallic to galvanized rigid steel conduit where ductbanks enter structure walls and slabs. (Manholes and Handholes shall be considered structure walls).
 - 3. Terminate conduits in insulated grounding bushings.
 - 4. Continue conduits inside buildings in accordance with Section 26 05 33.13, Rigid Conduits, and as shown or indicated in the Contract Documents.
 - 5. Provide expansion and deflection fittings in accordance with Section 26 05 33.26, Expansion/Deflection Fittings.
 - 6. Plug and seal empty spare conduits entering structures. Conduits in use entering structures shall be sealed watertight with duct sealant.
 - 7. At existing structures/buildings transition underground runs to exposed runs at building exterior walls. Run conduits vertically up on exterior wall as required to enter buildings above existing recessed ceilings and/or to avoid new/existing equipment or systems. Provide vertical conduits as required and

provide above grade expansion/deflection fittings per Specification section 26 05 33.26. Provide pull boxes, sized as required, on exterior of building to transition from vertical conduit runs on exterior to horizontal conduit runs to be routed through the exterior wall of the structure/building.

F. Ductbank Reinforcing:

1. Provide reinforcing for all ductbanks:
2. Install ductbank reinforcement as shown or indicated on the Drawings.
3. Provide maximum clearance of 1.5 inches from bars to edge of concrete encasement.

G. Connections to Structures:

1. Firmly anchor ductbanks to structure walls or slabs. Epoxy-grout ductbank rebar into structure concrete to eliminate sheer forces between ductbank and structure wall concrete.
2. Ductbank penetrations through structure walls shall be watertight.

H. Grounding:

1. Provide bare stranded copper ductbank ground cable in each ductbank envelope. Make ground electrically continuous throughout entire ductbank system.
2. Connect ground cable to building and station ground grid or to equipment ground buses. Also, connect ground cable to steel conduit extensions of underground ductbank system.
3. Provide ground clamp and bonding of each steel conduit extension to maintain continuity of ground system.
4. Terminate ground cable at last manhole or handhole for outlying structures.

I. Detectable Underground Warning Tape:

1. Provide detectable underground warning tapes complying with Section 26 05 53, Identification for Electrical Systems, over the full length of each underground ductbank.
2. Install warning tapes approximately 12 inches below grade.
3. Provide multiple tapes across the width of each ductbank. Locate center of a warning tape above each edge of ductbank, and at intervals across top width of ductbank so that clear space between tapes does not exceed six inches.

J. Reused Existing Ducts:

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

++ END OF SECTION ++

SECTION 26 05 43.23

MANHOLES AND HANDHOLES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install manholes and handholes for electrical systems Work.

B. Coordination:

1. Coordinate manhole and handhole installation with piping, sheeting other excavation supports, and other Underground Facilities, and locate clear of interferences.
2. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before manhole and handhole for electrical systems Work.
3. Notify other contractors in advance of installing manholes and handholes for electrical systems to provide other contractors with sufficient time for installing items included in their contracts that will be installed with or before manhole and handhole for electrical systems Work.

C. Related Sections:

1. Section 31 23 05, Excavation and Fill.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. AASHTO, Specifications for Highway Bridges.
2. ANSI A14.3, Fixed Ladders – Safety Requirements.
3. ANSI/SCTE 77, Specification for Underground Enclosure Integrity.
4. ASTM A48/A48M, Specification for Gray Iron Castings.
5. ASTM A615/A615M, Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
6. ASTM C478, Specification for Precast Reinforced Concrete Manhole Sections
7. ASTM C1028, Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method.
8. ASTM D4101, Specification for Polypropylene Injection and Extrusion Materials.

1.3 QUALITY ASSURANCE

- A. Component Supply and Compatibility:
 - 1. Obtain all manholes and handholes furnished under this Section from a single Supplier, unless otherwise acceptable to ENGINEER.
 - 2. Manhole and handhole Supplier shall review and approve the Shop Drawing submittals for the manholes and handholes furnished.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Manholes: Plan and section drawings showing arrangement of each manhole, including interior and exterior dimensions, elevations, location of manhole wall penetrations, details of typical openings, jointing, inserts, and reinforcing.
 - b. Handholes: Submit schedule of handholes to be furnished and dimensions and pertinent data for each.
 - c. Castings:
 - 1) Schedule of casting types and models to be furnished, with dimensional data and other pertinent data for each.
 - 2) Fabrication and erection of all frame and cover assemblies. Include plans, elevations, and details of sections and connections. Show anchorage and accessory items. Provide setting drawings for location and installation of castings and anchorage devices.
 - 3) Where Site-specific castings are specified with unique lettering on manhole or handhole cover, provide Shop Drawing for castings indicating appropriate detail to indicate conformance to the Contract Documents.
 - d. Layout of Manhole Electrical Systems: Where manholes have extensive electrical systems and supports for electrical systems, submit for each plans, sections, and details indicating proposed layout of such materials and equipment in each manhole.
 - 2. Product Data:
 - a. Manufacturer's technical information, specifications, and literature for manholes, handholes, castings, and accessories proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Material and Construction:
 - 1. Material shall be precast or cast-in-place reinforced concrete. Reinforcing shall be in accordance with Section 03 20 00, Concrete Reinforcing. Concrete shall be in accordance with Section 03 30 00, Cast-in-Place Concrete.
 - 2. Provide minimum interior dimensions as shown or indicated. Provide a 12-inch by 12-inch by six-inch deep sump in manhole floor

3. Duct entrances shall be sized and located to suit the ductbanks.
4. Precast Manholes:
 - a. Except where otherwise specified, precast manhole components shall consist of reinforced concrete pipe sections specially designed and constructed for use as manholes and manufactured in accordance with ASTM C478, except as modified in this Section.
 - b. Precast, reinforced concrete manhole bases, riser sections, flat slabs, and other components shall be manufactured by wet-cast methods, using forms that provide smooth surfaces free of irregularities, honeycombing, and other imperfections.
 - c. Joints between manhole components shall be tongue-and-groove type employing a single, continuous rubber O-ring gasket. Circumferential and longitudinal steel reinforcing shall extend into bell and spigot ends of joint without breaking steel continuity. Joints between base sections, riser sections, and top slabs of manholes six feet in diameter and less shall be rubber and concrete joints. Joints for manhole components greater than six-foot diameter shall have steel bell and spigot rings.
 - d. Precast manhole components shall:
 - 1) have sufficient strength to withstand loads imposed upon them; and
 - 2) be constructed for minimum earth cover loading of 130 pounds per cubic foot, AASHTO H-20 wheel loading, and an allowance of 30 percent in roadways and 15 percent in rights-of-way for impact.
 - 3) Manhole bases shall have two cages of reinforcing steel in the walls, each reinforcing cage shall be of area equal to that required in the riser sections.
 - 4) Wall thickness shall be not less than five inches.
 - 5) Concrete top slabs shall be not less than eight inches thick.
 - e. Lifting holes, when provided, shall be tapered. Not more than two lifting holes shall be cast into each section. Provide tapered, solid rubber plugs to seal lifting holes. Lifting holes shall be made to be sealed by plugs driven from the outside face of section only.
 - f. Point of intersection (P.I.) of ductbank centerlines shall be marked with 1/4-inch diameter steel pin firmly enclosed in floor of each manhole base and protruding approximately one-inch above finished floor of base.
 - g. Mark date of manufacture and name or trademark of manufacturer on inside of manhole barrel.
 - h. Barrel of manhole shall be constructed of various lengths of riser pipe manufactured in increments of one foot to provide correct height with the fewest joints. Provide not less than one foot clear between openings in barrel of manholes for ductbanks or other penetrations and the nearest joint. Provide special manhole base or riser sections as required.
 - i. Provide at top of manhole barrel a precast or cast-in-place slab, or precast eccentric cone, as shown or approved, to receive manhole frame and cover.

B. Accessories:

1. Frames and Covers:
 - a. Manufacturers: Provide products of one of the following:
 - 1) Neenah Foundry Company.

- 2) Campbell Foundry Company.
 - 3) Or equal.
 - b. Material: Cast iron complying with ASTM A48/A48M, Class 30A.
 - c. Covers: Watertight, sealed type marked "ELECTRICAL" in raised two-inch letters. Identify covers as shown or indicated on the Drawings.
 - d. Grout the frame to the manhole or handhole.
2. Pulling Irons:
- a. Products and Manufacturers: Provide one of the following:
 - 1) Catalog No. 8119 by A.B. Chance Company.
 - 2) Catalog No. DU2T3 by McGraw Edison Company.
 - 3) Or equal.
 - b. Material: Galvanized steel.
 - c. Cast in the wall opposite to centerline of each incoming ductbank and 12 inches below centerline of bottom line of ducts.
3. Cable Racks:
- a. Products and Manufacturers: Provide one of the following:
 - 1) Catalog No. J5125 by MacLean Power Systems.
 - 2) Catalog No. C203-1125 by A.B. Chance Company.
 - 3) Or equal.
 - b. Material: Galvanized steel.
 - c. Cable racks shall adequately support cables with space allowed for future cables.
 - d. Each rack shall be a vertical assembly of two-foot cable racks extending from within six inches of manhole roof slab to within six inches of manhole floor.
4. Cable Hooks:
- a. Products and Manufacturers: Provide one of the following:
 - 1) Catalog No. J5132A by MacLean Power Systems.
 - 2) Catalog No. C203-1132 by A.B. Chance Company.
 - 3) Or equal.
 - b. Material: Galvanized steel.
 - c. Length: 7.5-inch minimum.
5. Insulators:
- a. Products and Manufacturers: Provide one of the following:
 - 1) Catalog No. J5122 by MacLean Power Systems.
 - 2) Catalog No. C203-1120 by A.B. Chance Company.
 - 3) Or equal.
 - b. Material: Porcelain.
6. Manhole Steps – Polypropylene
- a. Products and Manufacturers: Provide one of the following:
 - 1) P-14938, by Lane International.
 - 2) Or equal.
 - b. Material: Polypropylene complying with ASTM D4101 with 1/2-inch diameter Grade 60 steel reinforcing bar complying with ASTM A615/A615M.
 - c. Color: Black

- d. Provide manhole steps as shown or indicated. Manhole steps shall have raised treads and comply with ANSI A14.3, ASTM C478, and OSHA requirements.
- e. Steps shall be 15.25 inches wide and, when installed, protrude from manhole wall by six inches.
- f. Space steps uniformly at a maximum of 12 inches on centers, and project evenly from manhole or chamber walls.

2.2 SMALL HANDHOLES

- A. Material and Construction:
 1. Manufacturer: Provide products of one of the following:
 - a. Strongwell Quazite
 - b. Or equal
 2. Material: Precast polymer concrete.
 3. Duct entrances sized and located to suit ductbanks.
 4. Enclosures and covers shall be UL-listed.
 5. Enclosures, boxes, and covers shall comply with test provisions of ANSI/SCTE 77 for Tier 22 applications.
 6. Covers shall have coefficient of friction of not less than 0.50, in accordance with ASTM C1028.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Excavation and Backfill:
 1. Provide manholes and handholes for electrical systems where shown or indicated and verify at the Site the required locations.
 2. Perform excavation and filling required for installing manholes and handholes for electrical systems, in accordance with Section 31 23 05, Excavation and Fill.
 3. Provide manholes and handholes on granular subbase course as shown or indicated. If not shown, provide layer of compacted select fill not less than six inches deep on which manhole or handhole for electrical systems will be installed.
 4. Carefully set, level, and align at proper grade manhole bases and handholes.
- B. Precast Manholes:
 1. Set manhole sections vertical with steps and sections in true alignment. Butter the base of each bell or groove end at joints between components with one-to-two proportion cement-sand mortar to provide uniform bearing between

- components. Seal joints with cement mortar inside and out and trowel smooth to contour of wall surface. Raised or rough joint finishes are unacceptable.
2. Install sections, joints, and gaskets in accordance with manufacturer's recommendations.
 3. Tightly seal each lifting hole with solid rubber plug driven into hole from outside of barrel; fill remaining void with one-to-two proportion cement-sand mortar.
- C. Manhole and handhole structures shall be watertight. Provide foam sealant to seal all penetrations into manholes and handholes for electrical systems.
- D. Cable Supports in Manholes:
1. Attach cable racks with three-inch by 3/8-inch diameter "tamp-in" studs mounted in one-inch holes drilled into walls of manholes in absence of inserts. Provide PVC coating on racks.
 2. Provide cable hooks to support each cable on each rack along the cable run within manholes. Provide PVC coating on hooks.
 3. Individually support each cable at each hook on porcelain insulators. Provide sufficient slack for each cable.
 4. Securely tie each cable in place at each insulator block to prevent excessive movement of insulators, cables, or fireproof tape. Tie cables with non-metallic 3/4-inch strapping tape manufactured by 3M or equal, or tie down with nylon straps.
- E. Grounding:
1. Provide 3/4-inch by 10-foot copper-clad ground rod for each manhole.
 2. Bond all exposed metal manhole accessories and concrete reinforcing rods with No. 4 AWG minimum bare copper wire and connect to ground rod and to the ductbank ground cable.
- F. Metal Pull Box:
1. Provide NEMA 4X, stainless steel, wall-mounted pull box inside each manhole and handhole for electrical systems where analog signal and fiber cables are mixed with power cables.
 2. Route conduits for analog and fiber cables directly into and out of metal pull box so that analog cables are not exposed.
- G. Grade Rings:
1. Provide grade rings for manholes when required to adjust cover to proper grade. Construct grade ring on manhole roof slab or cone section on which manhole frame and cover will be placed.
 2. Height of grade ring shall be as required to bring frame to proper grade and shall not exceed 12 inches in height.
- H. Grading at Manholes and Handholes:
1. Unpaved Areas:
 - a. Install manholes and handholes in unpaved areas as shown or directed by ENGINEER to rim elevation higher than finished grade.

- b. Grade the ground surface to drain away from manholes and handholes.
 - c. Provide fill around manholes and handholes to level of upper rim of manhole or handhole frame, and evenly grade the surface to a one (vertical)-to-five (horizontal) slope to surrounding grade, unless otherwise shown or directed by ENGINEER.
2. Paved or Travelled Areas:
- a. Install manholes and handholes in paved or travelled areas to meet final grade of paved or concrete surface.
 - b. In paved areas in state or county highways or municipal streets or roads, manholes and handholes shall be 1/2-inch below elevation of final surface course (also known as top course or wearing course) of pavement.
 - c. Manholes and handholes shall not project above finished roadway pavement.
3. CONTRACTOR shall be solely responsible for proper height of manholes and handholes necessary to reach final grade. ENGINEER's review of Shop Drawings and other submittals for manholes and handholes is general in nature. Provide random-length precast manhole riser sections to adjust manholes to accommodate field conditions for final grading and final elevations.

3.3 FIELD QUALITY CONTROL

- A. Watertightness:
- 1. Manholes and handholes for electrical systems shall be free of visible leakage. Inspect each manhole and handhole accompanied by ENGINEER, and repair leaks.

++ END OF SECTION ++

SECTION 26 05 45

UTILITY SERVICES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install electric service and associated equipment at the Site.
2. CONTRACTOR shall refer to NYSEG SP-1099 Specifications for Customer Electric Service for additional requirements. All equipment referred to be furnished and installed by the Customer in this document shall be provided and installed by the CONTRACTOR.
3. CONTRACTOR shall furnish and install the following Work regarding electric service:
 - a. Riser poles and pole-mounted isolation switch, lightning arresters, and cable terminators.
 - b. Grounding platform and associated grounding.
 - c. 15 KV primary cable and connections.
 - d. Overhead conductors from metering pole to riser pole, including dead-end insulators.
4. Electric utility company, NYSEG, will furnish and install the following:
 - a. Metering transformers, meters, enclosure, and associated metering equipment.
5. The Contract Price includes an allowance amount specified in Section 01 21 00, Allowances, to be used for paying the electric utility company for construction costs incurred by electric utility company and invoiced to CONTRACTOR relative to electrical service for the Site.
 - a. For purposes of determining Cost of the Work and CONTRACTOR's fee associated with construction by the electric utility company, the electric utility company will be considered as a Subcontractor to CONTRACTOR.
 - b. Comply with Section 01 21 00, Allowances, regarding submittal of costs proposed to be paid under the allowance. Do not include in proposed payment under the allowance CONTRACTOR's cost other than cost invoiced to CONTRACTOR by electric utility company and CONTRACTOR fee (overhead and profit). Include such costs, if any, under other, non-allowance payment items.
 - c. Include in an Application for Payment costs invoiced to CONTRACTOR by electric utility company, accompanied by electric utility company's invoice to CONTRACTOR for construction associated with the electric service.
 - d. If costs payable under the allowance exceeds the allowance, OWNER will issue a Change Order to pay CONTRACTOR such extra amount, or will

- pay CONTRACTOR such extra amount by other means available under the Contract.
- e. If actual invoiced costs are less than the allowance amount, the Contract Price will be reduced by the difference between cost eligible and recommended by ENGINEER for payment, and the allowance amount via a Change Order.
6. Work in connection with electric service shall be in accordance with requirements of the electric utility company..
- B. Coordination:
1. CONTRACTOR shall coordinate with electric utility company relative to electric service connections and requirements. CONTRACTOR shall make all necessary arrangements with the electric utility company.
 2. The Contract Price as awarded includes all costs associated with providing electric service to the Site.
- C. Related Section:
1. Section 26 05 13, Medium Voltage Cables

1.2 REFERENCES

- A. Standards referenced in this Section are:
1. ANSI C37.35, Guide for the Application, Installation, Operation and Maintenance of High Voltage Air Disconnecting and Load Interrupter Switches.
 2. ANSI C37.46, Specifications for Power Fuses and Fuse Disconnecting Switches
 3. ANSI/IEEE C62.11, IEEE Metal Oxide Surge Arresters of AC Power Circuits.
 4. ANSI C135.1, Galvanized Steel Bolts and Nuts for Overhead Line Construction.
 5. ANSI C135.2, Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for Overhead Line Construction.
 6. SP-1099, NYSEG Specifications for Customer Electric Service.
 7. AWWA C4, Poles - Preservative Treatment by Pressure Processes.

1.3 QUALITY ASSURANCE

- A. Pre-installation Conference:
1. Prior to transmitting submittals for materials and equipment related to electrical service, and prior to installing materials and equipment associated with electrical service, arrange a conference at the Site with the following:
 - a. Electric utility company.
 - b. Supplier representatives (as required) for materials and equipment associated with electrical service.
 - c. Installers of other work related to and adjacent to electric services Work.
 - d. ENGINEER and Resident Project Representative (as applicable).
 - e. Other representatives directly concerned with the performance of electric service Work.

2. Review at the conference the following relating to electrical service:
 - a. Review Project requirements including Contract Documents, approved Shop Drawings and other submittals, requests for interpretation transmitted by CONTRACTOR to ENGINEER, and other pertinent documents.
 - b. Review scope of Work and scope of utility company work.
 - c. Review required samples and submittals, both completed and to be completed.
 - d. Review proposed costs for work that will be invoiced by utility companies.
 - e. Review status of Work related to utility services and Progress Schedule related to utility services.
 - f. Review availability of materials, tradesmen, equipment, and facilities required for progress, to avoid delays, and to protect the Work from damage.
 - g. Review required inspection, testing, certifying, and quality control procedures.
 - h. Review methods for complying with requirements of utility companies.
3. Reconvene conference at earliest opportunity if additional information must be developed to conclude the required topics of the conference.
4. Record in writing discussions of conference and decisions and agreements and disagreements; and revisions or changes agreed upon, reasons therefore, and parties agreeing or disagreeing with them. Furnish copy of record to each party attending and the OWNER.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 1. Shop Drawings:
 - a. Drawings showing proposed layout of electrical utility service.
 2. Product Data:
 - a. Manufacturer's literature and technical information, including technical specifications, indicating compliance with the Contract Documents for materials and equipment and construction procedures specified in this Section.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Riser Pole and Miscellaneous Equipment:
 1. General: Work related to the pole and associated equipment shall comply with NESC Grade C. Insulation levels shall be in accordance with 15 KV class minimum.
 2. Materials and equipment shall be new and of current manufacture.
 3. Pole: Pole shall be Class 2, fifty feet tall, southern yellow pine, and treated over its full length with pentachlorophenol, chromated copper arsenate (CCA), or creosote in accordance with AWWA Section C4.
 4. Framing: Pole shall be framed with three-inch by four-inch by eight-foot cross arms of southern yellow pine or Douglas fir. Cross arms shall be braced with

one-inch by 1.75-inch wood braces. Cross arms and braces shall be pressure treated with pentachlorophenol.

5. Line Conductors and Connectors: Line conductors shall be sized per NYSEG requirements, types shall be ACSR, AAAC, copper, or copper-weld with polyethylene covering. Ground wires shall be 7/16-inch, high strength, zinc-coated steel with minimum breaking strength of 14,500 pound-force. Connections shall be ANSI Class A.
6. Insulators: Shall be porcelain, line-post or suspension type, except for dead end type insulators. Insulator class shall be in accordance with requirements of electric utility company.
7. Pole Line Hardware: Nuts, bolts, washers and miscellaneous hardware shall be of type specifically developed for pole line installations. Steel or wrought iron hardware shall be hot-dip galvanized in accordance with ANSI C135.1.
8. Anchor Systems:
 - a. Guy wire shall be hot-dipped galvanized 3/8-inch extra-high strength steel with Class B coating. Guy wire shall include suitable strain insulators. Insulators shall be located at least eight feet above grade and six feet from pole top.
 - b. Guy hardware shall have 15,000-pound rating minimum. Anchors shall be either cross-plate or screw type. Anchors shall be galvanized in accordance with ANSI C135.2. Cross-plate anchors shall have cross section of 200 square inches minimum with 3/4-inch by eight-foot rod. Screw anchors shall be an eight-inch diameter helix; 7,000 foot-pound-rated with 3/4-inch by seven-foot rod.

B. Group-operated Load Break Switch:

1. Load Break Switch:
 - a. Switch shall be load break type suitable for operation on overhead distribution systems. Switch interrupting shall be by internal deionizing gas quenching device.
 - b. Switch shall be three-pole, preassembled unit mounted on steel cross arm.
 - c. Switch shall be equipped with operating rod and operating handle, rod shall include an insulator unit in vertical operating shaft. Handle shall be suitable for padlocking.
 - d. Group-operated load break switches shall comply with ANSI C37.35 and ANSI C37.46.
2. Ratings: 12.47 KV nominal, 15 KV maximum, 110 BIL. Current ratings for the switch shall be 600 ampere continuous with momentary rating of 65KA RMS asymmetrical and three-second short time current rating of 20 KA RMS symmetrical.
3. Padlocks: Switch operating handle shall be provided with padlock attachment suitable for locking. Provide padlocks and keys for each switch.
4. Contactor shall ground the switch as per NYSEG specifications.
5. Manufacturers: Provide products of one of the following:
 - a. S and C Electric Company.
 - b. ABB Company.
 - c. Or equal.

C. Fused Loadbreak Cutouts:

1. Fused loadbreak cutouts shall be disconnecting type, 180-degree opening vertical mounting type with portable load break hook-stick tool. Contacts shall be mounted on a 3/16-inch thick galvanized formed steel channel. Contacts shall be heavily silvered copper with 1/4-inch steel yoke and stainless steel loading springs. Hinges shall be bronze mounted on standard station post type wet process porcelain insulators. Fuse holder shall have porcelain jacket over glass epoxy sleeve. Holder shall accept fuse size shown. Fused load break cutouts shall comply with ANSI C37.35 and ANSI C27.46.
2. Ratings: 15 KV, 95 KV BIL, single pole.
3. Manufacturers: Provide products of one of the following:
 - a. S and C Electric Company.
 - b. Hubbell Power Systems.
 - c. Or equal.

D. Lightning Arresters:

1. Arresters: Arresters shall be standard distribution class valve arresters, metal-oxide type, suitable for operation on both overhead and underground distribution systems. Arresters shall be capable of cross arm mounting and shall have line and ground terminals capable of accepting copper or aluminum conductors from No.6 solid to No. 2 stranded. Test arresters in accordance with ANSI C62.11.
2. Ratings: Arresters shall be rated for 15 KV.
3. Identification: Provide each arrester unit with permanent nameplate that shall include the following:
 - a. Manufacturer.
 - b. Model.
 - c. Voltage rating.
 - d. Date of manufacturer.
 - e. Duty cycle rating.
4. Manufacturers: Provide products of one of the following:
 - a. Cooper Power Systems.
 - b. ABB Company.
 - c. Or equal.

E. Cable Terminators:

1. Terminators: Shall be slip-on type porcelain; factory assembled and shall include built-in stress relief and insulating material for bracket mounted on metering/ riser pole. Equip each terminator with adapter kits and connectors suitable for use with copper shielded cable of type specified in Section 26 05 13, Medium Voltage Cables.
2. Ratings: 15 KV, 95 KV BIL suitable for operation on a 12.47 KV supply. Current rating to be the same as for the cable.
3. Manufacturers: Provide products of one of the following:
 - a. G and W Electric Company.
 - b. Joslyn Manufacturing Company.
 - c. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install electric service materials and equipment in accordance with requirements of electric utility company service materials and equipment in accordance with requirements of telephone company. Install materials and equipment in accordance with NESC.
- B. Install equipment in accordance with manufacturer's written recommendations.
- C. Install aerial ground conductors in parallel to and above line conductors to shield lines from lightning.
- D. Install guys where lines begin, end, and change direction to balance line tensions as required to suit the installation.
- E. Set pole to depth of seven feet below grade and install ground rod adjacent to base of pole. Install 1/0 ground cable up the pole for grounding of pole devices. Protect ground cable with wood molding. Provide grounding at poles as required per NYSEG specifications at the new and existing poles. Bond to overhead neutral at locations as required by SP-1099.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Provide field testing and inspection of the load break switches. Field testing shall be in accordance with the manufacturer's recommendations and shall be performed by manufacturer's authorized representative.
 - 2. After installation and before equipment is energized; the load break switches shall be inspected, adjusted, and tested. The manufacturer's representative shall inform OWNER and ENGINEER if the equipment has been correctly installed, adjusted, and tested. No equipment is to be energized without the permission of OWNER.
 - 3. Perform the following tests and inspections before energizing load break switches. Provide test equipment and services for testing load break switches.
 - 4. Inspect the physical and mechanical conditions.
 - 5. Inspect all electrical connections to ensure connections are clean and tight, using a calibrated torque wrench.
 - 6. Perform operational checks and tests recommended by the equipment manufacturer. Verify that switches operate open and close correctly after they are energized.
- B. Supplier's Services:
 - 1. Provide services of qualified factory trained specialists from manufacturer to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of gang-operated load break switches. Training requirements, duration of instruction, and qualifications requirements shall be

in accordance with Section 01 79 23, Instruction of Operations and
Maintenance Personnel.

++ END OF SECTION ++

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals shown, specified, and required to furnish and install identification for electrical apparatus and electrical Work.

B. Related Sections:

1. Section 26 05 19, Low Voltage Electrical Power Conductors and Cables.
2. Section 26 05 13.23, 15KV Cable.
3. Section 40 61 13, Process Control Systems General Provisions.

1.2 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the following:

1. NEC Article 110, Requirements for Electrical Installation.
2. NEC Article 210, Branch Circuits.
3. NEC Article 215, Feeders.
4. NEC Article 504, Intrinsically Safe Systems.
5. NEC Article 700, Emergency Systems.
6. NEC Article 701, Legally Required Standby Systems.
7. NEC Article 702, Optional Standby Systems.
8. 40 CFR 1910.145 (OSHA) – Specification for Accident Prevention Signs and Tags.
9. NFPA 70E, Electrical Safety in the Workplace.

1.3 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings: Submit the following:
 - a. Complete description and listing of proposed electrical identification and electrical identification devices for associated equipment or systems.
 - b. Conduit and wire identification numbering system and equipment signage.
2. Product Data:
 - a. Manufacturer's literature, cut sheets, specifications, dimensions and technical data for all products proposed under this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Engraved Identification Devices (Nameplates and Legend Plates):
1. Nameplates:
 - a. Laminated thermoset plastic, 1/16-inch thick, engraved condensed block black lettering on white background, square corners, and beveled front edges, or match existing.
 - b. Size: As required.
 - c. Letter Size: Minimum 3/16-inch.
 - d. Nameplates one-inch or less in height shall have one mounting hole at each end. Nameplates greater than one-inch in height shall have mounting holes in the four corners.
 2. Legend Plates:
 - a. Legend plates for pushbuttons, pilot lights, selector switches, and other panel-mounted devices shall be large size with dimensions of approximately 2-7/16 inches wide by 2-13/32 inches tall (Allen Bradley large automotive size), plastic, custom engraved with black letters on white background.
 - 1) Provide standard-size legend plates where devices are mounted on motor control centers and spacing of devices precludes using automotive-size legend plates.
 - b. Lettering size and line weight shall be the same for all legend plates on the same panel or enclosure. Maximum size shall be 1/4-inch and minimum size shall be 1/8-inch.
- B. Safety Signs and Voltage Markers:
1. Provide high voltage signs for equipment operating over 600 volts.
 2. High-Voltage Safety Signs for Outdoor Applications:
 - a. Products and Manufacturers: Provide one of the following:
 - 1) B-120-45471 by Brady.
 - 2) Or equal.
 - b. Unless otherwise shown or indicated, high voltage safety signs shall be not less than 10 inches high by 14 inches wide, of fiberglass reinforced plastic, and shall comply with 40 CFR 1910.145. Signs shall resist fading from exposure to temperature extremes, ultraviolet light, abrasive, and corrosive environments, and shall read, "DANGER – HIGH VOLTAGE – KEEP OUT"
 - c. Mounting hardware shall be Type 316 stainless steel.
 3. High-Voltage Safety Signs for Indoor Applications:
 - a. Products and Manufacturers: Provide one of the following:
 - 1) B-302-84084 by Brady.
 - 2) Or equal.
 - b. High voltage safety signs for installation on indoor equipment shall be either pressure-sensitive acrylic or vinyl, and shall be not less than 10

inches high by 14 inches wide, shall comply with 40 CFR 1910.145, and shall read, “DANGER – HIGH VOLTAGE – KEEP OUT”.

4. Cable Tray Safety Signs:
 - a. Products and Manufacturers: Provide one of the following:
 - 1) B-302-86139 by Brady.
 - 2) Or equal.
 - b. Cable tray safety signs shall be pressure-sensitive vinyl conforming to 40 CFR 1910.145, 5 inches by 3.5 inches in size, and shall read, “DANGER – HIGH VOLTAGE”
5. Low-Voltage Safety Signs:
 - a. Products and Manufacturers: Provide one of the following:
 - 1) B-302-86060 by Brady.
 - 2) Or equal.
 - b. Low voltage safety signs shall be pressure-sensitive vinyl complying with 40 CFR 1910.145, five inches by 3.5 inches in size, and shall read, “DANGER – 480 VOLTS”.
6. Low-Voltage Markers:
 - a. Products and Manufacturers: Provide one of the following:
 - 1) CV442xx by Brady.
 - 2) Or equal.
 - b. Low voltage markers shall be either pressure-sensitive vinyl or vinyl cloth with black lettering on orange background and shall read, “120 VOLTS”, “208 VOLTS”, “120/208 VOLTS”, or “240 VOLTS” as required.

C. Voltage System Identification Directories:

1. General:
 - a. Directories shall be laminated thermoset plastic, 1/16-inch thick, engraved block black letters on white background, square corners, and beveled front edges.
 - b. Directories shall identify all voltage systems within building or structure.
 - c. Directories shall list the colors that identify ungrounded and grounded conductors of each system.
 - d. Colors shall be in accordance with Section 26 05 19, Low Voltage Electrical Power Conductors and Cables, Section 26 05 13, Medium Voltage Cables.
 - e. Example Directory Text:

Voltage System Identification		
System	A, B, C	Neutral
277/480	Brown, Orange, Yellow	Gray
120/208	Black, Blue, Red	White

2. Large directories for rooms shall have text height not less than 1/2-inch.
3. Small directories for equipment shall have text height of not less than 1/4-inch.

D. Conduit Labels:

1. Products and Manufacturers: Provide one of the following:
 - a. B-915-xxxxx by Brady.
 - b. Or equal.
2. Shall be pre-tensioned acrylic/vinyl construction coiled to completely encircle conduit for conduit up through five-inch diameter, or pre-molded to conform to circumference of conduit six-inch diameter and larger.
3. Attach strap-on style for six-inch diameter conduit with stainless steel springs.
4. Shall be blank for use with custom printed labels.
5. Custom Labels:
 - a. Shall have black lettering on yellow background.
 - b. Shall not contain abbreviations in legend.
 - c. Shall be custom printed on continuous tape with permanent adhesive using thermal printer specified below.

E. Wire Identification:

1. Heat Shrinkable Wire and Cable Labeling System:
 - a. Products and Manufacturers: Provide one of the following:
 - 1) B-341 PS-xxx-2W by Brady.
 - 2) Or equal.
 - b. White heat-shrinkable irradiated polyolefin shrink-on sleeves. Labels shall be thermal printed. Labels shall be not less than two inches wide.
2. Wrap-Around Wire and Cable Labeling System:
 - a. Products and Manufacturers: Provide one of the following:
 - 1) THT-XX-427 by Brady.
 - 2) Or equal.
 - b. Self-laminating white/transparent self extinguishing vinyl strips. Length shall be sufficient to provide at least 2.5 wraps. Labels shall be thermally printed and not less than two inches wide.

F. Detectable Underground Warning Tape:

1. Products and Manufacturers: Provide one of the following:
 - a. Indentoline by Brady.
 - b. Or equal.
2. Material: Polyethylene or polyester with detectable metal core and polyester underlamine.
3. Width: Two inches.
4. Color and Labeling: Yellow or red with permanently imprinted black letters: "CAUTION – Buried Electric Line", repeated continuously over full length of tape.

G. Thermal Printing System:

1. Utilize thermal transfer process to provide non-smearing labels and markers.
2. Wire and Cable Markers:
 - a. Portable, Products and Manufacturers: Provide one of the following:
 - 1) BMP 61 by Brady.
 - 2) Or equal.

- b. Desktop, Products and Manufacturers: Provide one of the following:
 - 1) S3100 by Brady.
 - 2) Or equal.
- 3. Cable Markers:
 - a. Portable, Products and Manufacturers: Provide one of the following:
 - 1) BMP 71 by Brady.
 - 2) Or equal.
 - b. Desktop, Products and Manufacturers: Provide one of the following:
 - 1) S3100 by Brady.
 - 2) Or equal.

H. Generator System Warning Signs:

- 1. Generator warning signs shall be labeled in accordance with NEC Article 700, NEC Article 701, or NEC Article 702.
- 2. Material, Colors, Letters: Plastic with white letters on red background. Letters shall be not less than 3/8-inch high.
- 3. Attachment: Use stainless steel self-tapping screws.
- 4. Location warning sign shall read, "WARNING – THIS SITE EQUIPPED WITH A DIESEL DRIVEN STAND-BY GENERATORS ARE LOCATED ADJACENT TO THE ELECTRICAL DISTRIBUTION BUILDING".
- 5. Generator ground warning sign shall read, "WARNING – GENERATOR GROUNDED CIRCUIT CONDUCTOR IS CONNECTED TO THE GROUNDING ELECTRODE CONDUCTOR IN THIS ENCLOSURE. DO NOT OPERATE GENERATOR WHILE EITHER CONDUCTOR IS DISCONNECTED TO AVOID SEVERE SHOCK HAZARD AND POSSIBLE EQUIPMENT DAMAGE."

2.2 FABRICATION

A. Engraved Identification Devices (Nameplates and Legend Plates):

- 1. Nameplate and legend plate text is preliminary and subject to change pending final review and approval of nomenclature by ENGINEER after start-up and testing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide electrical identification in accordance with manufacturer recommendations and as required for proper identification of equipment and materials.

B. Engraved Identification Devices (Nameplates and Legend Plates):

- 1. Unless otherwise indicated in the Contract Documents, attach permanent nameplates with permanent adhesive and with 3/16-inch diameter, round head, stainless steel machine screws into drilled and tapped holes.
- 2. Provide nameplate with 1.5-inch high letters to identify each console, cabinet, panel, or enclosure as shown or indicated.

3. Provide nameplates for field-mounted motor starters, disconnect switches, manual starter switches, pushbutton stations, and similar equipment operating components, which shall describe motor or equipment function and circuit number.
4. Provide nameplates with 1/2-inch high letters to identify each junction and terminal box shown or indicated.
5. On switchgear, provide nameplates for each main and feeder circuit including control fuses, and for each indicating light and instrument.
 - a. Provide nameplate with 1.5-inch high letters giving switchgear designation, voltage rating, ampere rating, short circuit rating, manufacturer's name, general order number, and item number.
 - b. Identify individual door for each compartment with nameplate giving item designation and circuit number.
6. Motor Control Centers:
 - a. Provide nameplate with 1.5-inch letters with motor control center designation.
 - b. Identify individual door for each unit compartment with nameplate identifying controlled equipment.
7. Except conduit, all electrical appurtenances including lighting panels, convenience outlets, fixtures, and lighting switches, shall be provided with nameplates indicating appropriate circuit breaker number(s).
8. Push Buttons:
 - a. Provide legend plates for identification of functions.
 - b. Provide nameplates for identification of controlled equipment.
 - c. Provide red buttons for stop function.
 - d. Provide black buttons for other functions.
9. Pilot Lights:
 - a. Provide legend plates for identification of functions.
 - b. Provide nameplates for identification of controlled equipment.
 - c. Shall have lens colors as shown or indicated. Where no color is indicated, provide the following lens colors:

Color	Legend
Green	Running, Open
Red	Stopped, Closed
Amber	Alarm
Blue	Power
White	Status

10. Selector Switches:
 - a. Provide legend plates for identification of functions.
 - b. Provide nameplates for identification of controlled equipment.
11. Panel Mounted Instruments:
 - a. Provide nameplates for identification of function.
12. Interiors of Cabinets, Consoles, Panels, Terminal Boxes, and Other Enclosures:
 - a. Provide nameplates for identification.
 - b. Provide each item inside cabinet, console, panel, terminal box, or enclosure

with laminated plastic nameplate as shown on approved Shop Drawings and CONTRACTOR's other submittals. Install nameplates with adhesive.

- c. Interior items requiring nameplates include:
 - 1) Terminal blocks and strips.
 - 2) Bus bars.
 - 3) Relays.
 - 4) Rear of face-mounted items.
 - 5) Rear of door-mounted items.
 - 6) Interior mounted items that require identification when mounted externally.
- d. Circuit Breaker Directory:
 - 1) Provide engraved laminated plastic directory listing function and load controlled for each circuit breaker within panel used for power distribution.

13. Re-label existing equipment whose designation have changed.

C. Safety Signs and Voltage Markers:

- 1. Provide safety signs and voltage markers on and around electrical equipment as shown or indicated.
 - a. Install rigid safety signs using stainless steel fasteners.
 - b. Clean surfaces before applying pressure-sensitive signs and markers.
- 2. Install high voltage safety signs on all equipment doors providing access to uninsulated conductors, including terminal devices, greater than 600 volts.
- 3. Provide cable tray safety signs on both sides of cable trays at maximum intervals of 20 feet. Install signs on side rails of tray as acceptable to ENGINEER.
 - a. Label cable trays that contain conductors greater than 600 volts with cable tray safety signs.
 - b. Cable trays that contain conductors greater than 208 volts and less than 600 volts shall be labeled with low voltage safety signs.
 - c. Cable trays that contain conductors of 120/208 volts shall be labeled with low voltage markers.
 - d. Do not label cable trays that contain only instrument signal cables.
 - e. Label cable trays that contain intrinsically safe wiring or cables in accordance with NEC Article 504.
- 4. Install low voltage safety signs on equipment doors that provide access to uninsulated 480-volt conductors, including terminal devices.
- 5. Install low voltage markers on each terminal box, safety disconnect switch, and panelboard installed, modified, or relocated as part of the Work and containing 120/208 volt conductors.

D. Voltage System Identification Directories

- 1. Provide voltage system identification directories as required by NEC Article 210 and NEC Article 215.
- 2. Provide in each electrical room voltage system identification directory mounted on wall or door at each entrance to room.
- 3. For panelboards, switchboards, motor control centers, and other branch circuit or feeder distribution equipment that are not located in electrical rooms, provide

voltage system identification directory mounted on equipment.

- a. Directories shall be affixed using epoxy glue. Screws or bolts shall not penetrate equipment enclosures.
- b. Directories shall be readily visible and not obscure labels and other markings on equipment.

E. Arc-flash Safety Signs:

1. Provide arc-flash safety signs as required by NEC Article 110.
2. Provide signs for switchboards, panelboards, motor control centers, and industrial control panels. Provide signs for control panels that contain 480 volt equipment. Provide arc flash warning signs on other equipment where the incident energy is greater than 1.2 calories per square centimeter.

F. Conduit Labels:

1. Provide conduits with conduit labels unless otherwise shown or indicated.
2. Do not label flexible conduit.
3. Do not label exposed single conduit runs of less than 25 feet between local disconnect switches and their associated equipment.
4. Conduit labels shall indicate the following information:
 - a. Contract Number: Alphanumeric, three or four digits, as applicable.
 - b. Conduit Number: Alphanumeric as shown on the Drawings, as assigned by CONTRACTOR for unlabelled conduits, and in accordance with approved submittals.
5. Conduits that contain intrinsically safe wiring shall have an additional pipe marker provided that has blue letters on white background and reads, "INTRINSICALLY SAFE WIRING".
 - a. Install intrinsically safe pipe markers in accordance with NEC Article 504 along entire installation. Spacing between labels shall not exceed 25 feet.
6. Provide conduit labels at the following locations:
 - a. Where each conduit enters and exits walls, ceilings, floors, or slabs.
 - b. Where conduit enters or exits boxes, cabinets, consoles, panels, or enclosures, except pull boxes and conduit bodies used for pull boxes.
 - c. At maximum intervals of 50 feet along length of conduit.
7. Orient conduit labels to be readable.

G. Wire and Cable Identification:

1. Color-coding of insulated conductors shall comply with Section 26 05 19, Low Voltage Electrical Power Conductors and Cables, Section 26 05 13, Medium Voltage Cables.
2. Use heat-shrinkable wire labels where wire or cable is terminated. Use wrap-around labels where wire or cable is to be labeled but is not terminated.
3. Do not provide labels for the following:
 - a. Bare (uninsulated) conductors, unless otherwise shown or indicated as labeled.
4. Provide wire and cable labels for the following:
 - a. New, rerouted, or revised wire or cable.
 - b. Insulated conductors.

- c. Wire and cable terminations:
 - 1) Wire labels shall be applied between 1/2-inch and one inch of completed termination
 - 2) Apply cable labels between 1/2-inch and one inch of cable breakout into individual conductors.
 - a) Label individual conductors in a cable after breakout as specified for wires.
 - d. Wire or cable exiting cabinets, consoles, panels, terminal boxes, and enclosures.
 - 1) Label wires or cables within two inches of entrance to conduit.
 - e. Wire or cable in junction boxes and pull boxes
 - 1) Label wires or cables within two inches of entrance to conduit.
 - f. Wire and cable installed in cable tray.
 - 1) Wire and cable shall have labels at maximum intervals of 20 feet.
 - g. Wire and cable installed without termination in electrical manholes.
 - 1) Wire and cable shall have wrap-around labels applied within one foot of exiting manhole.
5. Wire and Cable Identification System:
- a. Wire and cable labels shall be imprinted with an identifying designator.
 - 1) Wire and cable extending between two devices or items and that does not undergo a change of function shall be identified by a single unique designator as specified below.
 - b. Field Wiring:
 - 1) Wire or cable designator shall consist of:
 - a) Three left-most characters shall consist of the Contract number under which wiring or cable was installed.
 - b) Fourth character from the left shall be an asterisk (*), a plus sign (+) or a hyphen (-). Do not use other punctuation symbols in a wire designator.
 - c) Remaining characters shall be alphanumeric and make wire designator unique.
 - d) Numbering shall reflect actual designations used in the Work and shall be documented in record documents.
 - c. Cabinet, Console, Panel, and Enclosure Wiring, Internal:
 - 1) New Cabinets, Consoles, Panels, and Enclosures:
 - a) Wire and cable inside cabinets, consoles, panels, and enclosures shall have designators as specified in Section 40 61 13, Process Control Systems General Provisions.
6. Modified Cabinets, Consoles, Panels, and Enclosures:
- a. New or rerouted wire or cable in existing cabinets, consoles, panels, and enclosures shall be labeled as shown on the Drawings or be assigned a ten-character designator equivalent to field wire designator.

H. Terminal Strip Labeling:

- 1. Label panel side of terminal to match panel wire number.
- 2. Label field side of terminal to match field wire number. Terminal number shall not include the Contract number.

- I. Generator System Warning Signs:
 1. Provide warning signs for generator systems as required by NEC.
 2. Install generator location warning sign on or immediately adjacent to service equipment, or to “normal” source disconnecting means when generator is located out of sight of service equipment or disconnecting means.
 3. Install generator grounding warning sign on enclosure or immediately adjacent to point where generator neutral is connected to grounding electrode system if connection is made remote from generator.

+ + END OF SECTION + +

SECTION 26 05 73

ELECTRICAL POWER DISTRIBUTION SYSTEM STUDIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. The Engineer will be performing the Short-circuit Study, Protective Device Evaluation Study, Protective Device Coordination Study, and Arc Flash Analysis. The contractor shall provide the Engineer information as required to perform the power distribution studies.
2. CONTRACTOR shall provide all labor, materials, equipment, and incidentals required to provide the Engineer field and equipment data as required to perform Power Distribution System Studies including but not limited to:
 - a. Multifunction protective relay product data
 - b. Overcurrent protective devices product data
 - c. Utility Fault contributions
 - d. Feeder size, length, and raceway information.
 - e. Motor and Transformer data
 - f. Disconnect switch ratings
3. The Engineer will provide to the Contractor arc flash warning labels for application on the equipment by the Contractor. The Contractor shall apply arc flash warning labels for each piece of electrical distribution equipment, VFDs, disconnect switches, starters, and control panels with starters as follows:
 - a. Floor Standing Equipment: Labels shall be provided on the front of each individual enclosure section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area.
 - b. Wall Mounted Equipment: Labels shall be provided on the front of the equipment enclosure or a nearby adjacent surface, depending upon equipment configuration.
 - c. For each Medium Voltage and Low Voltage Switchgear, one (1) label shall be provided for each vertical section. Labels will be applied on the front and rear of each switchgear vertical section if the switchgear includes rear access.
 - d. For each Low Voltage Switchboard, one (1) label shall be provided for each vertical section. Labels will be applied on the front of the Switchboard and on the rear if the Switchboard includes rear access.
 - e. For each Distribution Panel, one (1) label shall be provided on the front of each Distribution Panel section.
 - f. For each Panelboard, one (1) label shall be provided on the front of each Panelboard section.
 - g. For each facility Transformer, one (1) label shall be field applied. If the Transformer includes access to the internal components with removable panels, one (1) label will be provided on each removable panel.

- h. For each Enclosed Disconnect Switch or Enclosed Circuit Breaker external to electrical distribution equipment, one (1) label shall be provided on the front of the enclosure.
 - i. For each VFD, one (1) label shall be field applied to the front of the VFD.
 - j. For each Control Panel with Motor Starters, one (1) label shall be provided on the front of the Control Panel.
 - k. For each Generator, one (1) label shall be provided on the front of the generator unit-mounted circuit breaker.
 - l. For all other equipment and locations, one (1) label shall be provided on the front of the equipment enclosure.
- 4. CONTRACTOR shall obtain the services of a Professional Engineer to provide the protective relay settings and configuration files for the generator multifunction relays.
 - 5. The Engineer will provide the CONTRACTOR trip unit settings for overcurrent protective devices. The contractor shall apply the settings provided by the Engineer at each overcurrent protective device.
 - 6. The Engineer will provide the CONTRACTOR protection setting for all multifunction relays except for the generator feeders. The contractor shall obtain professional services as required to generate configuration files and upload the settings to the associated relays.
 - 7. CONTRACTOR shall obtain professional services of Field Engineer as required to perform current and voltage injection tests of all multifunction protective relays (secondary injection) and low voltage switchgear power breakers (primary injection).

B. Related Sections:

- 1. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

A. Standards referenced in this Section are:

- 1. ANSI/IEEE C37.91, Guide for Protective Relay Applications to Power Transformers
- 2. ANSI/NCSL Z540.3 Requirements for the Calibration of Measuring and Test Equipment.
- 3. IEEE 141, Recommended Practice for Electric Power Distribution in Industrial Plants (IEEE Red Book).
- 4. IEEE 242, Recommended Practice for Protection and Coord. of Industrial and Commercial Power Systems (IEEE Buff Book).
- 5. IEEE 399, Analysis (IEEE Brown Book), Recommended Practice for Power System Analysis.
- 6. IEEE 1584, Guide for Performing Arc-Flash Hazard Calculations.
- 7. NFPA 70E, Electrical Safety in the Workplace.

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Professional Engineer:
 - a. Engage a registered professional engineer legally qualified to practice in the jurisdiction where the Project is located and experienced in providing engineering services of the kind indicated. Professional engineer may be employed by independent consulting firm or manufacturer of power distribution equipment.
 - b. Professional engineer shall have not less than five years of experience performing electrical power distribution system studies similar in scope and size to the studies required for the Project.
 - c. Submit qualifications data.
 - 2. Field Engineer:
 - a. Field engineer performing protective device testing shall be experienced in type of testing required and testing equipment used on the Project.
 - b. Field engineer may be an employee of the protective device equipment manufacturer.

- B. Test equipment and instrument calibration shall comply with accuracy standards of NIST and ANSI/NCSS Z540.3.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Testing Plan: Submit work plan for field testing. Submit and obtain ENGINEER's approval prior to performing tests. Plan shall indicate schedule of field testing, time frames for tests, and duration of equipment outage for testing. Submit shutdown requests for each outage in accordance with Section 01 14 16, Coordination with Owner's Operations.

- B. Informational Submittals: Submit the following:
 - 1. Test Reports:
 - a. Results of field testing.
 - 2. Qualifications Statements:
 - a. Professional engineer.
 - b. Field engineer.

- C. Closeout Submittals: Submit the following:
 - 1. Final settings of protective devices. Submit compilation of final settings for each equipment lineup within 10 days of programming the associated protective devices.
 - 2. Electronic Files:
 - a. Protective Devices:
 - 1) Settings for all microprocessor-based protective devices.
 - 2) Software versions used to program the protective devices.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

A. General:

1. Coordinate with the Engineer performing the studies and assist the Engineer with collecting information necessary to complete the studies.

3.2 FIELD TESTING

A. Site Tests:

1. Provide protective device field testing in accordance with manufacturers' recommendations. Field testing shall be done by the CONTRACTOR's field engineer. Field testing results shall be documented in a report that shall include the final settings of protective devices.
2. Field engineer shall provide necessary tools and equipment and adjust, set, calibrate, and test protective devices. Protective relays and meters in medium- and low-voltage equipment shall be set, adjusted, calibrated, and tested in accordance with manufacturers' recommendations and the coordination study. Provide minor adjustments, repairs, and lubrication necessary for proper operation.
3. Electromechanical protective relays provided in accordance with the Contract Documents shall be set and tested for acceptance. Testing shall include visual and mechanical inspection. Testing shall include overcurrent time and pick-up tests.
4. Solid state and multi-function trip devices shall be set, including required programming necessary for the protection required. Devices shall be checked, configured, and tested for setting and proper operation.

++ END OF SECTION ++

SECTION 26 11 16

SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope: CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install secondary unit substations.
- B. Related Sections:
 - 1. Section 26 05 53, Identification for Electrical Systems.
 - 2. Section 26 05 73, Electrical Power Distribution System Studies.
 - 3. Section 26 43 00, Surge Protective Devices.

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. ANSI/IEEE C37.13, Definite Purpose Switching Devices for Use in Metal-Enclosed Low-Voltage.
 - 2. ANSI/IEEE C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - 3. IEEE C37.16, Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC (3200 V and below) Power Circuit Breakers.
 - 4. IEEE C57.12.90, Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - 5. ISO 9002, Quality Systems -- Model for Quality Assurance in Production, Installation and Servicing.
 - 6. UL 489, Branch Circuit Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.
 - 7. NEMA TR 1, Transformers, Regulators and Reactors.
 - 8. NEMA TP 1, Guide for Determining Energy Efficiency for Distribution Transformers.
 - 9. ANSI/NETA ATS, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
 - 10. ANSI/NETA MTS, Standard for Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems
 - 11. UL 1066, Low Voltage Power Circuit Breakers.

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer:
 - a. Manufacturer shall have not less than five years experience manufacturing and servicing products substantially similar to those required for the

- Project and, upon request, shall submit documentation of not less than five installations in satisfactory operation for not less than five years each.
- b. Manufacturer shall be ISO 9002 certified.
2. Independent Testing Firm for Field Quality Control:
 - a. Retain independent testing firm to perform acceptance field-testing of the equipment.
 - b. Testing firm shall have experience in inspecting and testing equipment of the type required and shall be a member of NETA.
 - c. Test Equipment, Calibration, and Reporting: Test equipment, instrument calibration, and test reports shall be in accordance with ANSI/NETA ATS.
- B. Component Supply and Compatibility:
 1. Obtain all materials and equipment included in this Section regardless of component manufacturer from a single secondary unit substation manufacturer.
 2. Secondary unit substation manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.
 3. Components shall be suitable for the specified service conditions and shall be integrated into overall assembly by secondary unit substation manufacturer.
- C. Regulatory Requirements: Comply with the following:
 1. United States Department of Energy, 10 CFR Part 431, Energy Conservation.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 1. Shop Drawings:
 - a. Three-line diagrams.
 - b. Control schematics and elementary wiring diagrams showing numbered terminal points and interconnections to other units.
 - c. Construction details of enclosures with conduit entry locations and connection details between assemblies.
 - d. Dimensional information including front view elevation and floor plan information.
 - e. Components list and nameplate schedule.
 - f. Summary sheets with schedules of equipment.
 - g. Key interlock scheme and sequence of operation.
 2. Product Data:
 - a. Manufacturer's technical information, including catalog information.
 - b. Manufacturer's technical specifications with assembly and component ratings.
 - c. Time current curves for protective devices.
 3. Custom NEMA 3R enclosure, switchgear, and equipment anchorage details with design calculations signed by a professional engineer licensed in the State of New York.
 4. Construction details of the custom enclosure including components, installation details, conduit entry locations, connection details between assemblies, and switchgear.
 5. Testing Plans, Procedures, and Testing Limitations:
 - a. Not less than thirty days prior to factory testing, submit description of

- proposed factory testing methods, procedures, and apparatus.
- b. Not less than thirty days prior to field testing, submit description of proposed testing methods, procedures, and apparatus.

B. Informational Submittals: Submit the following:

1. Manufacturer's Instructions:
 - a. Special shipping, storage and protection, and handling instructions.
 - b. Installation data for the equipment, including setting drawings, templates, and directions and tolerances for installing anchorage devices.
2. Source Quality Control Submittals:
 - a. Report of results of testing and inspections performed at manufacturer's factory.
 - b. Factory Production Testing Reports: Submit copies of factory-certified production test reports.
3. Field Quality Control Submittals:
 - a. Report of results of field-testing.
4. Supplier Reports:
 - a. Submit written report of results of each visit to the Site by Supplier's service technician, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
5. Qualifications Statements:
 - a. Manufacturer, when requested by ENGINEER.
 - b. Independent testing firm for field quality control.

C. Closeout Submittals: Submit the following:

1. Operations and Maintenance Data:
 - a. Submit in accordance with Section 01 78 23, Operations and Maintenance Data.
 - b. Include acceptable test reports, maintenance data and schedules, description of operation, wiring diagrams, and list of spare parts recommended for one year of operation with current price list.
 - c. Include record drawings of control schematics, with point-to-point wiring diagrams.

D. Maintenance Material Submittals: Furnish the following:

1. Spare Parts:
 - a. Furnish, tag, and box for shipment and long-term storage the following for each power center lineup:

Item	Quantity per Power Center Lineup
a. Feeder breakers, size as shown on Drawings	As shown on the Drawings
b. Spare power fuses	One per of each size and type used
c. Control power fuse	Five sets of each type and size used
d. Pilot light	Two per 10 of each type used

- b. Breaker lifting device shall be provided. Breaker lifting device shall be capable of inserting and removing any breaker from the disconnect position of any compartment.
- c. Breaker moving device shall be provided. Breaker moving device shall be capable of moving any breaker into and out of any compartment and around the switchgear room.
- d. Submit list of additional recommended spare parts for an operating period of one year. Describe each part, quantity recommended, and current unit price for each.
- e. Deliver spare parts at the same time as switchgear.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Packing:
 - 1. Shipping sections shall be designed to be shipped by truck, rail, or ship.
 - 2. Indoor sections shall be bolted to skids.
 - 3. Package and separately ship breakers and accessories.
- B. Handling:
 - 1. Equipment shall be equipped to be handled by crane. Where cranes are not available, equipment shall be suitable for placement on rollers using jacks to raise and lower the groups.
 - 2. Handle equipment in accordance with manufacturer's instructions. Furnish one copy of such instructions with equipment at time of shipment.
- C. Storage:
 - 1. Store switchgear equipment in a clean, dry location with controls for uniform temperature and humidity. Protect equipment with coverings and maintain environmental controls.
 - 2. Protect equipment from corrosion and deterioration.

1.6 PREVENTIVE MAINTENANCE SERVICE PLAN

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals required to provide all Manufacturer's recommended preventive maintenance from the period when the equipment is operational until date of Substantial Completion. The maintenance shall follow the Manufacturer's recommended plan and be performed by the Manufacturer's trained technicians every three months, at a minimum.
- B. CONTRACTOR shall provide a Preventive Maintenance Service Plan to the OWNER for a period of three years after date of Substantial Completion. During this period, the Manufacturer's trained technicians shall provide all labor, materials, equipment and incidentals required to perform all Manufacturer's recommended preventive maintenance. The maintenance shall follow the Manufacturer's recommended plan and be performed quarterly, at a minimum.

- C. The following services shall be provided at a minimum for Preventive Maintenance Service Plan:
1. Metal-enclosed switches
 - a. Perform visual inspection every six months with equipment energized.
 - 1) Inspect the switch exterior for signs of rust and degradation of paint.
 - b. Perform infrared inspection every twelve months with equipment energized.
 - 1) Perform infrared inspection at cable terminations to ensure that the maximum temperature is within recommended operational parameters.
 - c. At the end of the third year:
 - 1) De-energize and inspect the enclosure interior for signs of rust and degradation of paint.
 - 2) Lubricate main contact and switch mechanism per the manufacturer's recommendation.
 - 3) Tighten any loose connections.
 - 4) Inspect for signs of overheating and voltage creepage over insulating surfaces by looking for indications of carbonization.
 - 5) Perform inspection and tests per the latest NETA MTS requirements.
 2. Liquid-filled transformers
 - a. Perform visual inspection every twelve months with equipment energized.
 - 1) Confirm oil level and pressure gauges to ensure that oil and pressure readings are within the manufacturer's recommended operational parameters.
 - 2) Inspect the transformer exterior for signs of oil stains and degradation of paint.
 - b. Perform infrared inspection every twelve months with equipment energized.
 - 1) Perform infrared inspection to ensure that the transformer's maximum temperature is within the manufacturer's recommended operational parameters.
 - 2) Perform infrared inspection at cable terminations to ensure that the maximum temperature is within recommended operational parameters.
 - c. At the end of the third-year, de-energize transformer and inspect the oil sealed tank, conservator, and sealed systems
 - 1) Tighten any loose connections.
 - 2) Inspect for signs of overheating and voltage creepage over insulating surfaces by looking for indications of carbonization.
 - 3) Perform inspection and tests per the latest NETA MTS requirements.
 - d. Take and test Oil Samples every twelve months.
 - 1) Perform oil testing in accordance with the manufacturer's recommendations.
 - 2) At a minimum, testing shall include:
 - a) Appearance at 15°C
 - b) Dielectric breakdown voltage test
 - c) Dissolved gas analysis

3. Dry Type Transformer
 - a. Perform visual inspection every twelve months with equipment energized.
 - 1) Inspect the transformer exterior for signs of rust and degradation of paint.
 - 2) Remove vacuum dust or dirt that may restrict transformer airflow.
 - b. Perform infrared inspection every twelve months with equipment energized.
 - 1) Perform infrared inspection to ensure that transformer's maximum temperature is within the manufacturer's recommended operational parameters.
 - 2) Perform infrared inspection at cable terminations to ensure that the maximum temperature is within recommended operational parameters.
 - c. At the end of the third year:
 - 1) De-energize and inspect the enclosure interior for signs of rust and degradation of paint.
 - 2) Tighten any loose connections.
 - 3) Inspect for signs of overheating and voltage creepage over insulating surfaces by looking for indications of carbonization.
 - 4) Perform inspection and tests per the latest NETA MTS requirements.
4. Low Voltage Switchgear
 - a. Perform visual inspection every twelve months with equipment energized.
 - 1) Inspect the switchgear exterior for signs of rust and degradation of paint.
 - 2) Operate air breakers and confirm proper operation.
 - b. Perform infrared inspection every twelve months with equipment energized.
 - 1) Perform infrared inspection at cable terminations to ensure that the maximum temperature is within recommended operational parameters.
 - c. At the end of the third year:
 - 1) De-energize and inspect the enclosure interior for signs of rust and degradation of paint.
 - 2) Tighten any loose connections.
 - 3) Inspect for signs of overheating and voltage creepage over insulating surfaces by looking for indications of carbonization.
 - 4) Inspect for signs of cracks, breaks, delamination, warping, and blisters in insulated parts.
 - 5) Inspect for foreign or loose objects and rusty or bent structural framework.
 - 6) Perform inspection and tests per the latest NETA MTS requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT PERFORMANCE

- A. Equipment Description: Secondary unit substations shall be a assembly consisting of a primary switch, transformer, and secondary low-voltage distribution section that is electrically connected and physically joined.

2.2 MANUFACTURERS

- A. Manufacturers: Provide products by one of the following:
 - 1. ABB.
 - 2. Eaton/Cutler-Hammer.
 - 3. Schneider Electric/Square D Company
 - 4. Or equal.

2.3 PRIMARY SECTION

- A. For Indoor Substation provide air-filled high-voltage primary compartment. High-voltage primary compartment section shall be grounded, metal-enclosed, 15KV, dead-front, freestanding structure, containing an air-filled compartment equipped with the following:
 - 1. One set of clamp-type terminals with two hole copper compression connectors suitable for cables shown or indicated on the Drawings.
 - 2. Lightning arrestors, distribution class, 15 KV.
- B. For Outdoor Substation, provide metal-enclosed, 15 KV, dead-front, freestanding structure.
 - 1. The air interrupter switch shall be in accordance with the following:
 - a. Switch shall be manually/electrically operated stored-energy, gang-operated, quick make quick break type, with separate main and arcing contacts and arc quenching chambers.
 - b. Switch shall be such that the speed of opening and closing shall be independent of operator action.
 - c. Switch shall be three pole, load breaking with the continuous current rating in amperes and the fault-close and momentary rating as shown on the Contract Drawings.
 - d. Switch shall include interlocks in accordance with the following:
 - 1) Switch shall be prevented from closing with the switch compartment door not fully closed and latched.
 - 2) Switch compartment door shall be prevented from opening when the switch is closed.
 - e. Switch enclosure shall be grounded steel.
 - f. The switch enclosure shall have a sight window for visual inspection of switch contacts.
 - g. The switch enclosure shall be provided with space heaters.
 - h. The switch enclosure shall be provided with lightning arrestors, distribution class, and 2-hole copper compression connectors.

2. Switch motor operator shall operate at 120 VAC. The motor operator controller shall accept remote open and close signals from the substation mimic panel.

2.4 TRANSFORMER SECTION

- A. For outdoor Substations provide Oil-Filled Transformers. Transformer sections shall consist of oil-filled transformer complying with ANSI C57.12.00, equipped with the following:
 1. Rating: KVA capacity as indicated on the Drawings, three-phase, 60 Hertz, 95KV BIL, 12.47 KV Delta connected primary, 480/277-volt wye connected secondary as shown on the Drawings, with neutral brought out through a bushing.
 2. Coolant: Coolant shall be non-toxic, fire-resistant, biological-based natural ester dielectric fluid. Coolant shall be 100-percent derived from edible seed oils and performance-enhancing additives shall be food grade. Coolant shall be FM-approved, UL-classified, Envirotemp FR3 fluid.
 3. Efficiency: Energy-efficient, complying with 10 CFR Part 431, standard efficiency levels
 4. Windings:
 - a. Primary and secondary windings shall be copper construction.
 - b. Winding temperature rise by resistance shall not exceed 55 degrees C.
 - c. Hottest spot winding temperature rise shall not exceed 65 degrees C.
 - d. Provide thermally-upgraded insulation allowing continuous loading of 112 percent of 55 degrees C KVA rating with winding temperature rise not exceeding 65 degrees C and hottest spot temperature rise not exceeding 80 degrees C.
 5. Taps: Full capacity, two 2.5-percent primary taps above normal, and two 2.5-percent primary taps below normal.
 6. Impedance: Standard, but not less than 5.5 percent.
 7. Enclosure:
 - a. Outdoor, weatherproof, and rodent-proof.
 - b. Flange equipped to mate to primary compartment section and air terminal for secondary cable connection.
 - c. Sealed tank construction.
 - d. Lifting hooks.
 - e. Welded cover
 - f. Provision for jacking the housing for both the high- and low voltage sides.
 8. Accessories:
 - a. No load tap changer, externally operated with cover mounted operating handle. Provide operating handle with key interlock, single lock type. Provide lock and key compatible with, and that function with, entire key interlock system specified.
 - b. Provide following with alarm contacts wired to NEMA 4X control box.
 - 1) Liquid level gauge
 - 2) Dial-type oil thermometer
 - 3) Pressure/vacuum gage with alarm contacts.

- c. Drain valves with 3/8-inch diameter sampler.
 - d. Ground pad.
 - e. Diagrammatic nameplate.
 - f. Cover mounted mechanical pressure relief device with automatic resealing resetting operation and mechanical signal for indication of device operation.
 - g. Provisions for mounting and wiring future low-velocity single-phase cooling fans.
 - h. Instruction nameplate.
 - i. Lifting hooks.
 - j. Jacking pads.
 - k. Welded handhole.
 - l. Upper filter pressure cap.
 - m. Provisions for rolling and skidding.
 - n. Oil required to place transformer into service.
 - o. Provide provision for future forced air-cooling equipment. All associated devices shall be mounted in the NEMA 4X enclosure. Include mounting provisions for cooling fans. Provide all required temperature-sensing devices, and controls.
- B. For indoor substation provide dry-type transformer: Transformer sections shall consist of air cooled, open, dry-type transformer, naturally ventilated, complying with IEEE C57.12, 51, equipped with the following:
1. Rating: KVA capacity as indicated on the Drawings, three-phase, 60 Hertz, 95 KV BIL, 12.47 KV delta connected primary, 480/277-volt wye connected secondary with the neutral brought out through a bushing.
 2. Windings:
 - a. Insulation shall be Class H, 220 degrees C, used throughout the construction. Winding temperature rise shall not exceed 80 degrees C above 40 degrees C ambient.
 - b. Cores shall be steel construction assembled and rigidly clasped for mechanical strength and reduce vibration. Core shall be grounded to the frame with flexible grounding strap.
 - c. Windings shall be copper and have high dielectric and mechanical strength insulation. Coils shall be braced and include internal barriers and end coil insulation. Windings shall withstand without damage impulse, induced, and dielectric test voltage and short circuit testing.
 - d. Completed winding assembly shall be vacuum pressure impregnated for environmental protection. Impregnation shall be a multi-cycle heat, dry, and apply process of polyester epoxy or silicone resin to impregnate coils and provide protective shield to bus, core, and support structure.
 3. Taps: Full capacity, two 2.5-percent primary taps above normal and two 2.5-percent primary taps below normal. Easily accessible bolted tap links in high-voltage windings shall be changed when transformer is de-energized
 4. Impedance: 5.75 percent.
 5. Efficiency: Energy-efficient, complying with 10 CFR Part 431, standard efficiency levels.
 6. Enclosure:

- a. Heavy-gage sheet steel with ventilation louvers. Provide NEMA enclosures for indoor units.
 - b. Removable panels for access to taps.
 - c. Vibration isolating pads.
 - d. Provisions for lifting and jacking.
 - e. Base suitable to permit skidding or rolling.
 - f. Diagrammatic nameplate.
 - g. Bus transition sections suitable for connection of primary section and secondary low voltage section of substation lineup.
 - h. Ground pad.
7. Accessories:
- a. Provide provision for future forced air-cooling equipment. All associated devices including transformer control panel shall be mounted inside enclosure. Include mounting provisions for cooling fans. Provide all required temperature-sensing devices, and controls.

2.5 SECONDARY DISTRIBUTION SECTION

- A. Low-Voltage Switchgear:
1. Switchgear shall consist of individually-mounted power air circuit breakers in draw-out type construction complying with ANSI/IEEE C37.20 Series. Switchgear shall have ratings as follows:
 - a. 600-volt, three-phase, 60 Hertz, three-wire or four wire as indicated on drawings.
 - b. Continuous AC main bus ampacity and bracing as indicated on the Drawings.
 2. Bus System:
 - a. Power Bus: Three-phase tin-plated copper with current capacity and short circuit rating as indicated on the Drawings.
 - b. Main and vertical buses shall be phase- and ground-isolated and insulated from each other.
 - c. Each circuit shall consist of necessary bus connection between section bus and breaker line side stubs. Equip load studs with load extension busses terminating in solder-less type terminals in rear cable compartment.
 - d. Ground Bus: Tin-plated copper with current capacity equal to half capacity of main power bus and drilled with lugs of appropriate capacity as required.
 3. Structure:
 - a. Each vertical steel unit shall be self-contained and self-supported structure having one or more individual breaker or instrument compartments, centralized bus compartment, and rear cabling compartment segregated from bus sections by means of solid insulating barriers. Equip rear compartments with hinged access doors each secured with minimum of three bolts and captured nuts.
 - b. Each individual breaker compartment shall be completely segregated from adjacent compartments by barriers at rear, top, bottom and sides, and equipped with draw-out rails, levering out mechanism, and primary and secondary contacts. Current transformers for instrumentation shall be located within the appropriate breaker compartment wired through shorting

- terminal blocks.
- c. Outgoing section and feeder circuit breakers shall be arranged for termination of steel conduit and copper cable feeders. Number of conduits and cables associated with each feeder shall be as shown or indicated on the Drawings.
4. Circuit Breakers:
- a. Main, tie, and feeders shall be 600-volt AC, 60 Hertz, three-pole, draw-out type power circuit breakers, 100-percent equipment-rated. Breakers shall include electronic microprocessor-based trip system. Breaker frame size, sensor rating, and short-circuit rating shall be as shown or indicated on the Drawings. Breakers shall comply with ANSI/IEEE C37.13, IEEE C37.16, and UL 1066.
 - b. Each main and tie circuit breakers shall be an electrically operated stored energy mechanism with provisions for local and remote operation and capable of local manual powered and unpowered operation. Electrically operated breakers shall be complete with AC operators, open/close push buttons and control switches as shown on the Contract Drawings.
 - c. Equip breaker removable elements with disconnecting contacts, wheels, and interlocks for draw-out operation. Draw-out design shall allow closure of compartment door with breaker in the “connected”, “test”, and “disconnected” positions. Provide mechanical interlock to prevent breaker racking while in closed position. Withdrawn position shall allow 180-degree unit rotation and provisions for padlocking provided for all positions.
 - d. Electronic trip system shall include plug-in protection programmer, flux shift trip device, and current sensor package. Programmer, sensor, and flux-shifting trip device shall be constructed as integral elements of the breaker, requiring no externally mounted assemblies for proper operation.
 - 1) The trip unit’s protective functions shall include adjustable continuous and instantaneous current elements with adjustable long time, short time, and zero sequence ground fault pickup and delay.
 - 2) For each of the main and tie circuit breakers, it shall be possible to isolate the functioning of the instantaneous functions and the trip unit shall include a discriminator circuit to prevent the breaker from being closed and latched into a fault. The discriminator circuit shall have the capability of being disabled from the front of the unit.
 - 3) Solid-state, microprocessor-based, nine-function programmer shall provide true RMS current sensing and include adjustable continuous and instantaneous current elements with adjustable long time, short time, zero sequence ground fault pickup, and delay and zone selective interlocking. Main, tie, and feeder circuit breakers shall be connected for zone selective interlocking to allow instantaneous bus protection.
 - 4) The trip unit’s monitoring and communication circuitry shall include communications, control, and energy monitoring features, to permit both local and remote interface with the breakers circuits from a breaker interface module at the switchgear or a networked human machine interface or workstation (HMI) at a central monitoring point.
 - a) Provide modules as required to connect trip units to the

switchgear ethernet network.

- 5) The protective, monitoring and communication type trip units shall provide complete communications and energy monitoring functions and be capable of passing the following minimum information to the breaker interface module or the HMI.
 - a) Harmonic content and percent THD.
 - b) Wave form analysis.
 - c) Energy consumption plus VA and VAR
- e. Mimic Diagram
 - 1) As shown on the Contract Drawings, a Mimic Diagram representing the single line diagram of the switchgear shall be painted or affixed to the front elevation of switchgear.
 - 2) Diagram shall begin with the incoming feeders, incorporate graphic representations of all the main elements of the switchgear that are fed or within the switchgear, such as transformers and breakers, and terminate in graphic or labeled representations of loads fed by the switchgear.
- f. Mimic Panel
 - 1) A stand-alone local control panel (Mimic Panel) shall be provided as shown the Contract Drawings.
 - 2) It shall be possible to execute from the Mimic Panel all the operations an operator can accomplish while standing directly in front of the switchgear such as opening and closing breakers and verification by status indicators.
 - 3) The Mimic Panel shall have a Mimic Diagram as described in this Section, except that all graphic representations of circuit breakers shall be replaced by actual breaker control switches one for each breaker, along with corresponding breaker and device status indicators.
 - 4) All indicator lamps shall be low burden LED type with power taken from the same source as the switchgear.
 - 5) All breaker control switches shall be of the same make and model as used on the switchgear.
 - 6) The Mimic Panel shall be fabricated in UL listed panel shop.
 - 7) The panel shall be NEMA Type 12.
 - 8) The panel shall be an enclosed, front accessible and fabricated from reinforced sheet steel.

B. Accessories:

1. Maintenance closing handle.
2. Indicating lights for circuit breaker status - red for "CLOSE", green for "OPEN" and amber for "OVER-CURRENT TRIP".
3. Shunt trip.
4. Auxiliary contacts for remote indication of circuit breaker status: open, close, and over-current trip.
5. Targets for overload, short circuit, and ground trip indication.
6. Test kit for testing of breaker trip unit.
7. Provide key and electrical interlock systems as required for the interlocking schemes shown or indicated on the Drawings. Each system shall be complete

with necessary keys and locks for the schemes indicated.

2.6 MAIN METERING DEVICE

- A. Provide a main meter device as shown on the Drawings and the Contract Documents.
 1. Microprocessor-based monitoring device shall provide complete electrical metering in one package. Device shall include self-contained potential transformers and self-protected internal fuses.
 2. Mount device on the compartment door to allow personnel access to meter menu and display.
 3. Device shall include trend analysis, event logging, and recording, and include the following direct-reading metered values:
 - a. Volts: 0.2 percent accuracy.
 - b. Amperes: 0.2 percent accuracy
 - c. Watts, Vars and VA: 0.5 percent accuracy
 - d. Power Factor: 1.0 percent accuracy
 - e. Frequency: 0.05 percent accuracy
 - f. Watt and VA Hours: 0.5 percent accuracy
 - g. Var. Hours: 1.0 percent accuracy
 - h. Watt, Var, and VA Demand: 0.4 percent accuracy
 - i. THD-Voltage: 50th harmonic
 - j. THD-Current: 50th harmonic
 - k. Individual Ampere Harmonics: 50th harmonic
 - l. Individual Voltage Harmonics: 50th harmonic
 4. Provide metering device with the following additional features:
 - a. Trend analysis displaying minimum and maximum values for each metered parameter with date and time of each occurrence.
 - b. Input range of device shall accommodate external current transformers with ranges from 100/5 to 5000/5 and potential transformers from a ratio of 120:120 to 500,000:120.
 - c. Alarm contacts rated five amps at 120 vac.
 - d. Three analog outputs programmable to reflect the metered parameters, except kilowatt hours and kilovar hours.
 - e. Ethernet communication capability.
 5. Control power shall be drawn from monitored incoming AC line. Device shall have non-volatile memory and not require battery backup. During power failure, device shall retain preset parameters.

2.7 SURGE PROTECTIVE DEVICES

- A. Provide surge protective device in accordance with Section 26 43 00, Surge Protective Devices for each secondary distribution bus as shown or indicated on the Drawings. Surge protective device shall be included and factory-mounted within secondary distribution equipment by secondary distribution equipment

manufacturer. Surge protective device monitoring and display shall be visible from front of secondary distribution equipment.

2.8 ETHERNET NETWORK

- A. Provide an Ethernet network to interconnect all the Breaker Electronic trip units and Metering Devices. Provide gateways as required to convert other protocols to Ethernet/IP.
- B. Provide Din Rail mounted managed Ethernet switch with ports as required.
- C. Provide CPTs and power supplies as required to power the Ethernet switch.

2.9 OUTDOOR ENCLOSURE

- A. Coatings for enclosures are specified in Article 2.9 of this Section.
- B. Each enclosure shall be suitable for housing the distribution equipment and the additional equipment as shown on the Drawing. Enclosure construction shall be NEMA 3R, non-hazardous with walls, roof and ceiling fabricated from interlocking panels and structural grid base.
- C. The enclosure shall be designed in accordance with the IBC, New York Edition for use under the following conditions:
 - 1. Design of enclosure structure shall be per design parameters as listed on general notes of structural drawings and per latest applicable building code.
 - 2. Roof, ground and drift snow loading, wind loading and seismic as described by the Structural Drawings.
 - 3. Floor loading, 250 pounds per square foot total.
 - 4. Base deflection, L/240.
 - 5. Exterior ambient temperature, summer 100 degrees F, winter -20 degrees F.
 - 6. Interior ambient temperature, summer 80 degrees F, winter 55 degrees F with air conditioning.
 - 7. Lighting, 40 foot candles maintained at floor.
- D. Each enclosure shall be of all welded, seamless construction utilizing ASTM structural steel members, sized, and arranged for proper strength when lifting the complete factory fabricated and equipped assemblies. All welding shall be performed by certified welders and be in accordance with the requirements of AWS D1.1. The enclosure materials shall consist of the following:
 - 1. The structural and HVAC design calculations for the enclosure shall be certified, signed, and sealed by a professional engineer licensed in the State of New York. Heating and cooling load calculations shall be provided using an industry recognized software calculation program such as Carrier Block Load or HAP or Trane Trace.
 - 2. The Drawings show preliminary an overall enclosure size and arrangement and the distribution equipment requirements. The drawings are for purposes of guidance and for showing the functional features and spacing required. The drawings do not show all components required, and the enclosure construction

- shall incorporate all specified requirements for proper functionality and operation.
3. The customized enclosure shall be factory assembled and tested to the maximum extent possible. When multiple shipping sections are required, suitable shipping splits and terminations shall be provided for the enclosure and wiring reconnection in the field.
 4. The base shall be ASTM-A572 channel, wide flange and ASTM-A36 welded steel channel and angle support sections forming a self-supporting grid suitable for installation on concrete foundations. The base shall be cleaned, primed and covered with a bituminous undercoating and equipped with two stainless steel ground pads located at opposite corners.
 5. The floor shall be a minimum of 1/4-inch hot rolled smooth steel plate welded to the perimeter and longitudinal and/or transverse structural members of the base. The floor shall be finished with an application of ANSI-61 skid resistant epoxy and provided with floor cutouts where required for power and control cable entry/exit from the equipment. The cutouts locations shall be coordinated with the actual conduit installation. The cutouts shall be provided with 12-gauge galvanized cover plates.
 6. The enclosure walls, roof and ceiling shall be double wall construction fabricated from G90 galvanized steel, minimum of 18-gauge thickness. Exterior and interior walls, exterior roof and interior ceiling shall be of self-framing, interlocking design, with maximum panel width of 16-inch. The roof shall be sloped one inch per foot.
 7. The walls roof and floor shall be fully insulated. The walls and roof shall be provided with fiberglass batt type R-11 insulation. The floor shall be provided with three-inch spray applied polyurethane foam R-18 insulation.
 8. The enclosure switchgear wall areas shall be provided with 14-gauge galvanized steel, gasketed and insulated hinged rear access doors for each breaker compartment. The doors shall include a 3-point latching system with stainless steel, type 316L hardware, pad lockable handles with gasketing, drip shields/water flashing. A sloped roof type overhang shall be provided above each rear access door which extends out the width of the door. The rear doors shall be provided with identification nameplates that match front compartment designations.
 9. The floor directly below all switchgear shall be provided with suitable support channels. The channels shall raise the switchgear above the enclosure floor elevation to allow the doors to be opened without removing the insulating floor mats. The channels installation shall not interfere with the lift truck operation during breaker removal.
- E. The enclosure entire metal surfaces shall be provided with severe duty type coatings. All metal surfaces shall be thoroughly cleaned and prepared in accordance with paint manufacturer's recommendations and coated with one coat of epoxy type primer. Surfaces located indoors shall be given one shop finish epoxy coat and exterior surfaces shall be given two shop finish epoxy coats. A top coat of polyurethane shall be applied to all finished surfaces. Enclosure colors shall be white for interior surfaces. Exterior door and frame surfaces shall be ANSI 61 Gray. All remaining

visible exterior surfaces colors shall be selected by the Owner from color chart and samples.

- F. The enclosure shall be provided with personnel doors 36-inch x 84-inch and equipment double door 72-inch x 84-inch as shown on the Drawings. The doors shall be insulated and fire rated with 18-gauge double wall construction with neoprene gasket, drip shields and water flashing. Doors shall be equipped with stainless steel hardware, type 316L and shall be key lockable with panic hardware and a “DANGER, HIGH VOLTAGE, KEEP OUT” sign. At each door provide stairs and railings as required per applicable codes.
- G. The enclosure shall include provisions for channeling runoff from the roof to prevent nuisance leaks and erosion.
- H. Enclosure Heating, Air Conditioning and Ventilation
 - 1. Each enclosure shall be provided with heating and air conditioning systems and ventilation suitably sized for the ambient conditions specified, enclosure dimensions, materials of construction, solar heat gain, and electrical heat gain.
 - 2. Two (2) air conditioning units at a minimum shall be provided for the enclosure to split the cooling load. The heating and air conditioning systems shall be designed to maintain the enclosure interior temperature at the heating and cooling specified conditions during the outdoor design conditions specified. Air conditioning and heating equipment shall be provided complete with all appurtenances as recommended by the equipment manufacturers for a complete system installation which shall include but not be limited to the following:
 - a. Each unit shall be sized at 66 percent of the total cooling load to provide some level of redundancy.
 - b. The air conditioning units shall be provided with a lead/lag controller from the same HVAC equipment manufacturer. The controller shall stage each unit to maintain set point, rotate lead and lag designated units and provide summary alarm dry contacts for remotely signaling a system alarm.
 - c. Air conditioning units shall operate on non-CFC refrigerant and shall be high efficiency type with an SEER range of 18 to 21.
 - d. Two (2) electric type heaters at minimum shall be provided to heat the switchgear room in the winter.
 - e. The heaters shall be of the electric horizontal unit heater type with external mounted thermostats. One (1) thermostat in the switchgear room shall be set 5 degrees below the other. The heaters shall be as manufactured by Chromalox series LUH with WCRT-100 heavy duty NEMA 4X thermostat or approved equal.
- I. The enclosure shall be provided with lighting consisting of indoor and emergency LED lighting fixtures. Outdoor weatherproof full cutoff type LED light fixtures shall be provided, one (1) over each door. The outdoor fixtures shall be photocell

controlled. Refer to fixture schedule on Contract Drawings for additional fixture requirements.

- J. The enclosure shall be provided with a 1/4-inch x 2-inch copper ground bar running the entire length of the building. The switchgear ground bus shall be connected on each end to the ground bar with a suitably sized green insulated copper ground cable. Insulated ground cables shall be provided from the ground bar to all enclosure electrical equipment.
- K. The enclosure shall be provided with fire extinguishers, one (1) located adjacent to each of the doors.
- L. The enclosure wiring shall be single conductor copper cable type XHHW installed in conduit. Conduits shall be RGS.
- M. Provide panelboards in accordance with Specification Section 26 24 16.
- N. Provide receptacle in accordance with the Specification Section 26 27 26.13.
- O. Provide snap switches in accordance with Specification Section 26 27 26.23.

2.10 WIRING AND DEVICE IDENTIFICATION

- A. Provide control wiring and internal device identification for each compartment, including:
 - 1. Identify control conductors with permanent wire markers. Each wire shall be identified by a unique number and shall be attached to the wire at each termination point.
 - 2. Identify each control device with permanent markers. Each device shall be identified by a unique number and shall be attached to each device.
 - 3. Identify numbering system for each wire and control device on wiring diagrams and shall be the actual designations used in the Work.

2.11 FINISHING

- A. Shop Painting:
 - 1. Surface Preparation: Thoroughly clean substation's metal surfaces, provide surface preparation in accordance with paint manufacturer's recommendations.
 - 2. Primer: Provide one coat of standard primer.
 - 3. Finish Coat:
 - a. Surfaces located indoors, including surfaces inside enclosure, shall receive one shop coats of standard finish.
 - b. Provide exterior surfaces located outdoors two shop coats of standard finish.
 - c. Color of finishing coats shall be ANSI No. 61, "light gray".

2.12 SOURCE QUALITY CONTROL

- A. Tests:
1. Perform factory tests on equipment prior to shipment.
 2. Switchgear shop tests shall include the following:
 - a. Physical inspection shall be performed including torque tests of bus bolts.
 - b. Mechanical operations shall be performed to insure proper functioning of operating mechanisms and interchangeability.
 - c. Continuity test shall be performed on power and control wires.
 - d. Functional operations test which shall include pick up, dropout, time delay, sequence and polarity.
 - e. Primary hi-potential tests shall be performed. Primary current carrying parts shall be tested between phases, phase to ground, and line to load. The applied voltage shall be twice rated voltage plus 1000V for 1 minute.
 - f. Hi-Potential tests on control and secondary wiring shall be performed. Control circuit wiring shall be tested for 1500 volts to ground for 1 minute.
 - g. Power cables and buses shall be tested, for insulation breakdown resistance and circuit isolation. Test voltage frequency shall not be less than the frequency of the rated voltage of the equipment tested.
 3. Transformer Testing: Perform the following tests on all transformers except as specified below. Numbers shown do not necessarily indicate the sequence in which tests will be made. Tests shall be in accordance with ANSI Standard Test Code for Transformer, C57.12.90 and C57.12.91.
 - a. Resistance measurements of all windings on the rated voltage connection of each unit and at tap extremes.
 - b. Ratio tests on rated voltage connection and on all tap connections.
 - c. Polarity and phase-relation tests on rated voltage connection.
 - d. No-load loss at rated voltage on rated voltage connection.
 - e. Exciting current at rated voltage on rated voltage connection.
 - f. Impedance and load loss at rated current on rated voltage connection of each unit and on tap extremes.
 - g. Temperature Test:
 - 1) Temperature test shall be made when there is no available record of a temperature test made in accordance with ANSI standards on a duplicate or essentially duplicate unit.
 - 2) Subject to limitations of the preceding paragraph, when transformer is furnished with auxiliary cooling equipment to provided more than one kVA rating, perform temperature tests for all nameplate kVA ratings.
 - h. Applied potential tests.
 - i. Inducted potential tests.
 4. The Mimic Panel shall be wired and tested at the factory, including all connections, terminals and terminal blocks, to demonstrate that it has been properly assembled.
 - a. Perform breaker control and status control panel visual and mechanical inspection of all components for proper installation.

- b. Electrical operations consisting of opening and closing of the circuit breakers using the panel control switches and verification of status lights.
- c. Hi-pot testing of control circuits.
- d. Alarm simulation and annunciator display and functional testing.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which materials and equipment will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install equipment in accordance with manufacturer's recommendations and instructions, Laws and Regulations, and the Contract Documents. Install equipment as shown on concrete bases, and on support channels in concrete in accordance with equipment manufacturer's recommendations.
- B. Install terminations, lugs, and required appurtenances to properly terminate power supplies.
- C. Install control wiring terminations and appurtenances necessary to complete the installation of control and monitoring devices.
- D. Connections to existing facilities shall be in accordance with Section 01 14 16, Coordination with Owner's Operations.

3.3 FIELD QUALITY CONTROL

- A. Site Tests:
 - 1. Site Testing, General:
 - a. Provide field-testing and inspection of substation equipment. After installation, inspect, adjust, and test each substation.
 - b. Testing and inspection shall be in accordance with the manufacturer's recommendations, Laws and Regulations, and the Contract Documents, and shall be performed by the manufacturer's factory-trained representative.
 - c. Through CONTRACTOR, manufacturer's representative shall inform OWNER and ENGINEER when equipment is correctly installed.
 - d. Do not energize equipment without OWNER's permission.
 - 2. Perform the following tests and checks before energizing equipment:
 - a. Verify proper installation of equipment and ratings.
 - b. Inspect all mechanical and electrical interlocks and equipment for proper operation.
 - c. Check tightness of bolted connections.

- d. Measure insulation resistance of each bus section phase-to-phase and phase-to-ground.
- e. Measure insulation resistance of each switch, circuit breaker, and fuse pole to pole and from pole to ground.
- f. Perform other tests and adjustments recommended by equipment manufacturer.
- g. Perform the following tests for each transformer:
 - 1) Insulation resistance.
 - 2) High potential.
 - 3) Turns ratio tests at all tap positions.
3. Thirty days after transformer testing is completed and transformers are placed into operation, obtain oil samples and perform insulating liquid testing for each transformer. Insulating liquid testing shall be laboratory-tested in accordance with ANSI/NETA MTS including optional testing.
4. Provide testing equipment and services for testing the equipment specified.
5. Provide acceptance testing of substation equipment by an independent testing firm. Independent testing firm shall inspect and test each substation. Perform testing and inspection, after completing of field-testing specified in Paragraph 3.3.A.2 of this Section.
 - a. Visual and Mechanical Inspection: Perform inspection of each substation in accordance with ANSI/NETA ATS. Inspection shall include:
 - 1) Inspect for physical, electrical, and mechanical condition.
 - 2) Check for proper anchorage, required area clearances, physical damage and proper alignment.
 - 3) Inspect all connections for high resistance.
 - 4) Check all electrical and mechanical interlock systems for proper operation.
 - 5) Check blade alignment and arc interrupter operation. Check arc chutes as required.
 - 6) Inspect insulators for evidence of damage or contamination.
 - 7) Clean and lubricate as required.
 - b. Electrical Tests: Perform electrical testing of each substation in accordance with ANSI/NETA ATS. Testing shall include:
 - 1) Perform ground-resistance tests.
 - 2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground.
 - 3) Perform an over-potential test on each bus section, each phase-to-ground.
 - 4) Perform insulation-resistance tests on each switch and circuit breaker, phase-to-phase and phase-to-ground.
 - 5) Perform DC over-potential test on each switch in the closed position. Test each pole with other poles grounded.
 - 6) Perform contact-resistance test.
 - 7) Perform control and metering wiring performance test.
 - 8) For each circuit breaker, determine trip characteristics by primary current injection.
 - 9) each transformer perform resistance measurements and power factor tests of all windings.

B. Manufacturer Services:

1. Unloading and Installation: Manufacturer's factory-trained representative shall be present during unloading of the equipment and installation in the equipment's final location. Representative shall train installing personnel in advance in the proper handling and rigging of the equipment. This shall be at least two eight-hour days.
2. Post-installation Check: Manufacturer's factory-trained representative shall check and approve the installation before initial operation. This shall be at least two eight-hour days.
3. Manufacturer's factory-trained representative shall adjust the system to initial settings as specified in Article 3.4 of this Section.
4. Testing and Start-up: Testing, checkout and start-up of the equipment shall be performed under the technical direction of the manufacturer's factory-trained representative. Representative shall operate and test the system in the presence of ENGINEER and verify that equipment complies with the Contract Documents. This shall be at least two eight-hour days at the Site per substation. Do not energize system without authorization from manufacturer's representative.
5. Manufacturer's technicians and specialists shall instruct operations and maintenance personnel.
 - a. Furnish services of manufacturer's qualified, factory-trained specialists to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of equipment.
 - b. Training requirements, duration of instruction, and qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
 - c. Number of hours on-Site shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
6. Technician shall revisit the Site as often as necessary until installation is acceptable.
7. Provide services of manufacturer's factory-trained representatives to correct defective Work within 72 hours of notification by OWNER during the correction period.
8. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

3.4 ADJUSTING

- A. Calibrate, set, and program protective devices. Coordinate protective devices furnished under this Section and provide proper settings of all devices in accordance with the findings of study specified under Section 26 05 73, Electrical Power Distribution System Studies.

++ END OF SECTION ++

SECTION 26 12 19

PAD-MOUNTED, LIQUID-FILLED MEDIUM VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified and required to furnish and install pad-mounted, liquid-filled medium voltage transformers.
 2. CONTRACTOR shall refer to NYSEG SP-1099 Specifications for Customer Electric Service for additional requirements.
- B. Related Sections:
1. Section 03 30 00, Cast-in-Place Concrete.
 2. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

- A. Standards referenced in this Section are:
1. IEEE C2, National Electrical Safety Code.
 2. ANSI/IEEE C57.12, General Requirements for Distribution, Power and Regulating Transformers.
 3. ANSI/IEEE C57.12.13, Liquid-Filled Transformers Used in Unit Installations including Unit Substations – Conformance Requirements.
 4. ANSI/IEEE C57.12.22, Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High Voltage Bushings; 2500 kVA and Smaller.
 5. ANSI/IEEE C57.12.27, Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations – Conformance Requirements.
 6. ANSI/IEEE C57.12.28, Pad-Mounted Equipment Enclosure Integrity.
 7. ANSI/IEEE C57.12.90, Test Code for Distribution Power and Regulation Transformers and Guide for Short Circuit Testing of Distribution and Power Transformers.
 8. ANSI/IEEE C57.12.91, Test Code for Dry-Type Distribution and Power Transformers.
 9. ANSI/IEEE C57.93, Guide for the Installation of Liquid-Immersed Power Transformers.
 10. ANSI/NETA ATS, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
 11. ANSI/NETA MTS, Standard for Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems
 12. SP-1099, NYSEG Specifications for Customer Electric Service.

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer: Shall have not less than five years' experience in designing, manufacturing, and servicing equipment for installations of the size and type required for the Project. When requested by ENGINEER, submit list of installations in satisfactory operation.
- B. Regulatory Requirements: Comply with the following:
 - 1. NEC Article 450, Transformers and Transformers Vaults (Including Secondary Ties).
 - 2. United States Department of Energy, 10 CFR Part 431, Energy Conservation.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Transformer layout including dimensions and locations of anchors.
 - 2. Product Data:
 - a. Manufacturer's technical information for proposed pad-mounted, liquid-filled medium voltage transformers.
 - b. Anchorage system information with load calculations and installation information.
 - 3. Testing Plans, Procedures, and Testing Limitations:
 - a. Proposed factory test methods, procedures, and apparatus.
 - b. Proposed field test methods, procedures, and apparatus.
- B. Informational Submittals: Submit the following:
 - 1. Certifications:
 - a. Seismic certification
 - 2. Source Quality Control Submittals:
 - a. Submit transformer factory test reports.
 - 3. Field Quality Control Submittals:
 - a. Submit transformer field test reports
 - 4. Qualifications Statements:
 - a. Manufacturer, when requested by ENGINEER

1.5 DELIVERY AND HANDLING

- A. Equipment shall be constructed for handling by crane. Where cranes are not available equipment shall be suitable for placement on rollers using jacks to raise and lower the groups.
- B. Delivery, storage, and handling shall comply with manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 EQUIPMENT PERFORMANCE

- A. Performance Criteria:
1. Rating: Liquid-Filled Medium Voltage Transformers shall be three-phase, 60 Hertz. Ratings shall be as shown on drawings.

2.2 MANUFACTURERS

- A. Manufacturers
1. Eaton.
 2. ASEA Brown Boveri.
 3. Square D Company.
 4. Or equal.

2.3 MATERIALS

- A. Materials:
1. Coolant: Coolant shall be non-toxic, fire resistant, biological-based natural ester dielectric fluid. Coolant shall be 100-percent derived from edible seed oils and performance-enhancing additives shall be food grade. Coolant shall be FM-approved, UL-classified, Envirotemp FR3 fluid.
 2. Efficiency: Energy efficient, complying with 10 CFR Part 431 standard efficiency levels.
 3. Windings:
 - a. Copper construction for primary and secondary windings.
 - b. Winding temperature rise by resistance shall not exceed 55 degrees C.
 - c. Hottest spot winding temperature rise shall not exceed 65 degrees C.
 - d. Provide thermally upgraded insulation allowing continuous loading of 112 percent of the 55 degrees C KVA rating with winding temperature rise not exceeding 65 degrees C and hottest spot temperature rise not exceeding 80 degrees C.
 4. Taps: Full capacity, two 2.5-percent primary taps above normal and two 2.5-percent primary taps below normal.
 5. Liquid-filled medium voltage Transformers shall bear the UL label.
 6. Impedance: 5.75 percent.
- B. Construction:
1. Live-front construction.
 2. Construction shall be in accordance with ANSI/IEEE C57.12.13, ANSI/IEEE C57.12.22, ANSI/IEEE C57.12.27, and ANSI/IEEE C57.12.28.
 3. Compartmental-type unit consisting of transformer tank with high and low-voltage cable terminating compartment, assembled as an integral unit for mounting on a pad.

4. Tamper-proof design with no exposed screws, bolts, or other fastening devices that are externally removable, and no openings through which foreign objects might contact live parts.
 5. Full-height, air-filled, incoming and outgoing terminal compartments with hinged doors and steel barrier between compartments:
 - a. High-voltage, incoming compartment accessible only after door to low-voltage, outgoing compartment is open.
 - b. Compartment doors equipped for latching in the open position and capable of being secured with a single padlock.
 - c. Door hardware and hinge assemblies made of corrosion-resistant material.
 6. Lifting, jacking, and rolling provisions.
 7. Instruction Nameplate: Stainless steel plate and screws permanently affixed to a non-removable part in the low-voltage compartment and located to be readable with cables in place.
 8. Transformer Tank: Sealed tank constructed with welded main cover and bolted tamper-resistant handhole for access to internal connections.
 9. Tank grounding provisions in high-and low-voltage compartments.
 10. Low-voltage Bushings: Tinned, spade type.
 11. High-voltage Bushings: Porcelain, live-front arrangement.
 12. High-voltage Entrance: Three cast resin bushings with phase barriers between bushings.
 13. Terminals arranged for cabling from below.
 14. Identification: Identify pad-mounted liquid-filled medium voltage transformers in accordance with Section 26 05 53, Identification for Electrical Systems, with transformer identification number, primary and secondary power identification, and voltage.
- C. Accessories:
1. Lightning arrester mounting pads with three lightning and surge over voltage arrestors.
 2. Gang-operated internal oil-immersed load break switch with bayonet primary expulsion fuses.
 3. Fill plug and automatic pressure relief device.
 4. Drain valve and sampler.
 5. Tap changer handle.
 6. Liquid-level gage.
 7. Provision for vacuum-pressure gage.
 8. Dial-type thermometer with alarm contact.
 9. Oil required to place transformer into service.
- D. Finish
1. Liquid-filled medium voltage transformers shall include finish suitable for outdoor and indoor use, in accordance with the locations shown on the Drawings. Paint shall be an electro-statically deposited dry powder system applied to dry film thickness of not less than three mils. Paint products pad-mount green, Munsell No.7GY3.29/1.5.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests for Liquid-Filled Medium Voltage Transformers: Perform the following factory tests in accordance with ANSI/IEEE C57.12.90 and ANSI/IEEE C57.12.91:
 - 1. Resistance measurements of all windings on rated voltage connection of each unit and at tap extremes of one unit of each specified rating.
 - 2. Ratio tests on rated voltage connection and on all tap connections.
 - 3. Polarity and phase-relation tests on rated voltage connection.
 - 4. No-load loss at rated voltage on rated voltage connection.
 - 5. Exciting current at rated voltage on rated voltage connection.

 - 6. Impedance and load loss at rated current on rated voltage connection of each unit and on the tap extremes of one unit of each specified rating.
 - 7. Temperature Test: Perform tests when there is no available record of a temperature test made in accordance with ANSI/IEEE standards on a duplicate or essentially duplicate unit to the equipment required. Perform tests under conditions specified in ANSI/IEEE C57.12.90 on one unit of each specified rating.
 - 8. Applied potential tests.
 - 9. Induced potential tests.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install equipment in accordance with equipment manufacturer's recommendations, Laws and Regulations, and the Contract Documents.
- B. Install equipment with sufficient access and working for convenient and safe operation and maintenance.
- C. Install transformer on concrete pad at location shown on the Drawings. Modify pad as required to fit equipment furnished. Provide pad in accordance with Section 03 30 00 Cast-in-Place Concrete, and Section 05 05 33, Anchor Systems.
- D. Set taps for proper voltage at service distribution equipment.
- E. Unless otherwise shown or indicated, provide ground rod directly beneath transformer. Connect grounding electrode conductor(s) to ground rod. Where liquid-filled medium voltage transformers are to be mounted on existing concrete slabs, drill slab for ground rod penetration.

3.3 FIELD QUALITY CONTROL

- A. Site Tests:
1. Perform the following tests and checks before energizing equipment:
 - a. Inspect physical and mechanical condition, anchorages, alignment, and grounding.
 - b. Inspect all mechanical devices, gauges, and auxiliary devices for proper operation, indication, and liquid level.
 - c. Inspect all electrical connections to ensure connections are clean and bolts are tightened in accordance with manufacturer's recommendations using a calibrated torque wrench.
 - d. Tighten external bolts in accordance with manufacturer's recommendations and apply touchup paint to scratches.
 - e. Perform insulation resistance test.
 - f. Perform turns ratio tests at all tap positions.
 - g. Perform high potential test.
 2. Provide all testing equipment and services for testing the equipment specified.

++ END OF SECTION ++

SECTION 26 13 26

MEDIUM-VOLTAGE METAL CLAD SWITCHGEAR

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, services, and incidentals as shown, specified, and required to furnish and install 15KV medium-voltage metal clad switchgear as specified herein and as shown on the Contract Drawings.

B. Related Sections:

1. Section 26 05 53, Identification for Electrical Systems.
2. Section 26 05 73, Electrical Power Distribution System Studies.
3. Section 26 32 13, 12.47KV Engine Generators.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. ANSI/IEEE C37.010, Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (includes supplements ANSI/IEEE C37.010b and ANSI/IEEE C37.010d).
2. IEEE C37.04, Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
3. ANSI/IEEE C37.06, AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities.
4. IEEE C37.09, Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
5. IEEE C37.11, Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
6. ANSI C37.20.2, Standard for Metal-clad Switchgear.
7. IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
8. ANSI/NEMA C37.55, Medium-Voltage Metal-Clad Assemblies - Conformance Test Procedures.
9. IEEE C57.13, Performance and Test Requirements for Instrument Transformers of a Nominal System Voltage of 115 kv and above.
10. ANSI/NETA ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
11. ISO 9000, Quality Management Systems – Fundamentals and Vocabulary.
12. ISO 9001, Quality Management Systems – Requirements.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer:
 - a. Manufacturer shall have experience producing substantially similar equipment to that specified and shall be able to document at least five installations in satisfactory operation.
 - b. For equipment specified, manufacturer shall be ISO 9000 and ISO 9001 certified.
2. Independent Testing Firm:
 - a. Field Quality Control: Retain an independent testing firm to perform field acceptance testing of the medium-voltage metal clad switchgear. Testing firm shall have experience in inspecting and testing of medium-voltage metal clad switchgear and be a member company of NETA.
 - b. Test Equipment, Calibration and Reporting: Test equipment, instrument calibration, and test reports shall be in accordance with ANSI/NETA ATS.

B. New York State Electric & Gas, NYSEG Requirements:

1. The switchgear shall comply with the applicable requirements of NYSEG.
2. The manufacturer shall be familiar with the NYSEG switchgear and relaying requirements associated with the electric service of the size and type required and shall conform to all NYSEG requirements as part of this Contract. All work required by NYSEG shall be included in the lump sum price bid under this Contract.
3. It shall be the responsibility of the Contractor and his manufacturer to confirm and obtain from NYSEG the latest applicable requirements regarding the electric service and switchgear work that govern this specific installation. It should be noted that the NYSEG Specification defines the responsibilities of the "Customer". The Contractor shall be responsible for all Customer work in the NYSEG Specification.
4. It shall also be the responsibility of the Contractor to coordinate the work with NYSEG. NYSEG shall inspect the installation during and after the execution of the work.
5. The Contractor shall promptly make all necessary arrangements with NYSEG relating to the work of this Section, including the provision of the service feeder, the supply of equipment and the approval of plans, drawings and equipment specified under this Section. The Contractor shall begin making such arrangements immediately upon his receipt of the Notice to Proceed. It shall also be the responsibility of the Contractor to submit all drawings, product information and other required information, including field testing to NYSEG.
6. The costs of the coordination, necessary arrangements and submittals with NYSEG shall be included in the lump sum price bid for the work under this Contract.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
1. Shop Drawings:
 - a. Outline, summary sheets and equipment schedules.
 - b. Unit control schematics and elementary wiring diagrams.
 - 1) Elementary Diagrams and Interconnecting Wiring Diagrams having their terminals identified and indicating the internal wiring and all control and test switch developments
 - 2) Common Elementary and Interconnection Wiring Diagrams shall not be acceptable.
 - 3) Separate drawings for each equipment/compartment shall be supplied.
 - 4) Wire lists in lieu of wiring diagrams shall not be acceptable
 - c. Complete three-line diagrams detailing connections for all instrument transformers, relays, meters, etc.
 - d. Dimensional information, including front elevation and floor plans.
 - e. Construction details of enclosures with conduit entry locations and connection details between assemblies.
 - f. Key interlock scheme and sequence of operation.
 - g. Current and potential transformer data, curves, and burden calculations for each CT and PT circuit.
 - h. Complete Bill of Material
 - i. Mimic Panel
 - 1) Panel exterior front, side and plan view drawings
 - 2) Panel interior front view drawing
 - 3) Control schematic diagrams
 - 4) Connection wiring diagrams
 - 5) Bill of materials
 - 6) Catalog cuts and specification data
 - 7) Nameplate schedule
 - 8) Instruction bulletins from devices
 - 9) Test procedures and reports
- B. As -built record drawings
1. Product Data:
 - a. Technical specifications with assembly and component ratings.
 - b. Time current curves for protective devices.
 - c. Catalog cuts, components list, and nameplate schedule.
 - d. Instruction manuals of all protective relays for the equipment.
 2. Testing Plans: Thirty days in advance of actual factory and field testing, submit proposed testing procedures, methods and apparatus.
- C. Informational Submittals: Submit the following:
1. Design Data: Battery sizing calculations.
 2. Manufacturer's Instructions: Instructions for handling, storing, installing, and start-up.

3. Source Quality Control Submittals: Reports of completed factory testing, including testing procedures used and testing results.
4. Field Quality Control Submittals: Reports of completed field testing, including testing procedures used and testing results.
5. Manufacturer's Reports: Reports of visits to Site by manufacturer's technical service representative, including descriptions of problems encountered and problem resolutions implemented.
6. Qualifications Statements:
 - a. Manufacturer's qualifications and experience when requested by ENGINEER, including previous similar installations.
 - b. Independent testing firm.
7. Closeout Submittals: Submit the following:
8. Operations and Maintenance Data:
 - a. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation, and spare parts information.
 - b. Manuals shall include record drawings of control schematics, including point-to-point wiring diagrams.
 - c. Submit operation and maintenance manuals in accordance with Section 01 78 23, Operations and Maintenance Data.

D. Maintenance Material Submittals: Furnish the following:

1. Spare Parts and Maintenance Materials:
 - a. Furnish, tag, and box for shipment and long term storage the following spare parts and special tools for each medium-voltage metal clad switchgear lineup:

Item	Quantity per Medium-Voltage Metal Clad Switchgear Lineup
1) Circuit breakers, size per Drawings	In accordance with the Drawings
2) Manual ground and test device	One
3) Handle tool for manually charging breaker closing spring and manually opening shutter	One
4) Levering cranks for moving the breakers between test and connected positions	Two
5) Test jumper for operating the breaker while out of its compartment	One
6) Breaker lifting devices or mechanisms for lifting breaker on or off compartment	One complete set
7) Rail clamps for clamping breaker on extended rails	One complete set
8) Protective relay	One per each type used
9) Control relay	Five of each type used
10) Pilot light	Two per ten of each type used
11) Fuses	Two set of each type and size used

- b. Furnish list of additional recommended spare parts for operating period of one year. Describe each part, quantity recommended, and current unit price.
- c. Package spare parts in suitable containers bearing labels clearly indicating contents and equipment with which they are to be used.
- d. Provide single transport dolly for transporting circuit breaker outside its compartment. Dolly shall be suitable for transporting circuit breakers from medium-voltage metal clad switchgear provided under this Contract.
- e. Provide a test cabinet with 6ft umbilical cord that simulates the breaker control circuit for bench testing of the circuit breaker.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Shipping sections shall be designed to be shipped by truck, rail, or ship. Indoor sections shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.
- B. Medium-voltage metal clad switchgear shall be equipped to be handled by crane. Where cranes are not available switchgear shall be suitable for placement on rollers using jacks to raise and lower the groups.

1.6 PREVENTIVE MAINTENANCE SERVICE PLAN

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals required to provide all Manufacturer's recommended preventive maintenance from the period when the equipment is operational until date of Substantial Completion. The maintenance shall follow the Manufacturer's recommended plan and be performed by the Manufacturer's trained technicians every six months, at a minimum.
- B. CONTRACTOR shall provide a Preventive Maintenance Service Plan to the OWNER for a period of three years after date of Substantial Completion. During this period, the Manufacturer's trained technicians shall provide all labor, materials, equipment and incidentals required to perform all Manufacturer's recommended preventive maintenance. The maintenance shall follow the Manufacturer's recommended plan and be performed quarterly, at a minimum.
- C. The following services shall be provided at a minimum for Preventive Maintenance Service Plan:
 - 1. Perform visual inspection every six months with equipment energized.
 - a. Inspect the switchgear exterior for signs of rust and degradation of paint.
 - b. Operate Vacuum Breakers both locally and remotely to confirm proper operation in both the connected and test positions.
 - 2. Perform infrared inspection every twelve months with equipment energized.
 - a. Perform infrared inspection at cable terminations to ensure that the maximum temperature is within recommended operational parameters.
 - 3. Perform secondary current and voltage injection tests for all multifunction

protective relays every twelve months to test all programmed alarm and trip functions in each relay; verify all functions operate within manufacturer's published tolerances.

4. At the end of the third year:
 - a. De-energize and inspect the enclosure interior for signs of rust and degradation of paint.
 - b. Tighten any loose connections.
 - c. Inspect for signs of overheating and voltage creepage over insulating surfaces by looking for indications of carbonization.
 - d. Inspect for signs of cracks, breaks, delamination, warping, and blisters in insulated parts.
 - e. Inspect for foreign or loose objects and rusty or bent structural framework.
 - f. Perform inspection and tests per the latest NETA MTS requirements..

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

- A. Provide medium-voltage metal clad switchgear in accordance with arrangement indicated on Drawings. Switchgear shall be a metal-enclosed assembly of breaker housings, auxiliary housings, and vacuum circuit breakers assembled with individual vertical steel sections bolted together to form a rigid metal-clad assembly.
- B. Performance Criteria: Ratings for medium-voltage metal clad switchgear lineup shall be:
 1. 12.47 KV nominal.
 2. 15 KV maximum design.
 3. 95 KV BIL.
 4. 1200 amperes, main bus, continuous.
 5. Short circuit ratings:
 - a. 40 KA three-phase RMS symmetrical current.
 6. Short circuit current capability of breakers shall be in accordance with ANSI/IEEE C37.06.

2.2 MANUFACTURERS

- A. Manufacturer: Provide products of one of the following:
 1. Eaton.
 2. Schneider Electric
 3. ABB
 4. Or equal.

2.3 CONSTRUCTION

- A. Design, construct, and test medium-voltage metal clad switchgear in accordance with the following standards.

1. ANSI/IEEE C37.010, IEEE C37.04, IEEE C37.09, IEEE C37.11, ANSI C37.20.2 and ANSI/NEMA C37.55.
- B. Medium-voltage metal clad switchgear structure shall be metal-enclosed, dead front, free standing, dust resistant, and fabricated of code gauge steel.
- C. Buses:
1. Buses shall be copper with tin plated connections. Ground bus shall be 1/4-inch by 2-inch minimum. Power and ground buses shall run the length of the medium-voltage metal clad switchgear.
 2. Power bus supports, bus, and interconnections shall withstand stresses associated with short-circuit currents up through the close and latch rating of circuit breakers. Bus work momentary rating shall equal or exceed short circuit rating of circuit breakers.
 3. Main bus shall have epoxy, flame retardant, track-resistant insulation. Bus supports between units shall be glass polyester.
 4. Bus joints shall be plated, bolted, and insulated with boots. All medium voltage cable terminations shall also be insulated with boots, provided by the switchgear manufacturer.
 5. Ground bus shall be tin plated.
 - a. The ground bus shall be extended into each outgoing and incoming cable compartment for convenient field connection of cable shields
- D. Structure:
1. Each vertical section shall be capable of stacking breakers two high and auxiliaries four high.
 2. Each vertical steel unit shall be of a self-contained and self-supported structure having one or more individual breaker or instrument compartments, a centralized bus compartment, and a rear cabling compartment segregated from the bus sections. Equip rear compartments with hinged access doors secured with a minimum of three bolts each and captured nuts.
 3. Equip each individual breaker compartment to house removable breaker assembly. Breaker levering mechanism shall be cell mounted and include all interlocks to render breaker trip-free during levering. A ground contact shall ground the breaker between operating and test positions. Recess circuit breaker stationary primary disconnecting contacts within insulating tubes. Grounded safety shutters shall automatically cover stationary contacts when breaker element is withdrawn from the connected position. Provide draw-out type assembly with a mechanical interlock to prevent moving breaker into or out of operating position unless breaker is tripped. Breaker rails shall allow withdrawal of breaker for inspection.
 4. Cable compartment shall be at rear of breaker compartment. Rear door shall be hinged on each vertical compartment. Compartment shall have ample space for cables, stress cones, potheads, current transformers, and other related components. Provide barriers to isolate circuit terminations when two breakers are in the same vertical section.

5. Enclose main buses in a metal compartment with removable covers for accessibility. Design end bus compartments to allow future extension of bus.
6. Auxiliary compartments shall be used to mount potential transformers, control power transformers, and miscellaneous devices. Where rollout trays are provided to mount potential or control power transformers, equip movable carriage with primary and secondary disconnecting devices, grounding devices, and a safety barrier.
7. Equip enclosure front with nameplates for identification of equipment and operating functions. Nameplates shall be in accordance with Section 26 05 53, Identification for Electrical Systems.

2.4 CIRCUIT BREAKERS AND DEVICES

A. Circuit Breakers:

1. Power breakers shall be vacuum, draw-out type, 3-cycle interrupting rating, three-pole, 60 Hertz, with voltage and interrupting class as specified, and continuous current ratings in accordance with the Drawings.
2. Operation: Breaker shall be electrically operated by a motor-charged, spring type stored energy mechanism. Mechanism shall be front accessible and be charged by an electric motor. Include provisions to charge mechanism by a manual handle.
3. Breaker control voltage shall be 125volt DC close and trip.
4. Circuit breakers shall have interlocks as follows:
 - a. Trip or prevent closing of breaker upon insertion or removal from housing.
 - b. To discharge stored energy mechanism upon insertion or removal from housing.
5. Circuit breakers shall have mechanical indicators for:
 - a. Positive indication of breaker open or closed position.
 - b. Positive indication of breaker closing spring charged or discharged.
 - c. Positive indication of breaker test, connect, or disconnect position.
6. Breaker shall be horizontal draw-out type capable of being withdrawn on wheels on rails with provisions for padlocking in test and disconnect position. Primary disconnecting contacts shall be silver-plated copper. Each breaker shall contain three vacuum interrupters mounted separately. Breaker front panel shall be removable for inspection. Secondary contacts shall be silver-plated and automatically engage in breaker operating position.
7. Provide circuit breakers with control devices for operation and indication. Devices shall include fuses, auxiliary contacts, and other components as required for open-close-trip operation. Each circuit breaker compartment door shall include open-close status lights. Mount circuit breaker control switches remotely, on breaker control panel specified.
8. Termination Lugs: Incoming line and feeder cable lugs shall be two-hole compression copper terminals suitable for cables indicated on Drawings.
9. Each circuit breaker shall be furnished with a sufficient number of auxiliary switch contacts (52 AUX), mechanism operated switch contacts, (52 MOC) and truck-operated switch contacts (52 TOC) to provide all necessary interlocks for proper operation of connected equipment including remote and local positions.

B. Instrument Transformers:

1. Current transformers and potential transformers quantities and ratios shall be in accordance with the Drawings.
2. Current transformers shall be window type, 600V, 10KV BIL suitable for relaying and metering medium-voltage metal clad switchgear applications and mounting in the breaker compartment. Circuit transformers shall be accessible for inspection and maintenance and allow addition or changing without removing high voltage insulated connections.
3. Current transformers shall have a continuous thermal current rating factor of 1.33 or greater at 30 degrees C ambient. Current transformers shall have a short time thermal rating of 75 times or greater rated current for one second. Mechanical ratings shall equal the close and latch rating of circuit breakers.
4. Current transformers accuracy class shall be in accordance with IEEE C57.13, relaying accuracy shall be in accordance with:

Transformer Ratio	Minimum Relaying Accuracy Class
100/5	C100
150/5 to 300/5	C100
400/5 to 500/5	C200
600/5 to 1000/5	C200
1200/5 to 3000/5	C400

5. Current transformers used for differential protection shall have the same ratio, same secondary excitation characteristics, and same manufacturer type.
6. Potential transformers shall be draw-out type in rollout carriages and equipped with current limiting fuses both on primary and secondary sides. Potential transformers shall be automatically disconnected from the power source as access door is opened or carriage withdrawn. Locate potential transformers and fuses either in auxiliary compartment of the vertical section or in a separate auxiliary unit as required.
7. Insulate potential transformers for full voltage and BIL rating of medium-voltage metal clad switchgear. Potential transformers shall have a 0.3 percent ANSI accuracy classification and a thermal rating at 30 degrees C ambient of 750VA for 5 KV applications and 1500VA for applications above.
8. Current and potential transformer secondaries shall be grounded. Secondary leads of each current transformer shall be wired directly to shorting type terminal blocks.

C. Protective Relays:

1. Features Applicable to all Protective Relays
 - a. The Contractor shall furnish and install, in the metal-clad switchgear, the quantity, type and rating of protection relays as indicated on the Contract Drawings and specified in this Section.
 - b. Protective Relays shall be solid-state, microprocessor-based, multi-functional type that operates from the 5-ampere secondary output of current transformers and the 120 VAC secondary output of potential transformers.
 - c. Alternating-current devices, instruments and relays shall be suitable for

operation from 5 amp current and 120V potential circuits at 60Hz.

- 1) They shall not be injuriously affected by primary short circuit current rating of the assembly.
 - 2) All devices, instruments and relays shall be accurately adjusted and calibrated before shipment.
 - 3) The arrangement of equipment on the front of the switchgear panel shall be subject to approval by the Engineer.
- d. Protective relays shall be equipped with semi flush mounted cases, totally withdrawable, with integral test facilities and automatic current transformer shorting with sequenced disconnect, and conform to ANSI C37.90.
- e. Static relays shall be qualified for surge withstand capability (SWC) in conformance with ANSI C37.90.
- f. Control relays shall be designed to relieve control and auxiliary switches of interrupting currents above their rating.
- 1) The control arrangement equipment shall be such that a maintaining contact may be used if desired.
 - 2) Two spare control relays with 125VDC coil and four normally open and four normally closed contacts shall be provided and completely wired to terminal blocks.
 - 3) Timer relays shall be high-precision type, operating at 125VDC. The relay shall variable scale constant 1ms or 10 ms with a 10-99 multiplier. The relay shall be RXHM 2H by Hitachi or Approved Equal.
- g. Alarm relays shall be installed to monitor 125 VDC power supply to circuit breaker control circuit, to provide input to remote alarm should the power supply fail.
- h. The Contractor shall test and calibrate each protective relay in accordance with the manufacturer's recommendation, power system studies and best industry practice.
2. Lockout Relays
- a. Lockout relays (Device 86) shall be heavy-duty, multi-contact type with pistol grip handle control switch.
 - b. The mechanical target on the escutcheon plate assembly shall indicate relay position.
 - c. Reset position shall be indicated by a black target and tripped indication shall be by an orange target.
 - d. Coil voltage shall be 125 VDC.
 - e. Lockout relay shall be manufactured by Electroswitch.

D. Multifunctional Main Protective Device

1. Each Main breaker circuit shown on the Drawings shall be provided with an electronic microprocessor based, multifunctional protective device, Type SEL-751 as manufactured by Schweitzer Engineering Laboratories, Inc
2. The multifunction device for each breaker shall be a single unit including three phase voltage and currents including ground current monitoring. The device

shall make trip decisions from operator selectable protective functions and shall have a front panel and display for monitoring and setting of functions.

3. The multifunction device shall include the following features:
 - a. True RMS sensing of each phase and ground current.
 - b. Phase, neutral and ground over current functions with pickup, time delay and instantaneous adjustments, directional and non-directional capability and selectable curve shaping, ANSI, IAC and IEC.
 - c. Under-Over voltage and frequency, reverse power and sync check.
 - d. Metering including current, voltage, power and energy.
 - e. Communications with networking interfaces of Ethernet, RS232, RS485 and RS422 with ModBus RTU and TCP/IP protocols.
 - f. Provide contact outputs, including trip, close, relay healthy status plus five auxiliary programmable contacts.

E. Multifunctional Feeder Protective Device

1. Each breaker circuit shown on the Drawings shall be provided with an electronic microprocessor based, multifunctional protective device, Type SEL-751A as manufactured by Schweitzer Engineering Laboratories, Inc
2. The multifunction device for each breaker shall be a single unit including three phase voltage and currents including ground current monitoring. The device shall make trip decisions from operator selectable protective functions and shall have a front panel and display for monitoring and setting of functions.
3. The multifunction device shall include the following features:
 - a. True RMS sensing of each phase and ground current.
 - b. Phase, neutral and ground over current functions with pickup, time delay and instantaneous adjustments, directional and non-directional capability and selectable curve shaping, ANSI, IAC and IEC.
 - c. Under-Over voltage and frequency, reverse power and sync check.
 - d. Metering including current, voltage, power and energy.
 - e. Communications with networking interfaces of Ethernet, RS232, RS485 and RS422 with ModBus RTU and TCP/IP protocols.
 - f. Provide contact outputs, including trip, close, relay healthy status plus five auxiliary programmable contacts.

F. Multifunctional Generator Protective Device:

1. Each breaker circuit shown on the Drawings shall be provided with an electronic microprocessor based, multifunctional protective device, SEL-700G as manufactured by Schweitzer Engineering Laboratories, Inc.
2. The multifunction device for each breaker shall be a single unit including three phase voltage and currents including ground current monitoring. The device shall make trip decisions from operator selectable protective functions and shall have a front panel and display for monitoring and setting of functions.
3. The multifunction device shall include the following features:
 - a. True RMS sensing of each phase and ground current.
 - b. Phase, neutral and ground over current functions with pickup, time delay and instantaneous adjustments and selectable curve shaping.
 - c. Under-Over voltage and frequency, reverse power and sync check.

- d. Current unbalance, loss of excitation and generator differential.
- e. Metering including current, voltage, power and energy.
- f. Communications with networking interfaces of Ethernet, RS232, RS485 and RS422 with ModBus RTU and TCP/IP protocols.
- g. Dry contact outputs, including trip, close, relay healthy status plus auxiliary programmable contacts.

G. Single function Sync check relay

- 1. Provide single function sync check relay as shown on Contract Drawings. Relay shall be BE1-25 as manufactured by Basler.
- 2. Relay shall have following features:
 - a. Phase angle limit is adjustable over the range of 1 to 99 degrees.
 - b. Time delay is adjustable over a range of 1 to 99 cycles or 0.1 to 99 seconds.
 - c. Voltage monitoring circuits provide independent determination of bus and line voltage levels for following selectable closing conditions:
 - 1) Live Line/Live Bus (LL-LB)
 - 2) Dead Line/Live Bus (DL-LB)
 - 3) Live Line/Dead Bus (LL-DB)
 - 4) Dead Line/Dead Bus (DL-DB)

H. Auxiliary Components:

- 1. Control Wiring: Control wiring shall be stranded, tinned copper, Type SIS, rated 600 volts. Terminate wire with crimp type insulated spade terminals or non-insulated ring terminals. Armor or enclose control wires in grounded metal troughs where they pass through primary compartments.
- 2. Control Power Source, DC: Provide medium-voltage metal clad switchgear with a 125V dc control power source consisting of a storage battery and associated charger. Battery system shall be in accordance with requirements specified in this Section.
- 3. Key Interlocking: Provide key interlock systems as required for interlocking schemes depicted on Drawings. Each system shall be complete with all necessary keys and locks for the schemes indicated.
- 4. Circuit Breaker Control Panel: Provide medium-voltage metal clad switchgear with a NEMA 12 circuit breaker control panel for manual control of circuit breakers. Provide control panel with an Open-Trip control switch and Open and Close status lights for each circuit breaker.
- 5. Remote Breaker Racking Device: Equip each breaker compartment door for breaker racking. The 120-volt racking mechanism shall be mounted and remotely operated without opening compartment door. Equip mechanism with a motor, cord, and plug attachment, and a control switch with control cord 20 feet long and plug.
- 6. Provide surge arresters when shown on the Drawings and install in cable compartment and connect one for each phase. Arresters shall be distribution class, metal oxide varistor type, heavy duty, enclosed in a polymer housing. Arresters shall a nominal rating as shown on the Drawings and comply with NEMA LA 1.

7. Ground studs:
 - a. Ground studs shall OSHA approved ball and socket ground studs with 5/8-inch shank permanently affixed to each bus for connecting grounding cables.
 - b. The ground stud cap shall be easy removal with a shotgun type of "hotstick".
 - c. Provide ground studs as shown on the Drawings.
 - d. Provide one set of 4/0 AW, 600 Volt insulated, EPR portable ground cables with the appropriate grounding clamps.
 - 1) The grounding cables shall be approximately 10 foot in length and shall have a threaded grounding ferrule installed on each end. One end of the three phase cables shall have a ground clamp installed and the other end shall be joined together at a three way grounding terminal block and a socket type grounding clamp.
8. Phasing Receptacles:
 - a. Provide phasing receptacles as shown on the Drawings.
 - b. Receptacles shall be single flanged, 20 Amp, 3 pole, 4 wire with weatherproof lift cover plate. Provide pin and sleeve type receptacles manufactured by Leviton.
9. Live Line Indicators
 - a. Provide permanently affixed neon live line indicators, (glow tubes) two per phase connected to each incoming line terminal when shown on the Drawings.
 - b. Live line indicators shall illuminate the presence of voltage and be visible from the specified viewing windows in the switchgear rear compartment.
 - c. Live line indicators shall match the voltage rating of the connected voltage and shall be equipped with all necessary mounting hardware, brackets and clamps.
10. Test Switches
 - a. Test blocks and their associated testing accessories shall be provided for testing of instruments and protective relays that require periodic testing or calibration in-place.
11. Test blocks shall be provided with a nameplate engraved to identify individual current or potential test blocks, or a combination current/potential test block, as applicable.
12. Test devices shall be provided for insertion into the associated test block to permit application of the proper current or potential source for testing and calibration. Test devices shall be rated not less than 20 amperes and 125 Volts DC.
13. Mimic Bus
 - a. Continuous mimic bus, applied to front of switchgear, arranged in one-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.
 - b. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
 - 1) Medium: Pressure sensitive adhesive graphics secured with screws.
 - 2) Color: Red.

2.5 BREAKER CONTROL AND STATUS PANEL

A. General

1. Breaker Control and Status Panel (BSCP or “Mimic Panel”) shall be furnished and installed to control and indicate status and alarms for all circuit breakers in the medium voltage switchgear. The BSCP shall be furnished complete with lights, relays, switches, terminal blocks, NEMA 1 enclosure and associated devices as required and as specified herein. All equipment and components shall be coordinated as to electrical functions, mechanical and electrical design, completely equipped, ready for connection and placing into service.
2. Control power shall be rated 125 Volts DC.
3. The panel shall be of an enclosed indoor type and accessible from front doors only. The panel shall be fabricated from sheet steel, no thinner than 1/8”-inch, except the doors which shall be of sufficient thickness to provide a rigid design. The panel shall be suitably reinforced to provide a rigid self-supporting structure. The doors shall be reinforced as required, and gasketed. The hinges shall be of the fully concealed type. The door shall be arranged to swing through not less than 105 degrees from the closed position. Stops shall be provided as required to limit door swing and prevent damage to hinges or adjacent equipment.
4. General arrangement, shape, overall dimensions, and assembly of the panel shall be as shown on the Engineer’s Plans. Deviations from the arrangement and shapes indicated may be necessary to fit the fabricator’s standard construction practices or because of dimensional limitations of the various instruments and devices. Such deviations shall be subject to Engineer’s review.
5. Mimic buses of colored anodized extruded aluminum with concealed mounting hardware shall be furnished to show the bus and circuit configuration as indicated on the Plans. Unless otherwise noted, all buses shall be represented by mimic buses approximately one (1) inch wide. Buses and symbols shall be of dull, non-glare finish. Colors shall be as follows:

<u>Voltage</u>	<u>Color</u>
15 kV	red

B. Panel wiring shall conform to the following:

1. The panel shall be completely wired in the factory with NEC type SIS or equal, #14 AWG, extra flexible wire.
2. All necessary cleats, brackets, clamps, wiring gutters, troughs, terminal blocks and other miscellaneous hardware shall be supplied, and factory installed.
3. All wiring shall satisfactorily withstand a high potential test of 1500 volts ac for one minute.
4. All unused contacts of control switches and relays shall be factory wired to terminal blocks for possible future connection.
5. Terminal blocks shall be 30-Amp, barrier type with #10-32 washer-head screw terminals. Each terminal shall be identified by suitable engraved or painted wire numbers on the marking strip attached to the block. Terminal

blocks shall be provided for all external connections plus a sufficient number of spares to provide approximately 20% extra terminals. The spare points shall be so arranged that each series of blocks in a given area shall have a reasonable proportion of the spare points. Terminal blocks shall be conveniently located for connection to bottom entry external control cables. Location and arrangement of terminal blocks shall be reviewed by the Engineer.

6. All wiring within the panel compartments shall be tagged at both ends with high quality permanent type markers. Adhesive wire markers are not acceptable. Wiring shall be terminated with ring tongue, insulated, indent type terminals.
7. All control switches for control of power circuit breakers shall be similar to General Electric Type SBM, rotary switchboard type, of the spring-return, fixed handle type with a mechanical indicator (red-green flag window) to show the last manual operation of the switch. All control, instrument and synchronizing switches shall be G.E. Type SBM, rotary switchboard type. The handles shall be made of solid black plastic. They shall also contain "slip" contacts, which will remain closed after a manual close operation. At least two alarm circuits for breaker trip shall be provided, one for the panel amber light, one for future remote alarm.
8. Indicating lamps shall be of the low voltage, low burden type, mounted in assemblies that include series resistors with a higher than nominal resistance to ensure long life, and rectangular glass lenses of colors listed below. Lamps shall be similar to general Electric Type ET-16 LED.
9. All exterior surfaces shall be thoroughly cleaned of mill scale and rust by grit blasting. Oil and grease shall be removed chemically and at least three air-dried coats of paint shall be applied by flowing, brushing or dipping. The last two exterior finish coats shall be ANSI 61 light gray to match the switchgear. The interior surface finish coats shall be gloss white.

2.6 MAIN METERING DEVICE

- A. Provide a main meter device as shown on Drawings.
 1. Microprocessor-based monitoring device shall provide complete electrical metering in one package.
 2. Mount monitoring device on the compartment door to allow operator access to meter menu and display.
 3. Device shall include trend analysis, event logging, and recording. Device shall include the following direct reading metered values:
 - a. Volts: 0.2 percent accuracy.
 - b. Amperes: 0.2 percent accuracy
 - c. Watts, Vars and VA: 0.5 percent accuracy
 - d. Power Factor: 1.0 percent accuracy
 - e. Frequency: 0.05 percent accuracy
 - f. Watt, and VA Hours: 0.5 percent accuracy
 - g. Var Hours: 1.0 percent accuracy
 - h. Watt, Var and VA Demand: 0.4 percent accuracy

- i. THD-Voltage: 50th harmonic
 - j. THD-Current: 50th harmonic
 - k. Individual Ampere Harmonics: 50th harmonic
 - l. Individual Voltage Harmonics: 50th harmonic
4. Metering device shall have the following:
 - a. Trend analysis that shall display minimum and maximum values for each metered parameter with date and time of each occurrence.
 - b. Input range of device shall accommodate external current transformers with ranges from 100/5 to 5000/5 and potential transformers from a ratio of 120:120 to 500,000:120.
 - c. Alarm contacts rated five amps at 120 VAC.
 - d. Three analog outputs programmable to reflect each metered parameter, except kilowatt hours and kilovar hours.
 - e. Communication capability : Ethernet IP.
 5. Draw control power from monitored incoming AC line. Device shall have non-volatile memory and shall not require battery backup. During power failure, device shall retain preset parameters.

2.7 BATTERY SYSTEM

- A. The Contractor shall provide dual Battery Systems, including, but not limited to, 125 Volts DC batteries, battery chargers, automatic transfer switches, AC and DC distribution panelboards, disconnect switches, spill containments, hydrogen sensors and alarm panels, conduits, wiring, and other accessories as specified herein and shown on the Contract Drawings.
- B. Battery system design shall comply with the following:
 1. Voltage: 125 volts DC.
 2. Operating Temperature Range: -20 to 100 degrees F.
 3. The battery capacity shall be based on the following load duty cycle over a period of eight hours from a fully charged state with the battery charger out of service. A minimum capacity of 200-ampere-hours is required for an 8-hour discharge rate at 25-degrees Celsius.
 - a. Normal continuous demand of medium voltage switchgear loads, mimic panel indicating lamps, and Generator Protection and Switchgear Paralleling Control Panel PLC.
 - b. Simultaneous closing followed by tripping of all switchgear circuit breakers
 - c. Include 25-percent aging factor and a 30-percent design margin.
- C. Battery:
 1. Battery shall consist of maintenance-free, nickel cadmium cells with a minimum of 20 years design life expectancy under normal usage for the intended duty. Battery shall have a minimum fully charged rated capacity and minimum one minute discharge rate to 1.2 volts per cell as shown on Contract

Drawings.

2. Cells shall be of pocket plate construction, having active material contained within pockets of perforated steel strips.
3. Batteries shall be designed for float service.
4. Cells shall be provided with intercell, inter-tier, inter-step, end to end inter-rack, back to back inter-rack connectors, terminal lugs and terminal plates as required. Inter-Step and Inter-Row connections shall be by prefabricated cable jumpers with lead plated lugs. Size cable to accommodate maximum battery load.

D. Battery racks

1. Batteries shall be provided with two-tier structural steel support racks. Battery racks shall be provided with insulating plastic strips to cover all supports, hold downs and restraining rails that are in contact with the battery cells.
2. The battery rack(s) shall be constructed of such quality material to support and insure proper distribution of the batteries total weight.
3. The battery rack(s) shall be constructed of:
 - a. The battery rack frame shall be constructed of steel members powder-coated with light gray paint.
 - b. The battery rack rails shall be constructed of galvanized steel channels or steel channels powder-coated with light gray paint.
 - c. The battery rack rails shall have a 1/16-inch plastic channel attached by double-sided adhesive tape shall provide Rack Rail Insulation.
 - d. The battery rack hardware shall be zinc plated steel.

E. Charger:

1. Battery charger shall be microprocessor controlled, completely automatic, fully regulated, convection cooled, providing a constant output voltage, and temperature compensated.
2. The charger shall be a filtered unit capable of operating as a DC power supply with a battery eliminator. The battery and its associated charger shall be connected in parallel. The charger, in addition to charging the battery, shall carry the continuous connected load. The battery shall supply the balance of the heavy short time current demands. When the AC supply to the charger is interrupted, the battery shall supply all the required power for the specified load duty cycle.
3. The charger shall be engineered for a 30-year life expectancy with a MTBF of 60,000 hours.
4. Battery charger shall be rated as follows:
 - a. Capacity: In accordance with its associated battery size
 - b. Recharging: Shall be able to recharge the battery to capacity in 8 hours maximum.
 - c. Input Voltage: As shown on Contract Drawings
 - d. Output Voltage: 130VDC
 - e. Output Current: In accordance with its associated battery size and continuous DC load.
 - f. Regulation: 0.5-percent of output DC voltage over its complete load

- range with 10-percent variation of input AC voltage
 - g. Current Limit: Adjustable from 90- to 115-percent; factory set at 110-percent of output nominal current rating
 - h. Output Filter: 30 mV rms ripple.
- 5. Battery Charger Enclosure:
 - a. The enclosure shall be NEMA 250 Type 12 provided with a hinged front panel complete with lockable handle and a minimum of two-point latches.
 - b. The enclosure shall be free standing or wall mounted, ventilated, welded type, formed of sheet steel. The front of the enclosure shall be panel type with all meters and accessories mounted.
 - c. The enclosure shall be deburred and degreased following fabrication; a phosphate bath shall then be applied to the enclosure as a unit. Immediately, a rust-inhibiting coat of primer shall be applied with a finish coat of light gray paint.
- 6. Battery Charger Equipment
 - a. In addition to the charging circuit elements, each charger shall include:
 - 1) One analog DC Voltmeter, 0 to 150V
 - 2) One analog DC ammeter, range as applicable
 - 3) One AC input pilot light marked as "POWER ON"
 - 4) One transducer, 0 to 150V
 - 5) One - three-position selector switch marked AUTOMATIC, FLOAT and MANUAL EQUALIZE
 - 6) Two ground detection alarm relays, positive and negative, for local and remote (PLC) annunciation.
 - 7) One AC input two-pole or three-pole molded-case circuit breaker, NEMA AB 1
 - 8) One DC output two-pole molded-case circuit breaker, NEMA AB 1
 - 9) One equalizing time charger, 0 to 72 hours, to terminate a manually set adjustable equalizing charge of 1.44V per cell
 - 10) One DC failure (low voltage) alarm relay for local and remote annunciation to PLC
 - 11) One AC charger failure alarm relay for local and remote annunciation to PLC
 - 12) One test switch and two indicating lights for ground detection system, with remote annunciation to PLC
 - 13) One surge and transient protection package
 - 14) One indicating LED or pilot light for each fault/abnormal condition
 - 15) One Nameplate containing manufacturer's type and Serial No., complete rating information, and wiring diagram reference number
 - 16) One LED test switch, to test all LEDs
 - 17) The charger shall be provided with a remote shutdown contact. The contact shall be connected to the battery room ventilation system to power-down the battery charger upon failure of the ventilation system.
- 7. Automatic Charger Protection and Control
 - a. The charger output current during the equalize cycle shall be automatically limited to the eight-hour discharge rate for the battery to prevent the cell temperature from exceeding the unsafe limit

recommended by the manufacturer. An equalizing charge for a time preset on the equalizer timer shall be given to the battery following a charger outage, which requires the battery to carry the load for more than five seconds. The charger shall then revert to the normal cycle for full float charging. The equalizing timer shall be adjustable from zero to 72 hours.

- b. The charger shall have built-in protection from overloads including short circuit at its output terminals. This protection shall be by means of a current limiting device or a circuit, which will limit the output current to the rating of the charger without disconnecting the charger from the battery or AC, supply. The charger shall be self-protected against battery discharge into the charger on loss of input AC voltage.
8. Manual Charging Control: A three-position switch shall be installed on the panel door. This switch shall be marked AUTOMATIC, FLOAT, and MANUAL EQUALIZE. In the automatic position, the charger shall function in the automatic cycling manner described herein above. In the float position, the charger output shall be limited to the float condition and shall permit adjustment of the float rate. In Manual-Equalize position, the charger shall apply an equalizing voltage to the battery and permit adjustment of the equalizing rate. Rate adjustments shall be made by means of screwdriver operated devices mounted within the charger, behind the panel door. The adjustment devices shall be clearly identified as to function.

2.8 IDENTIFICATION

- A. Provide control wiring and internal device identification for each compartment, including:
 1. Identify all control conductors with permanent type wire markers. Identify each wire by a unique number and attached to wire at each termination point.
 2. Identify all control devices with permanent type markers. Identify each device by a unique number and attached to each device.
 3. Numbering system for each wire and control device shall be identified on wiring diagrams and shall reflect actual designations used in the Work.

2.9 FINISHING

- A. Thoroughly clean medium-voltage metal clad switchgear metal surfaces, provide surface preparation in accordance with paint manufacturer's recommendations, and provide one coat of standard primer. Surfaces located indoors shall be given one shop coats of standard finish. Provide exterior surfaces located outdoors two shop coats of standard finish. Color of finishing coats shall be ANSI No. 61, "light gray".

2.10 SOURCE QUALITY CONTROL

- A. Certified Shop Tests
 1. Each switchgear lineup shall be completely assembled, wired and tested at the factory, including all buses, connections, insulator, terminals and terminal blocks, to demonstrate that it has been properly assembled, properly lubricated,

- is not overheating, is not overloading and has no electrical or mechanical defects.
2. Shop testing shall be performed on the switchgear at the manufacturer's plant prior to shipment.
 3. Shop test shall be in accordance with the latest revisions of IEEE C37.20.2, IEEE C37.09 and shall demonstrate that the equipment tested conforms to the requirements specified.
 4. The manufacturer shall provide a shop test report. The report shall identify the tests performed and the results obtained.
 5. Switchgear shop tests shall include the following:
 - a. Breaker Testing
 - b. All tests shall be in accordance with the latest version of IEEE C37.09.
 - c. Alignment test with master cell to verify all interfaces and interchangeableness.
 - d. Circuit breakers operated over the range of minimum to maximum control voltage.
 - e. Factory setting of contact gap.
 - f. One-minute dielectric test per IEEE standards on primary and secondary circuits with breakers open and closed.
 - g. Alignment test with master breaker to verify interfaces.
 - h. Operation of wiring, relays and other devices verified by an operational sequence test.
 - i. Five (5) mechanical operations tests of each breaker.
 - j. Timing testing of all breakers.
 6. Switchgear Line up Tests
 - a. Physical inspection shall be performed including torque tests of bus bolts.
 - b. Mechanical operations shall be performed to insure proper functioning of operating mechanisms and interchangeability.
 - c. Continuity test shall be performed on power and control wires.
 - d. Functional operations test which shall include pick up, dropout, time delay, sequence and polarity.
 7. Primary hi-potential tests shall be performed.
 - a. Primary current carrying parts shall be tested between phases, phase to ground, and line to load.
 - b. The applied voltage shall be twice rated voltage plus 1000 for 1 minute.
 8. Hi-Potential tests on control and secondary wiring shall be performed.
 - a. Control circuit wiring shall be tested for 1500 volts to ground for one minute.
 9. Power cables and buses shall be tested, for insulation breakdown resistance and circuit isolation. Test voltage frequency shall not be less than the frequency of the rated voltage of the equipment tested.
- B. The breaker control and status panel shall be wired and tested at the factory, including all connections, terminals and terminal blocks, to demonstrate that it has been properly assembled.
1. Perform breaker control and status control panel visual and mechanical inspection of all components for proper installation.

2. Electrical operations consisting of opening and closing of the circuit breakers using the panel control switches and verification of status lights.
3. Hi-pot testing of control circuits.
4. Alarm simulation and annunciator display and functional testing.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. General:
 1. Install equipment on concrete bases in accordance with manufacturer's recommendations and instructions.
 2. Connections to existing facilities shall be in accordance with Section 01 14 16, Coordination with Owner's Operations.
- B. Terminations and Appurtenances:
 1. Install terminations, lugs, and required appurtenances to properly terminate power supplies.
 2. Install control wiring terminations and appurtenances necessary to complete the installation of control and monitoring devices.

3.3 FIELD QUALITY CONTROL

- A. Site Tests
 1. Provide field testing and inspection of medium-voltage metal clad switchgear. After installation, inspect, adjust, and test switchgear. Testing and inspection shall be in accordance with manufacturer's recommendations and be performed by manufacturer's factory-trained representative. Manufacturer's representative shall inform OWNER and ENGINEER when equipment has been correctly installed. Do not energize equipment without permission of OWNER.
 2. Perform the following tests and checks before energizing equipment:
 - a. Verify proper installation of medium-voltage metal clad switchgear and protective device settings.
 - b. Inspect all mechanical and electrical interlocks and breakers for proper operation.
 - c. Check tightness of bolted connections. Torque to manufacturer's requirements.
 - d. Measure insulation resistance of each bus section phase-to-phase and phase-to-ground.

- e. Measure insulation resistance of each circuit breaker pole-to-pole and from pole-to-ground.
 - f. Perform other tests and adjustments recommended by equipment manufacturer.
3. Qualified, factory-trained service representative, from protective relay manufacturer shall perform calibration, settings, and programming of actual protective devices provided.
 4. Provide acceptance testing of medium-voltage metal clad switchgear. Inspect and test each switchgear. Testing and inspection shall be performed by independent testing firm, after completion of field testing specified in Paragraph 3.3.A 1 of this Section.
 - a. Visual and Mechanical Inspection: Inspect each medium-voltage metal clad switchgear in accordance with ANSI/NETA ATS, including:
 - 1) Inspect for physical, electrical, and mechanical condition.
 - 2) Check for proper anchorage, required area clearances, physical damage, and proper alignment.
 - 3) Inspect all bolted connections for high resistance.
 - 4) Check electrical and mechanical interlock systems for proper operation.
 - 5) Perform mechanical operational tests on each circuit breaker and its operating mechanism.
 - 6) Measure and adjust as required circuit breaker mounting provisions.
 - 7) Inspect protective relay components, check for freedom of movement, proper travel and alignment, and tightness of mounting hardware and plugs.
 - 8) Clean entire switchgear.
 - b. Electrical Tests: Perform electrical testing of each medium-voltage metal clad switchgear in accordance with ANSI/NETA ATS, including performing:
 - 1) Ground-resistance tests.
 - 2) Insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground.
 - 3) An over-potential test on each bus section, each phase-to-ground.
 - 4) Insulation-resistance tests on each breaker. Test each pole, phase-to-phase and phase-to-ground.
 - 5) Minimum pickup voltage tests on trip and close coils.
 - 6) Trip each circuit breaker by operating each protective device.
 - 7) Vacuum bottle integrity test across each vacuum bottle with breaker in open position.
 - 8) Contact-resistance test on each breaker.
 - 9) Control and metering wiring performance test.
 - 10) parameters and timing tests on protective relays.

B. Manufacturer's Services

1. Unloading and Installation: Manufacturer's factory-trained representative shall be present during unloading of the equipment and installation in equipment's final location. Representative shall train installing personnel in advance in

proper handling and rigging of equipment. This shall be at least two eight-hour days.

2. Manufacturer's factory-trained representative shall test system as specified in Paragraph 3.3.A of this Section. Representative shall operate and test system in presence of ENGINEER and verify that equipment conforms to requirements. This shall be at least three eight-hour days.
3. Manufacturer's factory-trained representative shall adjust system to initial settings as specified in Article 3.4 of this Section.
4. Representative shall revisit the Site as often as necessary until all deficiencies are corrected, prior to readiness for final payment.
5. Provide services of manufacturer's factory-trained representatives to correct defective Work within 72 hours of notification by OWNER during correction period specified in the General Conditions and Supplementary Conditions.
6. Replacement parts or equipment installed during correction period shall be equal to or better than original.
7. Training: Furnish services of qualified factory trained specialists from manufacturer to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of materials and equipment. Training requirements, duration of instruction, and other qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
8. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

3.4 ADJUSTING

- A. Calibrate, set, and program protective devices. Coordinate protective devices furnished under this Section and include the proper settings of all devices in accordance with the findings of study specified under Section 26 05 73, Electrical Power Distribution System Studies.

+ + END OF SECTION + +

SECTION 26 22 14

DRY-TYPE LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified, and required to furnish and install dry type low-voltage distribution transformers.

B. Related Sections:

1. Section 26 05 05, General Provisions for Electrical Systems.
2. Section 26 05 26, Grounding and Bonding for Electrical Systems.
3. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. NEMA ST-20, Dry Type Transformers for General Applications.
2. DOE 2016, Guide for Determining Energy Efficiency for Distribution Transformers.
3. NEMA TP-2, Standard Test Method for Measuring the Energy Consumption for Distribution Transformers.
4. UL 1561, Dry Type General Purpose and Power Transformers.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. NEC Article 450, Transformers and Transformer Vault (Including Secondary Ties).

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
 - a. Schedule of transformers to be furnished with ratings and other required technical data.
 - b. Proposed location for each transformer, including pad layout, dimensions, and appurtenances.
2. Product Data:
 - a. Supplier's technical information for transformers proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Dry Type Two-Winding Transformer:

1. Type: Dry type, air cooled, low temperature rise. Transformers 15 kVA and larger shall be energy efficient, complying with DOE 2016 efficiency levels. Transformers less than 15 kVA shall be general purpose.
2. Rating: KVA, primary voltage and connection, secondary voltage and connection, frequency and number of phases shall be as shown on the Drawings.
3. Insulation: Insulation and average winding temperature rise (in a 40 degree C maximum ambient) for rated kVA per the following table. Energy efficient transformers shall be capable of 15 percent continuous overload at 150 degrees C temperature rise.

kVA Rating	Insulation Class (degrees C)	Temperature Rise (degrees C)
1 to 15 kVA	185	115
25 to 500 kVA	220	115

4. Winding Taps, Transformers 15 kVA and Less: Two 5-percent below rated voltage, full capacity taps on primary winding.
5. Winding Taps, Transformers 25 kVA and Larger: Two 2-1/2-percent above rated voltage and four 2-1/2+ percent below rated voltage, full capacity taps on primary.
6. Basic impulse level shall be 10 kV.
7. Sound Level: NEMA ST-20 standard.
8. Enclosure: UL listed for the application.
9. Identification: Identify transformers in accordance with Section 26 05 53, Identification for Electrical Systems, with the transformer number and voltages, connection data, kVA ratings, impedance, and overload capacity.
10. Transformers shall comply with NEMA ST-20, NEMA TP-1, NEMA TP-2, and UL 1561.
11. Transformers shall bear the label of the Underwriters' Laboratories, Inc.

B. Manufacturers: Provide products of one of the following:

1. Cutler-Hammer.
2. General Electric Company.
3. Square D Company.
4. Siemens.
5. Or equal.

2.2 SOURCE QUALITY CONTROL / SHOP TESTS

A. Shop Tests

1. Shop tests shall be performed at the transformer's manufacturer's plant prior to shipment.

2. Shop tests shall demonstrate that the equipment tested conforms to the requirements specified.
3. Each transformer shall be given a routine test in accordance with the latest requirements of UL, ANSI and NEMA standards.
4. The Contractor shall provide a shop test report. The report shall identify the tests performed and the results obtained.
5. Transformer shop tests shall be performed consisting of the following:
 - a. Applied potential shall be performed.
 - b. Induced potential shall be performed.
 - c. No load losses shall be performed.
 - d. Voltage ratio shall be performed.
 - e. Polarity shall be performed.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine the conditions under which the dry type transformers are to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install transformers on walls or floors at locations shown. Install floor mounted transformers on raised concrete bases. Provide sufficient access and working space for convenient and safe operation and maintenance.
- B. Mount transformers so that vibrations are not transmitted to the building structural parts and other equipment. Make connections to transformers with flexible conduit.
- C. Adjust tap settings to provide proper voltage at panelboards.
- D. Install dry type transformers in conformance with governing codes and manufacturer's instructions and recommendations, and the Contract Documents.

++ END OF SECTION ++

SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install panelboards.
- B. Related Sections:
 - 1. Section 26 05 05, General Provisions for Electrical Systems.
 - 2. Section 26 05 53, Identification for Electrical Systems.
 - 3. Section 26 22 14, Dry-Type Low-Voltage Distribution Transformers
 - 4. Section 26 43 00, Surge Protective Devices.

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. NEMA PB 1, Panelboards.
 - 2. UL 67, Panelboards.

1.3 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Listing of panelboards to be furnished with identification of their proposed location, and all electrical characteristics, including number and rating of branch circuit breakers and enclosure type.
 - 2. Product Data:
 - a. Manufacturer's technical information for panelboards proposed for use, including product literature and specifications. Indicate options and features to be provided.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements; Comply with the following:
 - 1. NEC Article 408, Switchboards and Panelboards.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling, and Unloading:
 - 1. Packing:
 - a. Inspect prior to packing to assure that assemblies and components are complete and undamaged.
 - b. Protect mating connections.

- c. Cover all openings into enclosures with-vapor inhibiting, water-repellent material.
 2. Deliver materials and equipment to Site to ensure uninterrupted progress of the Work. Deliver anchorage materials to be embedded in concrete in ample time to prevent delaying the Work. Upon deliver, check materials and equipment for evidence of water that may have entered equipment during transit.
 3. Comply with Section 01 65 00, Product Delivery Requirements.
- B. Storage and Protection:
1. Store panelboards in a clean, dry location with controls for uniform temperature and humidity. Protect equipment with coverings and maintain environmental controls.
 2. Comply with Section 01 66 00, Product Storage and Handling Requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Panelboards:
1. Manufacturers: Provide products of one of the following:
 - a. General Electric Company.
 - b. Eaton/Cutler-Hammer.
 - c. Schneider Electric/Square D Company.
 - d. Or equal.
 2. Rating: Voltage rating, current rating, number of phases, number of wires and number of poles as shown or indicated on the Drawings.
 3. Circuit Breakers: Molded case, bolt-in thermal magnetic type with number of poles and trip ratings as shown or indicated. Where indicated on the Drawings, circuit breakers shall be ground fault circuit interrupting type equipped with solid state sensing and five-milliamp sensitivity.
 4. Circuit breakers for 480-volt panelboards shall have minimum interrupting rating of 42,000 ampere RMS symmetrical, unless otherwise indicated on the Drawings. Circuit breakers for other panelboards shall have minimum interrupting rating of 22,000 ampere RMS symmetrical, unless otherwise indicated on the Drawings.
 - a. Circuit breakers of 150 amp frame or above shall be provided with electronic trip unit with adjustable LSIG protection.
 5. Bus Bars: Bus bars shall be 98 percent conductivity copper. Four-wire panelboards shall have solid neutral bar. Each panel shall have ground bus bar.
 6. Main: Panelboards shall have main circuit breaker, unless the Drawings specifically indicate main lugs only.
 7. Connect branch circuit breakers for sequence phasing.
 8. Enclosures: Panel enclosures shall be as required for the area classifications indicated in Section 26 05 05, General Provisions for Electrical Systems, unless otherwise indicated on the Drawings.

9. Construction: Code-grade steel, ample gutter space, flush door, flush snap latch and lock. Panelboards shall comply with NEMA PB 1 and UL 67.
10. Trim: Surface or flush as required.
11. Directory: Typed or computer-printed card, with transparent protective cover in frame on back of door giving circuit numbers and area or equipment served.
12. Identification: Identify panelboards in accordance with Section 26 05 53, Identification for Electrical Systems. Identification shall indicate panel number and voltage.
13. Directory of Existing Panelboards: When adding or removing breakers or loads from existing panelboards, provide a new typed or computer-generated directory card, indicating the circuit numbers and equipment served.
14. Provide surge protective device in accordance with Section 26 43 00, Surge Protective Devices, for each panelboard shown or indicated on the Drawings. Surge protective device shall be included and factory-mounted within panelboard by panelboard manufacturer. Surge protective device monitoring and display shall be visible from front of panelboard.

B. Integrated Panelboard and Transformer:

1. Products and Manufacturers: Provide products of one of the following:
 - a. Mini-Power Zone by Schneider Electric/Square D Company.
 - b. Mini-Power Center by Eaton/Cutler-Hammer.
 - c. Panel Tran by Acme Electric Corporation.
 - d. Or equal.
2. General: Unit shall consist of encapsulated dry-type transformer, primary and secondary main circuit breakers, and secondary panelboard all in one enclosure.
3. Transformer Rating: Transformer portion shall comply with Section 26 22 14, Dry-type Low-Voltage Distribution Transformers. KVA, primary voltage, secondary voltage, frequency and number of phases shall be as shown or indicated on the Drawings.
4. Branch Circuits: Molded case circuit breakers, plug-in thermal magnetic type with number of poles and trip ratings as shown or indicated on the Drawings.
5. Enclosure: Enclosures shall be as required for the area classifications indicated in Section 26 05 05, General Provisions for Electrical Systems, unless otherwise indicated on the Drawings.

2.2 SOURCE QUALITY CONTROL / SHOP TESTS

A. Shop Tests

1. Shop tests shall be performed at the panelboard's manufacturer's plant prior to shipment.
2. Shop tests shall demonstrate that the equipment tested conforms to the requirements specified.
3. Each panelboard shall be given a 60 Hertz, AC, Hi-Pot test, phase to phase and phase to ground, at twice rated voltage plus 1000 volts for one minute, 1500 volts minimum.
4. A shop test report shall be submitted detailing the tests performed and the results obtained.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Mounting: Install panelboards at locations shown or indicated. Set cabinets so that top branch circuit breaker is not over six feet above the floor.
- B. Directory: Complete typewritten or computer-printed directory indicating items controlled by each circuit breaker and the size of feeder serving the panel.
- C. Arrange circuits to balance the loads on the panelboards.
- D. Identify panelboards in accordance with Section 26 05 53, Identification for Electrical Systems.
- E. Install in accordance with Laws and Regulations, manufacturer's recommendations, and the Contract Documents. Verify proper installation prior to energizing panelboards.

++ END OF SECTION ++

SECTION 26 24 19

MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install motor control centers and modify existing motor control centers.

B. Coordination:

1. To properly size circuit breakers, starters, and control power transformers, obtain motor nameplate data on equipment being furnished under this and other contracts as required.
2. To properly size control power transformers, obtain data on motor space heater and other accessories.
3. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before motor control center Work.

C. Related Sections:

1. Section 26 05 53, Identification for Electrical Systems.
2. Section 26 05 73, Electrical Power Distribution System Studies.
3. Section 26 36 23, Automatic Transfer Switches.
4. Section 26 43 00, Surge Protective Devices

1.2 REFERENCES

A. Standards referenced in this Section are:

1. ANSI/IEEE C37.2, Electrical Power System Device Function Numbers and Contact Designations.
2. ANSI/NETA ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
3. NEMA ICS 18, Motor Control Centers.
4. NEMA ICS 1, Industrial Controls and Systems: General Requirements.
5. UL 845, Motor Control Centers.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Shall have not less than five years experience of producing equipment substantially similar to that required and shall be able to submit documentation of not less than five installations in satisfactory operation for at least five years each.

2. Independent Field Testing Firm:
 - a. Retain an independent testing firm to perform field acceptance testing of motor control centers.
 - b. Testing firm and its assigned personnel shall be experienced in inspecting and testing motor control centers.
 - c. Testing firm shall be a member company of NETA.
- B. Component Supply and Compatibility:
 1. Obtain materials and equipment included in this Section, regardless of component manufacturer, from one motor control center equipment manufacturer.
 2. Motor control center equipment manufacturer shall review and approve, or shall prepare, all Shop Drawings and other submittals for components furnished under this Section.
 3. Equipment shall be specifically constructed for specified service conditions. Equipment and components shall be integrated into overall motor control center equipment system by motor control center equipment manufacturer.
- C. Regulatory Requirements: Comply with the following:
 1. NEC Article 430, Motors, Motor Circuits, and Controllers.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 1. Shop Drawings:
 - a. Outline and summary sheets with schedules of equipment in each unit.
 - b. One-line diagrams indicating circuit breaker sizes, bus rating, motor controller ratings, and other pertinent information to demonstrate compliance with the Contract Documents.
 - c. Unit control schematic and elementary wiring diagrams showing numbered terminal points and interconnections to other units.
 2. Product Data:
 - a. Manufacturer specifications, cut sheets, dimensions, and technical data for all components, materials, and equipment proposed for use.
 3. Testing Plans, Procedures, and Testing Limitations:
 - a. Not less than 30 days prior to actual factory testing, submit proposed testing methods, procedures, and apparatus.
 - b. Not less than 30 days prior to actual field testing, submit proposed testing methods, procedures, and apparatus.
- B. Informational Submittals: Submit the following:
 1. Supplier Instructions:
 - a. Instructions for shipping, storing and protecting, and handling the materials and equipment.
 - b. Installation data for the equipment, including setting drawings, templates, and directions and tolerances for installing anchorage devices.
 - c. Instructions for start-up and troubleshooting.

2. Source Quality Control Submittals:
 - a. Reports of completed factory testing, including procedures used and test results.
3. Site Quality Control Submittals:
 - a. Reports of completed field testing, including procedures used and test results.
4. Supplier Reports:
 - a. Submit written report of results of each visit to Site by Supplier's service technician, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
5. Qualifications Statements:
 - a. Independent testing firm.
 - b. Manufacturer, when requested by ENGINEER.

C. Closeout Submittals: Submit the following:

1. Operations and Maintenance Data:
 - a. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation, and spare parts information.
 - b. Manuals shall include record drawings of control schematics, including point-to-point wiring diagrams.
 - c. Comply with Section 01 78 23, Operations and Maintenance Data.

D. Maintenance Material Submittals: Furnish the following:

1. Spare Parts:
 - a. Furnish, tag, and box for shipment and long term storage the following spare parts and special tools for each motor control center lineup furnished:

Item	Quantity per Switchgear Lineup Furnished
1) Starters and feeder breakers	Quantities and sizes as shown
2) Fuses	Six of each type and size used
3) Auxiliary control relays	Two, with at least two normally open and two normally closed contacts
4) Control power transformers	Two of each size used
5) Indicating lamps	Twelve
6) Covers for indicating lamps	Six of each color used
7) Starters: Contact kits for Size 1 motor starter	Five sets
8) Starters: Contact kits for Size 2, Size 3, and Size 4 motor starters	One set of each size

- b. Furnish a list of additional recommended spare parts for an operating period of one year. Describe each part, the quantity recommended and current unit price.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Packing, Shipping, Handling, and Unloading:
 - 1. Packing:
 - a. Inspect prior to packing to assure that assemblies and components are complete and undamaged.
 - b. Protect mating connections.
 - c. Indoor containers shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately..
 - d. Cover all openings into enclosures with-vapor inhibiting, water-repellent material.
 - 2. Upon delivery, check materials and equipment for evidence of water that may have entered equipment during transit.
 - 3. Handling:
 - a. Lift, roll or jack motor control center equipment into locations shown.
 - b. Motor control centers shall be equipped to be handled by crane. Where cranes are not available equipment shall be suitable for placement on rollers using jacks to raise and lower the groups.
- B. Storage and Protection:
 - 1. Store motor control center equipment in a clean, dry location with controls for uniform temperature and humidity. Protect equipment with coverings and maintain environmental controls.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Provide equipment by one of the following:
 - 1. ABB/General Electric Company.
 - 2. Schneider Electric/Square D Company.
 - 3. Eaton/Cutler-Hammer.
 - 4. Allen-Bradley
 - 5. Or equal.

2.2 MATERIALS

- A. General: Motor control center lineups shall comply with NEMA ICS 18 and be provided as shown with the following ratings:
 - 1. Service: Voltage rating and number of wires shall be as shown or indicated on the Drawings. Motor control center shall operate from a three-phase, 60 Hertz system.
 - 2. Wiring: NEMA Class II, Type B.
 - 3. Enclosure: NEMA 12.
 - 4. Interrupting Capacity Rating: Motor control center shall have an interrupting capacity rating as shown or indicated on the Drawings. Devices shall be suitable for minimum rating indicated.

5. Motor control center lineups shall be UL-rated as suitable for service entrance where shown or indicated on the Drawings and as required.

B. Construction: Provide equipment with the following:

1. Totally-enclosed structure, dead front, consisting of nominal 20-inch deep, 20-inch wide, 7.5-foot high vertical sections bolted together to form a unit assembly.
2. Vertical sections shall have side sheets extending the full height and depth of section.
3. Removable lifting angles for each shipping section.
4. Two removable floor sills for mounting.
5. Horizontal wireways top and bottom, isolated from horizontal bus and readily accessible.
 - a. Wireway openings between sections shall have rounded corners and rolled edges.
6. Isolated vertical wireways with cable supports, accessible through hinged doors, for each vertical section.
 - a. Wireway shall be separate from each compartment and remain intact when compartment is removed.
7. All-metal non-conducting parts electrically continuous.
8. Comply with NEMA ICS 18.

C. Bus System:

1. Rating: Bus bracing and bus current capacities as shown or indicated on the Drawings.
2. Bus bars shall be tin-plated, copper-rated, and comply with UL heat rise standards.
3. Bus bar connections shall be easily accessible with simple tools.
4. Main Horizontal Bus:
 - a. Continuous, edge-mounted, and isolated from wireways and working areas.
 - b. Mount the bus in vertical center of motor control center to provide easy access and even heat distribution.
 - c. Bus shall be supported, braced, and isolated by high-strength, non-tracking, FRP material.
5. Vertical Bus:
 - a. Continuous, and isolated by glass polyester barrier.
 - b. Rated for 300 amperes continuous minimum, and at least equal to full-load rating of all installed units in the associated stack.
6. Grounding Bus: Full length mounted across the bottom, drilled with lugs of appropriate capacity as required.
7. Neutral Bus: Insulated, continuous through control center for four-wire services, drilled with lugs of appropriate capacity as required.

D. Unit Compartments:

1. Provide individual front door for each unit compartment. Fasten door to stationary structure, instead of the unit itself, so that door can be closed when unit is removed.

2. Starter and feeder unit doors interlocked mechanically with unit disconnect device to prevent unintentional opening of door while energized and unintentional application of power while door is open, with provisions for releasing interlock for intentional access and application of power.
3. Padlocking arrangement permitting locking disconnect device in the "OFF" position with at least three padlocks with door closed or open. Equip unit disconnect devices located in the top compartment, compartment sized 12 inches or higher, with extender handle complying with UL 845. Extender handle shall allow disconnect operating handle to be located above NEC's height limitation of six-feet, seven-inches above floor.
4. Equip compartments as shown or indicated on the Drawings:
 - a. Blank compartments, unused space, and compartments shown or indicated on the Drawings as "SPACE" or "EQUIPEED SPACE" shall have bus covers and be complete with necessary hardware for future installation of a plug-in unit.
 - b. Provide shutters for each compartment that automatically open when unit is inserted and automatically close when unit is removed.
5. Provide wiring and device identification:
 - a. Identify compartment doors, devices, and field wiring in accordance with Section 26 05 53, Identification for Electrical Systems.
 - b. Identify internal control conductors with permanent wire markers. Each wire shall be identified by a unique number attached to wire at each termination point.
 - c. Identify internal control devices with permanent markers. Each device shall be identified by a unique number attached to each device.
 - d. Numbering system for each wire and control device shall be identified on the wiring diagrams in the Shop Drawings and shall reflect the actual designations used in the Work.
6. NEMA 1 minimum motor starter size. Starter units completely draw out type in Sizes 1 and 2 and draw out type after disconnecting power leads only in Sizes 3 and 4.
7. Motor starters shall be NEMA-rated and include magnetic contactor, with encapsulated magnet coils. Wound coils are unacceptable. Control shall be 120 VAC unless indicated otherwise.
 - a. Starters shall be full-voltage non-reversing unless shown or indicated otherwise on the Drawings.
 - b. Reversing Starters:
 - 1) Single-speed, full-voltage with two contactors and extra interlocking contacts.
 - c. Reduced Voltage Solid-State Starter:
 - 1) General:
 - a) Provide solid-state, step-less, current limiting, soft-start, motor controllers (RVSS) as shown or indicated on the Drawings.
 - b) RVSS shall be three-phase type and shall include an overload relay and isolation contactors.
 - c) Provide subsystems that will protect RVSS from damage due to over-current and over-voltage.

- d) Current Rating: 115 percent of motor nameplate rated current, continuous, minimum.
- 2) Required Features:
 - a) Adjustable current limit of not more than 250 percent of motor nameplate full-load current throughout entire motor acceleration period including first three cycles of voltage waveform from instant start signal is engaged.
 - b) Adjustable voltage acceleration, from two to 30 seconds.
 - c) Adjustable voltage deceleration, from two to 30 seconds.
 - d) Phase loss detection.
 - e) LED diagnostic indicators.
 - f) Static over-current and over-voltage trip.
 - g) Phase reversal, line or fuse loss, and under-voltage protection.
 - h) Power unit over temperature protection.
 - i) Motor inverse time overload protection.
 - j) Input line transient over-voltage protection.
- 3) Enclosure:
 - a) Cooling fans, if required, shall incorporate anti-friction bearings and internal impedance type motor protection.
 - b) If cooling fans are used, enclosure for that section shall be NEMA 12 FVF, or NEMA 12 EFVFF force ventilated with filters, in accordance with NEMA ICS 1-110, installed by motor control center manufacturer.
- 4) On start-up, start driven equipment at zero current and allow driven equipment to accelerate to maximum speed without exceeding the set current limit.
- 5) On normal shutdowns, ramp driven equipment down at set deceleration rate that is non-regenerative for motor prior to shutdown.
- 6) On emergency shutdowns, remove power to motor.
- 7) Diagnostic LEDs: Provide LEDs on unit front that indicate the following:
 - a) Control power on.
 - b) Motor power on.
 - c) Motor starting.
 - d) Motor fault.
 - e) RVSS fault.
- 8) Control Outputs:
 - a) Control output shall be electrically isolated, dry, normally open SPDT contacts, rated 10 amps at 120 vac.
 - b) Provide the following control outputs:
 - d. Motor running.
 - e. Motor fault.
 - f. RVSS fault.

8. Overload Relays: Provide an overload relay for each motor starter. Overload relays shall be in accordance with the following:
 - a. Microprocessor Based Overload Relays: Relays shall be microprocessor based overload relays. Relays shall be multi-function with following functions:
 - 1) Phase Current Monitoring
 - 2) Voltage Monitoring
 - 3) Motor Power Factor Indication
 - 4) Trip Class
 - 5) Ground Fault Detection
 - 6) Programmable set points
 - 7) Phase-unbalance and phase-loss
 - b. Each overload relay shall be manual reset type and shall include provisions for resetting by an door mounted display unit.
 - c. Each overload relay shall include a minimum of three output relays, with Normally Open and Normally Closed Contacts.
 - d. Size each overload relay for full-load amperes and service factor of actual motors installed.
 - e. Relay shall have on board ethernet communication port for remote monitoring.
9. Individual control power transformers for all starters, capacity as required for all control circuit devices, 150 VA minimum, Class A insulation, two primary fuses, 120-volt secondary, one secondary fuse, and the other secondary leg grounded.
10. Separate Control: Where control power to starter is from a separate power source, provide control power fuse in unit and equip main disconnect with normally-open contact to isolate control circuit from source when controller disconnect is open.
11. Motor horsepower shown are preliminary. Circuit breaker trips and starter overload heaters to be coordinated with the actual equipment installed.
12. Auxiliary contacts, relays, timers as required for specified control functions and those shown on Drawings.
13. Starter devices, including spare contacts, shall be wired to numbered terminal blocks.
14. Terminal blocks for field connections to unit compartments shall be plug-in/pull-apart type. Terminals shall be fully accessible from the front. Terminals shall be mounted near the front of vertical wireway.
15. Control devices shall be 600-volt heavy duty, NEMA A600. Relays shall have convertible contacts.
16. Pilot devices shall be 30mm and oiltight.
17. Feeder Circuit Breakers: Thermal magnetic type.
 - a. Circuit breakers of 100 amp frame or less shall be mounted in a dual mount compartment (two breakers in one space factor) or shall mount in one-half space factor, unless otherwise shown or indicated on the Drawings.
 - b. Circuit breakers of 150 amp frame or above shall be provided with electronic trip unit with adjustable LSIG protection.
18. Motor Starter Circuit Breakers: Magnetic trip only motor circuit protectors.

19. Provide the following diagrams and tables inside of door for each compartment:
 - a. Elementary wiring diagram.
 - b. Table of overload heater sizes with correct heater highlighted.
 - c. Table of motor circuit protector settings with correct setting highlighted.
20. Where shown or indicated on the Drawings, provide automatic transfer switches integrally mounted within motor control center. Automatic transfer switches shall be in accordance with Section 26 36 23, Automatic Transfer Switches.
21. Main and Tie Circuit Breakers: Thermal magnetic, molded case type, unless shown or indicated otherwise. Where shown or indicated, equip main and tie breakers with key interlocking. Interlocking shall allow only two of the three breakers to be closed at a time. Provide locks and keys as required. Main circuit breakers shall be 100 percent amperage rated. Breakers shall have electronic trip unit with adjustable LSIG protection.

2.3 MAIN METERING DEVICE

- A. Provide a main meter device as shown or indicated on the Drawings.
 1. Microprocessor based monitoring device shall include complete electrical metering in one package. Device shall include self-contained potential transformers and self-protected internal fuses.
 2. Device shall be mounted on compartment door to allow operations and maintenance personnel access to meter menu and display.
 3. Device shall include trend analysis, event logging, and recording. Device shall also include the following direct-reading metered values:

a. Volts:	0.2 percent accuracy.
b. Amperes:	0.2 percent accuracy
c. Watts, Vars and VA:	0.5 percent accuracy
d. Power Factor:	1.0 percent accuracy
e. Frequency:	0.05 percent accuracy
f. Watt, and VA Hours:	0.5 percent accuracy
g. Var Hours:	1.0 percent accuracy
h. Watt, Var and VA Demand:	0.4 percent accuracy
i. THD-Voltage:	50th harmonic
j. THD-Current:	50th harmonic
k. Individual Ampere Harmonics:	50th harmonic
l. Individual Voltage Harmonics:	50th harmonic
 4. Metering device shall have the following additional features:
 - a. Trend analysis that displays minimum and maximum values for each metered parameter with date and time of each occurrence.
 - b. Input range of device shall accommodate external current transformers with ranges from 100/5 to 5000/5 and potential transformers from a ratio of 120:120 to 500,000:120. Three current transformers suitably rated shall be included.
 - c. Alarm contacts rated five amps at 120 VAC.
 - d. Three analog outputs programmable to reflect the metered parameters, except kilowatt hours and kilovar hours.

- e. Meter shall have on board ethernet communication port for remote monitoring.
- 5. Control power shall be drawn from monitored incoming AC line. Device shall have non-volatile memory and not require battery backup. During power failure, device shall retain preset parameters.

2.4 SURGE PROTECTIVE DEVICES

- A. Provide a surge protective device in accordance with Section 26 43 00, Surge Protective Devices, for each motor control center bus shown on the Drawings. Surge protective devices shall be included and factory-mounted within the motor control center by motor control center manufacturer. Surge protective device monitoring and display shall be visible from the motor control center front.

2.5 ETHERNET NETWORK

- A. Provide an Ethernet network to interconnect all the Motor Relays and Metering Devices. Provide gateways as required to convert other protocols to Ethernet/IP.
- B. Provide Din Rail mounted managed Ethernet switch with ports as required.
- C. Provide CPTs and power supplies as required to power the Ethernet switch.

2.6 SOURCE QUALITY CONTROL

- A. Certified Shop Tests:
 - 1. Shop testing shall be performed on MCCs at the manufacturer's plant prior to shipment.
 - 2. Shop tests shall be in accordance with the latest revisions of NEMA and shall demonstrate that the equipment tested conforms to the requirements specified.
 - 3. The Contractor shall provide a shop test report. The report shall identify the tests performed and the results obtained.
 - 4. MCC shop tests shall include the following:
 - a. Physical inspection shall be performed to ensure that unit is properly assembled and conforms to the approved drawings.
 - b. Physical inspection shall also include the verification of torques of bus bolts.
 - c. Mechanical operation tests shall be performed to ensure proper functioning of all operating mechanisms and that all mechanisms are properly lubricated.
 - d. Key interlock systems shall be tested to ensure operation as specified.
 - e. Simulated operation tests shall be performed to ensure the proper functioning of all controls, control circuits, control devices and indicators inclusive of securing and returning all field connected inputs and output for each unit of the MCC.
 - f. Continuity tests shall be performed on power and control wiring.

- g. High potential tests shall be performed on the power and control circuits.
 - 1) Power circuits shall be tested phase to phase and phase to ground at 2200 volt for one minute or 2700 volt for one second.
 - 2) Control circuits shall be tested at 1500 volt for one minute or 1800 volt for one second.
- h. Verify the functioning of all meters, HMIs, communications devices and channels.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which Work is to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install materials and equipment at locations shown or indicated on the Drawings. Install equipment on concrete bases in accordance with the Contract Documents and manufacturer's recommendations and instructions.
- B. For installations against masonry walls, provide an insulation board, 1/4-inch minimum thickness, between motor control center and wall for corrosion protection. Trim board neatly within outline of motor control center.
- C. Openings in top or side of motor control centers for other than conduit entrance are not allowed.
- D. Bundle cable circuits together within enclosures and identify with durable tag secured to cabling twine.
- E. Set motor circuit protectors at lowest setting that allows motor starting without nuisance tripping.
- F. Verify that wiring diagrams on inside of door of each compartment reflect the circuitry actually provided and that correct overload heater size and motor circuit protector setting are noted.
- G. Install in conformance with manufacturer's recommendations, Laws and Regulations, and the Contract Documents.
- H. Connections to existing facilities shall be in accordance with Section 01 14 16, Coordination with Owner's Operations.

3.3 FIELD QUALITY CONTROL

A. Site Tests:

1. Perform field testing and inspection of motor control centers. Inspect and test each motor control center after installation. Testing and inspection shall be in accordance with the manufacturer's recommendations and the Contract Documents, and be performed by manufacturer's factory-trained representative, Inform OWNER and ENGINEER when equipment is correctly installed, prior to testing. Do not energize equipment without permission of OWNER.
2. Test Equipment, Calibration and Reporting: All test equipment, instrument calibration and test reports shall be in accordance with ANSI/NETA ATS.
3. Perform the following minimum tests and checks before energizing equipment:
 - a. Verify all overload and device settings.
 - b. Inspect mechanical and electrical interlocks and controls for proper operation.
 - c. Check tightness of bolted connections.
 - d. Measure insulation resistance of each bus section, phase-to-phase and phase-to-ground.
 - e. Measure insulation resistance of each starter, phase-to-phase and phase-to-ground.
 - f. Measure insulation resistance of each control circuit with respect to ground.
 - g. Perform other tests recommended by equipment manufacturer.
4. Perform acceptance testing of motor control centers. Inspect and test each motor control center. Testing and inspection shall be performed by the independent testing firm, after completion of field testing specified in Paragraph 3.3.A.3 of this Section.
 - a. Visual and Mechanical Inspection: Perform inspection of each motor control center in accordance with ANSI/NETA ATS. Inspection shall include:
 - 1) Inspect for proper anchorage, damage, and grounding.
 - 2) Verify all overload and device settings.
 - 3) Check tightness of bolted connections.
5. Electrical Tests: Perform electrical testing of each motor control center in accordance with ANSI/NETA ATS. Testing shall include:
 - 1) Measure insulation resistance of each bus section, phase-to-phase and phase-to-ground.
 - 2) Measure insulation resistance of each starter phase-to-phase and phase-to-ground.
 - 3) Measure insulation resistance of each control circuit with respect to ground.
 - 4) Test motor overload units by current injection.
 - 5) Perform operational tests by initiating control devices for proper operation.
 - 6) Perform contact resistance test and insulation resistance test for each circuit breaker.
 - 7) Determine long-time, short-time, and instantaneous pick-up and delay as required.

- B. Manufacturer's Services: Provide a qualified, factory trained serviceman to perform the following:
1. Supervise unloading and installation of equipment.
 2. Instruct CONTRACTOR in installing equipment.
 3. Inspect, test, and adjust equipment after installation and ensure proper operation.
 4. Instruct operations and maintenance personnel in operation and maintenance of the equipment.
 5. Manufacturer's technician shall make visits to the Site as follows for each Motor control center :
 - a. First visit shall be for supervising unloading and handling of equipment and for instructing CONTRACTOR in proper equipment installation, and assisting in installing equipment. Technician shall train installing personnel in advance in proper handling and rigging of equipment. Minimum number of hours on-Site: 8 hours.
 - b. Second visit shall be for checking completed installation, start-up of system; and performing field quality control testing. Technician shall test the system as specified in Article 3.3.A of this Section. Technician shall operate and test the system in the presence of ENGINEER and verify that equipment complies with the Contract Documents and manufacturer's requirements. Technician shall adjust the system to initial settings as specified in Article 3.4 of this Section. Minimum number of hours on-Site: 8 hours.
 - c. Third visit shall be to instruct operations and maintenance personnel.
 - 1) Furnish services of manufacturer's qualified, factory-trained specialists to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of equipment.
 - 2) Training requirements, duration of instruction, and qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
 - 3) Number of hours on-Site shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
 - d. Technician shall revisit the Site as often as necessary until installation is acceptable.
 - e. Furnish services of manufacturer's factory-trained service technicians to correct defective Work within 72 hours of notification by OWNER during the correction period.
 6. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

3.4 ADJUSTING

- A. Calibrate, set, and program all protective devices. Coordinate protective devices furnished under this Section and provide proper settings of devices in accordance with the study performed under Section 26 05 73, Electrical Power Distribution System Studies.

+ + END OF SECTION + +

SECTION 26 27 26.13

LOW-VOLTAGE RECEPTACLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install low-voltage receptacles.
- B. Related Sections:
 - 1. Section 26 05 05, General Provisions for Electrical Systems.
 - 2. Section 26 05 53, Identification for Electrical Systems.
 - 3. Section 26 05 33.36, Outlet Boxes.

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. UL 498, Standard for Attachment Plugs and Receptacles.
 - 2. UL 514D, Cover Plates for Flush-Mounted Wiring Devices.
 - 3. UL 943, Standard for Ground-Fault Circuit-Interrupters.
 - 4. UL 1010, Standard for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations.
 - 5. UL 1449, Standard for Surge Protective Devices.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
 - 1. Americans with Disabilities Act.
 - 2. NEC Article 406, Receptacles, Cord Connectors, and Attachment Plugs (Caps).

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Product Data: Manufacturer's technical information for receptacles and cover plates proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Receptacles:
 - 1. Grounding receptacle, two-pole, three-wire, NEMA 5-20R configuration, ivory color.

- a. Single:
 - 1) Products and Manufacturers: Provide one of the following:
 - a) HBL5361I by Hubbell, Inc.
 - b) 5361-I by Pass & Seymour.
 - c) Or equal.
 - b. Duplex:
 - 1) Products and Manufacturers: Provide one of the following:
 - a) HBL5362I by Hubbell, Inc.
 - b) PS5362-I by Pass & Seymour.
 - c) Or equal.
 - c. Weather-resistant Duplex:
 - 1) UL-listed as weather-resistant.
 - 2) Products and Manufacturers: Provide one of the following:
 - a) HBL5362IWR by Hubbell, Inc.
 - b) WR5362-I by Pass & Seymour.
 - c) Or equal.
2. Corrosion-resistant grounding receptacle, two-pole, three-wire, yellow color.
 - a. Single, 125-volt, 20 ampere, NEMA 5-20R configuration:
 - 1) Products and Manufacturers: Provide one of the following:
 - a) HBL53CM61 by Hubbell, Inc.
 - b) Or equal.
 - b. Duplex, 125-volt, 20 ampere, NEMA 5-20R configuration:
 - 1) Products and Manufacturers: Provide one of the following:
 - a) HBL53CM62 by Hubbell, Inc.
 - b) Or equal.
 - c. Single, 125-volt, 30 ampere, NEMA 5-30 configuration:
 - 1) Products and Manufacturers: Provide one of the following:
 - a) HBL9308 by Hubbell, Inc.
 - b) Or equal.
 3. Grounding receptacle, two-pole, three-wire, 250-volt, 20 ampere, NEMA 6-20 configuration, brown color.
 - a. Single:
 - 1) Products and Manufacturers: Provide one of the following:
 - a) HBL5461 by Hubbell, Inc.
 - b) 5871 by Pass & Seymour.
 - c) Or equal.
 - b. Duplex:
 - 1) Products and Manufacturers: Provide one of the following:
 - a) HBL5462 by Hubbell, Inc.
 - b) 5862 by Pass & Seymour.
 - c) Or equal.
 4. Provide Type 302 stainless steel cover-plate conforming to UL 514D. Provide weatherproof-while-in-use cover where shown on the Drawings as “WP” or “WPU”, and provide where receptacles are located in wet or corrosive location.
 5. Receptacles shall comply with UL 498.

- B. Receptacles for Hazardous Locations:
1. Material: Factory-sealed receptacle suitable for installation in Class I, Group D hazardous locations. Copper-free aluminum receptacle and cover with cast gray iron alloy or cast malleable iron mounting box with zinc electroplate finish. Receptacle rated at 20 amperes, 125 to 250 volts AC, two-wire, and three-pole. Provide matching plug for each receptacle.
 2. Receptacles for hazardous locations shall conform to UL 1010.
 3. Products and Manufacturers: Provide one of the following:
 - a. Series CPS by Crouse-Hinds Company.
 - b. Type CPS by Appleton Electric Company.
 - c. Or equal.
- C. Ground Fault Interrupting Receptacles:
1. Duplex grounding receptacle, two-pole, three-wire, NEMA 5-20R configuration, 125-volt AC, 20 amperes, gray color with ground fault circuit interrupting (GFCI) protection.
 2. Ground fault interrupting receptacles shall comply with UL 943.
 3. Provide Type 302 stainless steel cover-plate conforming to UL 514D. Provide weatherproof-while-in-use cover where shown on the Drawings as “WP” or “WPU” and provide where located in wet or corrosive location.
 4. Products and Manufacturers: Provide one of the following:
 - a. GFR5362SGY by Hubbell, Inc.
 - b. 2091-GRY by Pass & Seymour.
 - c. Or equal.
 5. Weather-resistant Ground Fault Interrupting Receptacles
 - a. Products and Manufacturers: Provide one of the following:
 - 1) 2095TRWRGRY by Pass & Seymour.
 - 2) Or equal.
- D. Surge Suppression Receptacles:
1. Duplex grounding, surge suppression receptacle, two-pole, three-wire, NEMA 5-20R configuration 125-volt AC, 20 amperes, blue color, capable of absorbing transient surge of 6,000 volts minimum. Receptacle shall include power-on indicator light.
 2. Surge suppression receptacles shall comply with UL 1449.
 3. Provide Type 302 stainless steel cover-plate conforming to UL 514D. Provide weatherproof-while-in-use cover when shown on the Drawings as “WP” or “WPU”, and provide where located in a wet or corrosive location.
 4. Products and Manufacturers: Provide one of the following:
 - a. HBL5362SA by Hubbell, Inc.
 - b. 5362BLSP by Pass & Seymour.
 - c. 5380-GY by Leviton Manufacturing Company.
 - d. Or equal.
- E. Weatherproof Covers:
1. Where receptacles are installed in damp locations as defined in area classification portion of Section 26 05 05, General Provisions for Electrical

- Systems, provide receptacles as specified in Paragraphs 2.1.A through 2.1.D of this Section, as applicable, with weatherproof covers as specified below.
2. Provide covers that are UL-listed weatherproof and suitable for use in damp locations in accordance with NEC 406.
 3. Material:
 - a. Gasketed spring door type for wet and corrosive locations. Plates in corrosive locations shall have factory-applied 40-mil PVC coating.
 - b. Stainless steel screws and hardware.
 4. Products and Manufacturers: Provide one of the following:
 - a. Hubbell, Inc.
 - b. Crouse-Hinds Company.
 - c. Appleton Electric Company.
 - d. Or equal.
- F. Weatherproof-While-in-Use Covers:
1. Where receptacles are shown on the Drawings as “WP” or “WPU”, and where receptacles are installed in wet locations as defined in area classification portion of Section 26 05 05, General Provisions for Electrical Systems, provide receptacles as specified in Paragraphs 2.1.A through 2.1.D of this Section, as applicable, with weatherproof-while-in-use covers as specified below.
 2. Provide covers that are UL-listed, weatherproof while receptacle is in use, and are of ultraviolet-resistant construction suitable for outdoor use in accordance with NEC 406.
 3. Material:
 - a. Non-metallic box with hinged, non-metallic cover.
 - b. Sealing gaskets between box and cover.
 - c. Stainless steel screws and hardware.
 - d. Color: Gray finish
 4. Products and Manufacturers: Provide one of the following:
 - a. TayMac Corporation.
 - b. Pass and Seymour Type WIU
 - c. Or equal.
- G. Power Receptacles: 480-volt interlocked receptacle with enclosed safety switch service outlet. Provide service outlets, quantity as shown or indicated, for portable equipment.
1. Material: Copper-free aluminum enclosures with operating handle NEMA 4, with gasketed, hinged door.
 2. Switch: Heavy duty, three-pole, with visible blades, quick make-a-break mechanism with reinforced, positive-pressure-type blade and fuse clips. Switch shall be mechanically interlocked with receptacle. Switch cannot be closed until plug is fully inserted and plug cannot be withdrawn or inserted unless switch is open.
 3. Receptacle: Single ground receptacle, three-wire, four-pole, 600-volt, 60 amp. Provide two matching plugs.
 - a. Products and Manufacturers: Provide one of the following:
 - 1) Type WSR, and Type APS plugs by Crouse-Hinds Company.

2) Or equal.

- H. Power and Special Receptacles: Provide receptacles with number of poles and voltage and current rating as shown or indicated. Coordinate with equipment plugs. Provide matching plug for each receptacle.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Non-hazardous Locations: Install receptacles at locations shown, in outlet or device boxes in accordance with Section 26 05 33.36, Outlet Boxes.
- B. Hazardous Locations: Install receptacles in rigid metallic conduit systems.
- C. Install receptacles with ground pole in the down position.
- D. Mount receptacles 18 inches above finished floor in non-hazardous locations and 4.5 feet above finished floor in hazardous locations, in accordance with the Americans with Disability Act, unless otherwise shown or indicated in the Contract Documents.
- E. Mount receptacles 18 inches above finished floor in non-hazardous locations and 4.5 feet above finished floor in hazardous locations, unless otherwise shown or indicated in the Contract Documents.
- F. Install in conformance with Laws and Regulations.
- G. Identification:
1. Identify each conductor with circuit number and lighting panel number in accordance with Section 26 05 53, Identification for Electrical Systems.
 2. Identify each receptacle with permanent phenolic tag. Tags shall include circuit number and lighting panel number.

++ END OF SECTION ++

SECTION 26 27 26.23

SNAP SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install snap switches for lighting and other systems.
- B. Related Sections:
 - 1. Section 26 05 53, Identification for Electrical Systems
 - 2. Section 26 05 33.36, Outlet Boxes.

1.2 REFERENCES

- A. Standards referenced in this Section are listed below:
 - 1. UL 20, General Use Snap Switches.
 - 2. UL 894, Switches for Use in Hazardous (Classified) Locations.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements
 - 1. Americans with Disabilities Act

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Product Data: Manufacturer's technical information for switches proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Switches for Non-Hazardous Locations:
 - 1. Single pole AC toggle switch, quiet type, 120/277-volt AC, 20 amperes, Ivory, specification grade.
 - a. Products and Manufacturers: Provide one of the following:
 - 1) Catalog No. 1221-I, by Harvey Hubbel, Inc.
 - 2) Catalog No. 1991-I, by Arrow-Hart, Inc.
 - 3) Catalog No. 20AC1-I, by Pass & Seymour
 - 4) Or equal.

2. Single pole, three-way AC toggle switch, quiet type, 120/277-volt AC, 20 amperes, Ivory, specification grade.
 - a. Products and Manufacturers: Provide one of the following:
 - 1) Catalog No. 1223-I, by Harvey Hubbell, Inc.
 - 2) Catalog No. 1993-I, by Arrow-Hart, Inc.
 - 3) Catalog No. 20AC3-I, by Pass & Seymour
 - 4) Or equal.
3. Two-pole AC toggle switch, quiet type, 120/277-volt AC, 20 amperes, Ivory, specification grade.
 - a. Products and Manufacturers: Provide one of the following:
 - 1) Catalog No. 1222-I, by Harvey Hubbell, Inc.
 - 2) Catalog No. 1992-I, by Arrow-Hart, Inc.
 - 3) Catalog No. 20AC2-I, by Pass & Seymour
 - 4) Or equal.
4. Switches in non-hazardous areas shall be UL-listed in accordance with UL 20.

B. Switches for Hazardous Locations:

1. Material: Factory sealed tumbler switch suitable for installation in Class I, Group D hazardous locations. Cast gray iron alloy or cast malleable iron body and cover with zinc electroplate finish. Switch rated at 20 amperes, 120/277-volt AC.
2. Switches in hazardous areas shall be UL-listed in accordance with UL 894.
3. Products and Manufacturers: Provide one of the following:
 - a. Series EDS by Crouse-Hinds Company.
 - b. Type EDS by Appleton Electric Company.
 - c. Or equal.

C. Switch Covers:

1. Indoor covers shall be Type 304 stainless steel.
2. Outdoor, wet, or corrosive location covers shall be weatherproof and corrosion resistant.

D. Key Operated On-Off Switches:

1. Key operated switches shall be complete with legend plate and NEMA 4 enclosure and two keys for each switch.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switches at locations as shown or indicated in the Contract Documents in outlet or device boxes, in accordance with Section 26 05 33.36, Outlet Boxes.
- B. Mount wall switches 4.0 feet above finished floor unless otherwise noted.
- C. Identify each conductor with circuit number and lighting panel number. Identification shall be in accordance with Section 26 05 53, Identification for Electrical Systems.

++ END OF SECTION ++

SECTION 26 28 16.33

DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install disconnect switches.
- B. Related Sections:
 - 1. Section 26 05 05, General Provisions for Electrical Systems.
 - 2. Section 26 05 53, Identification for Electrical Systems.
 - 3. Section 26 27 26.23, Snap Switches.

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. UL 98, Enclosed and Dead-Front Switches.
 - 2. NEMA KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
 - 3. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. NEC Article 404, Switches.
 - 2. Disconnect switches shall bear the UL label.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Listing of each switch to be furnished, including location, rating, and NEMA enclosure type for each.
 - 2. Product Data:
 - a. Manufacturer's technical information for disconnect switches proposed for use.
- B. Maintenance Material Submittals: Submit the following:
 - 1. Extra Stock Materials:
 - a. Furnish one set of spare fuses for each fused disconnect switch to be installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Provide products of one of the following:
1. Square-D Company.
 2. Cutler-Hammer.
 3. General Electric Company.
 4. Siemens.
 5. Or equal.

2.2 MATERIALS

- A. Service Disconnect Switches:
1. Type: Fused, heavy-duty, single throw, quick-make, quick-break mechanism, visible blades in "OFF" position and safety handle.
 2. Rating: Voltage, current and short circuit ratings and number of poles as shown or indicated on the Drawings. Switch shall bear UL label indicating suitability for use as service equipment and shall comply with UL 98, NEMA KS 1, and NEMA 250.
 3. Provide auxiliary dry contacts to indicate switch position where shown on the Drawings.
- B. Single Throw, Circuit Disconnect Switches:
1. Type: Fused or unfused, horsepower rated, heavy-duty, single throw, quick-make, quick-break mechanism, visible blades in the "OFF" position and safety handle.
 2. Rating: Voltage and current ratings and number of poles as required for motor or equipment circuits being disconnected. Switches shall bear a UL label and shall comply with the requirements of UL 98, NEMA KS 1 and NEMA 250.
 3. Provide auxiliary dry contacts to indicate switch position.
- C. Double Throw Safety Switches:
1. Type: Unfused, double throw with center "OFF" position, quick-make, quick-break mechanism, visible blades in the "OFF" position, and safety handle.
 2. Rating: Voltage and current ratings and number of poles as required for circuits being disconnected. Switches shall bear UL label and shall comply with UL 98, NEMA KS 1, and NEMA 250.
 3. Provide auxiliary dry contacts to indicate switch position where shown on the Drawings.
- D. Disconnect Switches for 120-volt, Single-phase Circuits:
1. Refer to Section 26 27 26.23, Snap Switches.
- E. Enclosures: NEMA rating shall be as required for area classifications specified in Section 26 05 05, General Provisions for Electrical Systems.

F. Identification:

1. Identify enclosures in accordance with Section 26 05 53, Identification for Electrical Systems.
2. Provide nameplate to identify the equipment served by disconnect switch and associated source of power.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install equipment so that sufficient access and working space is provided for ready and safe operation and maintenance.
- B. Securely fasten equipment to walls or other structural supports on which they are mounted. Provide independent stainless steel supports where no wall or other structural surface exists. Mount disconnect enclosures at a height not exceeding six feet.
- C. Provide suitable 1/4-inch spacers to prevent mounting enclosure directly against walls.

++ END OF SECTION ++

SECTION 26 28 17

ENCLOSED CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment and incidentals required to furnish and install molded-case thermal magnetic circuit breakers each in NEMA-rated enclosure with size and trip rating as shown or specified.

B. Coordination:

1. Review installation procedures under other Sections and coordinate installation of items to be installed with or before enclosed circuit breakers Work.

C. Related Sections:

1. Section 26 05 05, General Provisions for Electrical Systems.
2. Section 26 05 29, Hangers and Supports for Electrical Systems.
3. Section 26 05 53, Identification for Electrical Systems.
4. Section 26 05 73, Electrical Power Distribution System Studies.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. NFPA 70, National Electrical Code.
2. NEMA AB 1, Molded-case Circuit Breakers
3. UL 50, Enclosures for Electrical Equipment
4. UL 50E, Enclosures for Electrical Equipment, Environmental Considerations
5. UL 489, Molded-case Circuit Breakers

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer:

- a. Manufacturer shall have not less than five years of experience producing substantially similar equipment to that required and, upon request, shall submit documentation of not less than five installations in satisfactory operation for not less than five years in the United States.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:

- a. Outline drawings with dimensions, materials of construction, installation details, accessories, and equipment ratings for voltage, amperage and short-circuit.

2. Product Data:
 - a. Manufacturer's technical information for enclosed circuit breakers proposed for use.
- B. Informational Submittals: Submit the following:
1. Certifications:
 - a. Manufacturer's certification of completed installation.
 2. Source Quality Control Submittals:
 - a. Results of required source quality control tests and inspections.
 3. Site Quality Control Submittals:
 - a. Results of required field quality control tests and inspections.
 4. Qualifications Statements:
 - a. Submit manufacturer qualifications when requested by ENGINEER.
- C. Closeout Submittals: Submit the following:
1. Operation and Maintenance Data:
 - a. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, and description of operation.
 - b. Recommended Spare Parts and Extra Stock Materials: Include list of additional spare parts or extra stock materials recommended for use with enclosed molded-case circuit breakers. Describe each recommended part, quantity recommended, current unit price, and ordering information.
 - c. Comply with Section 01 78 23, Operations and Maintenance Data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Provide equipment by one of the following:
1. Eaton Cutler Hammer
 2. General Electric
 3. Square-D
 4. Or equal

2.2 MATERIAL AND FABRICATION

- A. Type:
1. Breakers shall be molded-case with inverse time and instantaneous tripping characteristics.
 2. Circuit breakers shall be operated by toggle-type handle and shall have a quick-make, quick-break, over-center switching mechanism that is mechanically trip-free. Automatic tripping of circuit breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy with arc-extinction chutes. Push-to-trip button shall provide local manual means to exercise the trip mechanism.
 3. For frame sizes 150-ampere and above, provide with electronic trip units with LSIG functions.

4. For frame sizes 150-ampere below, provide with non-interchangeable trip.
5. Terminations: Provide terminals for accommodating two normal-range copper cables per phase.
6. Provide auxiliary contact (Form C-10 amp at 240 volts) for remote indication of breaker status.
7. Enclosed circuit breakers shall be UL-listed and bear the UL label, and shall comply with UL 489 and NEMA AB 1.
8. When used as main service breaker, breakers shall be UL listed as service entrance Rated.

B. Interrupting Capacities:

1. 400-ampere Frame and Above: Minimum 65,000 amperes RMS symmetrical at 480-volt, three-phase, 60 Hertz, or as shown.
2. 100-ampere, 150-ampere, and 225-ampere Frame: Minimum 22,000 amperes RMS symmetrical at 480-volt, three-phase, 60 Hertz, or as shown.

C. Enclosure:

1. NEMA type as required in Section 26 05 05 General Provisions for Electrical Systems.
2. Access Door Interlock: Provide disconnect device to prevent unintentional opening of door while circuit breaker is energized and unintentional application of load power while door is open, with provisions for releasing interlock for intentional access or application of power by authorized personnel.
3. External operating handle shall be integral part of the associated box, not the door. Operating handle shall have provisions for padlocking in the "OFF" position with door open or closed, and shall include prominent trip indication.
4. Identification: Provide nameplate identification of circuit breaker in accordance with Section 26 05 53, Identification for Electrical Systems. Identify load side equipment controlled and line side source.
5. Enclosures shall be UL-listed and comply with UL 50 and UL 50E.

2.3 SOURCE QUALITY CONTROL

A. Tests:

1. Perform standard factory tests on equipment furnished under this Section. Tests shall be in accordance with applicable NEMA and UL standards.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install in accordance with NFPA 70, and Laws and Regulations.

- B. Mounting and Installation:
 - 1. Install equipment to provide sufficient access and working space for ready and safe operation and maintenance. Equipment centerline shall not be less than four feet above finished floor.
 - 2. Securely fasten equipment to walls or other surfaces on which equipment is mounted. Provide independent supports complying with Section 26 05 29 Hangers and Supports for Electrical Systems, where there is no wall or other surface capable of supporting the equipment.
 - 3. Provide suitable 1/4-inch spacers to prevent mounting enclosure directly against walls.

- C. Adjustments: Perform field adjustments of circuit breakers as required to place equipment in operating condition. Adjustable breaker settings shall be in accordance with the accepted power distribution coordination study prepared under Section 26 05 73, Electrical Power Distribution System Studies, or as directed by ENGINEER.

3.3 FIELD QUALITY CONTROL

- A. Field Tests and Inspections:
 - 1. All test equipment and material shall be by CONTRACTOR.
 - 2. Perform visual and mechanical inspection including:
 - a. Inspect for physical, electrical, and mechanical condition.
 - b. Check for proper installation, required area clearances, physical damage and proper alignment.
 - c. Check electrical and mechanical interlock systems for proper operation.
 - d. Clean and lubricate as required.
 - e. Other testing and inspections recommended by manufacturer.

- B. Manufacturer's Services:
 - 1. Provide services of qualified, factory-trained manufacturer's representative to advise CONTRACTOR on installation of the equipment and to check the installed equipment prior to start-up.
 - 2. Qualified factory-trained manufacturer's representative shall certify in writing that equipment has been installed, adjusted, and tested in accordance with manufacturer's recommendations.
 - 3. Furnish services of qualified trained specialist, with minimum of five years experience, from manufacturer to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of the equipment. Training requirements, duration of instruction, and other requirements shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.

+ + END OF SECTION + +

SECTION 26 29 23

LOW-VOLTAGE VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
1. CONTRACTOR shall provide all labor, materials, equipment, services, and incidentals as shown, specified, and required to furnish and install low-voltage variable frequency drives, complete and operational.
 2. Variable frequency drives required under this Section are low-voltage, voltage source inverter, pulse width modulated. Variable frequency drives shall be customized.
 - a. Unless otherwise noted all VFDs shown on the Contract Drawings shall be provided by the Contract 4E: Electrical. Contract 4E: Electrical CONTRACTOR shall coordinate with other Contractors and ensure that VFDs provided are compatible with the equipment furnished under other Contracts.
- B. Costs for low-voltage variable frequency drives specified in this Section shall be included in the lump sum price bid for the associated driven equipment. Separate payment will not be made for variable frequency drives under the electrical Contract.
- C. Related Sections:
1. Section 26 05 29, Hangers and Supports for Electrical Systems.
 2. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

- A. Standards referenced in this Section are:
1. IEEE 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
 2. ISO 9000, Quality Management Systems, Fundamentals and Vocabulary.
 3. ISO 9001, Quality Management Systems, Requirements.
 4. ISO 9002, Quality Systems, Model for Quality Assurance in Production, Installation and Servicing.
 5. NEMA ICS 2, Controllers, Contactors and Overload Relays Rated 600 Volts.
 6. NEMA ICS 7, Industrial Control and Systems Adjustable Speed Drives.
 7. NEMA MG 1, Motor and Generators.
 8. UL 489, Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.
 9. UL 508, Industrial Control Equipment.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer:

- a. Low-voltage variable frequency drive manufacturer shall have not less than five years of experience designing and regularly manufacturing and servicing substantially similar equipment to that required, and upon ENGINEER's request shall submit documentation of not less than five installations in satisfactory operation for not less than five years each.
- b. Manufacturer shall be certified under ISO 9000, ISO 9001, or ISO 9002 for materials and equipment specified.
- c. For all required factory tests, low-voltage variable frequency drive manufacturer shall use a factory test facility that has calibrated its testing apparatus in the previous twelve months, and is staffed by qualified, experienced technicians.

B. Component Supply and Compatibility:

1. Drives specified under this Section employ a low switching frequency or pattern to minimize instantaneous rate of voltage change over time (dv/dt), and the adverse effects of potential bearing currents. Where alternate manufacturers are proposed, obtain manufacturer recommendations regarding bearing currents and provide equipment required at no additional cost to OWNER.
2. Each low-voltage variable frequency drive shall be fully compatible with associated driven equipment and motors. Variable frequency drives shall be matched to specific load requirements for each system. Operation of variable frequency drive shall not overstress motor insulation.
3. Similar components of drives associated with each system shall be products of a single manufacturer.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:

- a. Dimensional information and construction details of enclosures. Enclosure details shall consist of exterior and interior front door with nameplate legends, interior door front and rear views, and terminal block layout.
- b. Three-line power and control schematic diagrams.
- c. Wiring diagrams showing the interconnection of conductors to all devices with terminal assignments for remote devices.
- d. Functional description of system operation.
- e. VFD heat dissipation at full load, including heat rejection/cooling system.

2. Product Data:

- a. Manufacturer's technical specifications.
- b. Manufacturer's catalog cuts and product literature.

3. Testing Plans:
 - a. Not less than thirty days prior to source quality control testing, submit descriptions of proposed shop testing methods, procedures, apparatus, and limitations.
 - b. Not less than thirty days prior to field quality control testing, submit descriptions of proposed field testing methods, procedures, and apparatus.
- B. Informational Submittals: Submit the following:
1. Certificates:
 - a. Certification letters from low-voltage variable frequency drive manufacturer and motor manufacturer that the approved driven equipment has been reviewed and that variable frequency drive units and motors are compatible and shall be provided in accordance with the Contract Documents and requirements of the driven equipment.
 2. Source Quality Control Submittals:
 - a. Within five days of completing source quality control tests and inspections, submit test results with indication of whether all criteria of the Contract Documents for the specified equipment were met.
 3. Field Quality Control Submittals:
 - a. Within five days of completing field quality control tests and inspections, submit test results with indication of whether all criteria of the Contract Documents for the specified equipment were met.
 4. Manufacturer Reports:
 - a. Within five days of each visit to the Site by manufacturer's representative, submit written report of reason for visit, problems encountered, solutions implemented, and remaining work.
 5. Qualifications Statements:
 - a. Manufacturer, when requested by ENGINEER.
- C. Closeout Submittals: Submit the following:
1. Operation and Maintenance Data:
 - a. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation, list of recommended spare parts, and spare parts ordering information.
 - b. Manuals shall include record drawings of control schematics, including point-to-point wiring diagrams.
 - c. Include a listing of all programmable drive parameters and their settings at Substantial Completion. Submit parameters as both printed pages in the operations and maintenance manual and in electronic format on compact disc that can be directly uploaded to the drive in event of drive replacement or repair.
 - d. Comply with Section 01 78 23, Operations and Maintenance Data.

D. Maintenance Materials Submittals: Submit the following:

1. Spare Parts and Extra Stock Materials:

- a. Furnish, tag, and box for shipment and long-term storage spare parts and special tools for low-voltage variable frequency drives. Each set of spare parts and tools shall include manufacturer's recommended spare parts inventory for one year and include, at minimum, the following:

Item	Quantity per Four VFDs per HP Rating
1) Transistor and diode modules with accessories	One set
2) Power supply module	One
3) Fans	One set
4) Power fuses	One set of each size and type used
5) Control power fuses	Two sets of each size and type used
6) Pilot lights	Two per ten of each type used

- b. Furnish a list of recommended spare parts for an operating period of one year. Describe each part, the quantity recommended, and current unit price.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading:

1. Packing:

- a. Inspect prior to packing to ensure that assemblies and components are complete and undamaged.
- b. Protect mating connections.
- c. Cover all openings into enclosures with-vapor inhibiting, water-repellent material.
- d. Indoor containers shall be bolted to skids.

2. Upon delivery, check materials and equipment for evidence of water that may have entered equipment during transit.

3. Handling:

- a. Lift, roll or jack low-voltage variable frequency drive equipment into locations shown.
- b. Variable frequency drives shall be equipped for handling required for installation. Handle equipment in accordance with manufacturer's requirements.

B. Storage and Protection:

1. Store low-voltage variable frequency drive equipment in a clean, dry location with controls for uniform temperature and humidity. Protect equipment with coverings and maintain environmental controls.

PART 2 - PRODUCTS

2.1 EQUIPMENT PERFORMANCE

- A. System Performance:
 - 1. Driven equipment to be controlled by a low-voltage variable frequency drive shall be provided with a customized variable frequency drive. Each drive unit shall include an adjustable frequency controller with associated controls for continuous speed adjustment and protection of the driven equipment. Output speed control of motor shall be continuous throughout speed range of two to 60 Hertz under variable torque load or constant torque as specified for the driven equipment.
 - 2. Low-voltage variable frequency drives associated with each set of driven equipment shall be similar to each other.
 - 3. Variable frequency drives shall be UL-listed or ETL-listed and designed, built, and tested in accordance with UL 489, NEMA ICS 2, NEMA ICS 7, and UL 508.

2.2 MANUFACTURERS

- A. Provide low-voltage variable frequency drives by one of the following:
 - 1. Allen Bradley, Inc.
 - 2. ABB
 - 3. Eaton.
 - 4. Or equal.

2.3 ENCLOSURE

- A. Provide each low-voltage variable frequency drive with freestanding, front-access, NEMA 12, filtered and gasketed enclosure. Enclosure shall house all components required for the associated variable frequency drive.
- B. Enclosure shall provide adequate cooling for components within and include positive ventilation.
- C. Enclosure shall include circuit breaker disconnect switch. Circuit breakers shall be in accordance with UL 489. Switch handle shall be suitable for padlocking and be through-the-door type with handle height not exceeding six feet. Operation of switch shall remove the service supply from all internal components. Power devices shall be suitable for interrupting capacity of 65KAIC RMS symmetrical amperes. Include current limiting semi-conductor fuses where required for protection of solid state components.
- D. Enclosure door shall include an operator interface for access to controller's digital keypad and display.
- E. Equip enclosure front with nameplates for identification of equipment and operating functions. Nameplates shall be in accordance with Section 26 05 53, Identification for Electrical Systems.

- F. Equip enclosure with phenolic type terminal blocks suitably labeled for all internal and remote wiring requirements, plus twenty percent spare.

2.4 ADJUSTABLE FREQUENCY CONTROLLER

A. General:

1. Adjustable frequency controller shall be microprocessor-based, pulse width modulated design, suitable for operation on a 480-volt, three-phase supply. Controller shall produce an adjustable AC voltage/frequency output to vary speed of driven equipment. Controller shall consist of the following sections:
 - a. Six-pulse diode bridge converter input section for drive rated for 30HP or less. Eighteen-pulse diode bridge converter input section for drive rated for more than 30HP.
 - b. Fixed DC bus section.
 - c. Six-pulse power transistor inverter output section.
2. Controller switching frequency shall be adjustable and allow operation at 5,000 Hertz or less. Controller technology shall include a switching scheme that reduces the dv/dt of output supply.
3. Equip controller with a three-percent DC bus reactor or input line reactor.
4. Controller's solid state converter input section switching devices shall have 1600 volt PIV rating.
5. Overload rating of 110 percent variable torque, 150 percent constant torque for one minute.
6. RMS harmonic content of output current shall be less than five percent of fundamental current.
7. Able to withstand output terminal line-to-line short circuits without component failure.

B. Operating Criteria:

1. Operating criteria shall be in accordance with the following:
 - a. Ambient temperature range of zero to 40 degrees C.
 - b. Operational humidity of up to 90 percent non-condensing.
 - c. Altitude up to 3,300 feet above sea level.
 - d. Nominal voltage of 480-volts plus or minus ten percent, three-phase, three-wire. Include an under-voltage feature to allow trip-free operation down to 35 percent undervoltage.
 - e. Nominal frequency of 60 Hertz plus or minus three Hertz.
 - f. Input power factor of 95 percent displacement power factor at all operating speeds.
 - g. Efficiency of 96 percent at full speed and full load.

C. Features:

1. Controller shall have the following features:
 - a. Digital keypad and display module shall provide parameter setting, adjustments, and monitoring of control functions and faults. Display messages shall be in English.
 - b. Ethernet communication port shall allow connecting to programmable controller interface..

- c. Independent acceleration/deceleration rates shall provide two to 600 seconds minimum. When called to stop, motor shall decelerate to minimum speed before stopping.
- d. Power loss feature shall allow five cycle ride through capability for input supply interruptions.
- e. Time delay automatic restart shall allow restart after controller fault conditions with programmable attempts.
- f. Coasting motor restart shall allow controller to restart into a coasting motor without damage or tripping. Coasting motor restart feature shall allow switching from bypass mode to low-voltage variable frequency drive mode while operating, without shutdown.
- g. Isolated control inputs and outputs.

D. Protection:

- 1. Controller shall have protective functions as follows:
 - a. Input line metal oxide varistor transient protection.
 - b. Electronic over-current trip instantaneous and inverse time overload protection with thermal memory retention.
 - c. Over-temperature trip temperature protection.
 - d. Current limit trip protection.
 - e. Input line over- and under-voltage trip protection.
 - f. Ground fault trip protection.

2.5 OUTPUT FILTER

A. General:

- 1. Provide output filter to prevent overstressing motor insulation system. Provide output filter with each low-voltage variable frequency drive, when cable length between motor and variable frequency drive exceeds the following based on noted switching frequencies.
 - a. One KHZ switching frequency, 200 feet cable length.
 - b. Three KHZ switching frequency, 175 feet cable length.
- 2. Provide output filters in all other cases, based on recommendations of low-voltage variable frequency drive and motor manufacturers, when actual voltage peaks at motor terminals exceed NEMA MG 1 limits.

B. Features and Criteria:

- 1. Filter shall be three-phase, 600-volt class motor-protecting type consisting of suitable values of inductance, capacitance and resistance to form a damped, low pass filter.
- 2. Filter shall be low-loss type specifically designed to reduce voltage wave form dv/dt. Filter shall allow cable lengths at minimum exceeding actual application distances with waveform resulting in voltage spikes at motor terminal that are within NEMA MG 1 Part 31 voltage stress levels.
- 3. Filter shall be suitable for mounting within low-voltage variable frequency drive enclosure.

2.6 BYPASS CIRCUIT

A. General:

1. Provide each low-voltage variable frequency drive with contactor bypass capability. Mount bypass equipment within variable frequency drive enclosure.
2. Bypass configuration shall consist of output and bypass contactors, and line side isolation circuit breaker.
3. Bypass arrangement shall allow full speed operation of driven equipment while maintaining complete isolation of adjustable frequency controller.
4. Bypass circuit devices shall be in accordance with NEMA ICS 2.

B. Contactors:

1. Contactors shall be single speed full voltage, electrically operated, 600-volt, three-pole, industrial duty with ampere ratings as required for driven equipment.
2. Contactors shall have removable main contacts, 120-volt magnetic coil and interlocking contacts. Arrange interlocking contacts to prevent output and bypass contactors from being closed at the same time.
3. Bypass contactor shall include a low-voltage variable frequency drive/bypass selector switch and associated controls for manual selection of operating mode. Bypass contactor shall include transfer timer to provide an adjustable off delay when switching from variable frequency drive to bypass.

C. Overload Relays:

1. Provide three overload relays, one for each phase for bypass circuit of each low-voltage variable frequency drive.
2. Electronic Overloads: Relays shall be electronic type. Electronic relays shall be multi-function, adjustable, current sensing type, and include overload, phase-unbalance, phase-loss, and equipment type ground fault in one package.
3. Relays shall be manual reset type and include normally open auxiliary contact for alarm indication.

2.7 CONTROLS

A. General:

1. Equip each low-voltage variable frequency drive control system with relays, switches, fuses, indicating lights, and components required for a complete, functional system.
2. Variable frequency drive control shall be powered from a suitably sized and protected control power transformer.
3. Variable frequency drive control shall include status indicators, controller, and system fault condition displays and operating controls. Provide status indicators and operating controls associated with drive control on front door of enclosure.
4. Control arrangement shall be such that variable frequency drive internal electronic supply voltage is isolated from field wiring.

- B. Control and Pilot Devices:
 - 1. Relays shall be standard, latching type, and pneumatic or solid state time delay type. Provide relays with contacts rated ten amps, quantity as required.
 - 2. Pilot devices shall be heavy duty type, rated 10 amps continuous. Indicating lights shall be push-to-test transformer type with 12-volt secondaries.
- C. Auxiliary Features:
 - 1. Provide each low-voltage variable frequency drive with the following:
 - a. Status Indicators: Status indicators shall include separate pilot lights for indication of motor run (red), and bypass mode (blue).
 - b. Shutdown Indicators: Shutdown indicators shall include separate pilot lights (amber) for each shutdown condition. Arrange shutdown indication circuitry so that, when activated, indicator requires manual reset.
 - c. Contact Outputs: Contact outputs shall include separate dry contacts for remote indication of motor run, seal water alarm for equipment with seal water systems, each shutdown condition, and controller faults.
 - d. Speed Output: Speed output shall include four- to 20-mADC signal for remote indication of motor speed.
- D. Wiring and Device Identification:
 - 1. Provide control wiring and device identification for each low-voltage variable frequency drive:
 - a. Identify all control conductors with permanent type wire markers. Each wire shall be identified by a unique number and shall be attached to wire at each termination point.
 - b. Identify each control device with permanent type marker. Each device shall be identified by a unique number and shall be attached to each device.
 - c. Numbering system for each wire and control device shall be identified on wiring diagrams and shall reflect actual designations used in the Work.

2.8 SOURCE QUALITY CONTROL

- A. Tests:
 - 1. Perform factory tests on each low-voltage variable frequency drive prior to shipping. Tests shall consist of simulating expected load to be driven by operating load through speed ranges specified for driven equipment, for minimum of two hours per drive unit.
 - 2. Provide factory control and alarm tests on each drive unit by simulating each control signal and each alarm function to verify proper and correct drive unit action.
 - 3. Perform specified tests in addition to standard factory tests typically performed.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install equipment in accordance with manufacturer's recommendations and instructions and in conformance with Laws and Regulations, and the Contract Documents.
- B. Unless otherwise shown or indicated, install equipment on concrete bases Section 26 05 29, Hangers and Supports for Electrical Systems.
- C. Install equipment with sufficient access and working space provided for ready and safe operation and maintenance.
- D. For installations against masonry walls, provide an insulation board, 1/4-inch minimum thickness, between equipment and wall for corrosion protection. Trim board neatly within outline of equipment.
- E. Install all terminations, lugs, and required appurtenances necessary to properly terminate power supplies.
- F. Install control wiring terminations and appurtenances necessary to complete installing control and monitoring devices.
- G. Immediately prior to Substantial Completion, replace all enclosure filters and frames provided under this Contract with new filters and frames, except expanded metal filter types. Immediately prior to Substantial Completion, clean expanded metal filters.

3.3 FIELD QUALITY CONTROL

- A. Site Tests:
 - 1. After installation, inspect, adjust, and test each low-voltage variable frequency drive at the Site. Testing and inspection shall be in accordance with manufacturer's recommendations and be performed by manufacturer's factory-trained representative. Through CONTRACTOR, manufacturer's factory-trained representative shall inform OWNER and ENGINEER when equipment is correctly installed and ready to be energized. Do not energize equipment without permission of OWNER.
 - 2. Perform the following equipment inspection and testing and provide reports documenting procedures and results.
 - a. Verify all device settings and drive adjustments.
 - b. Inspect all mechanical and electrical interlocks and controls for proper

operation.

- c. Test each drive through specified speed ranges and loads for a minimum of two hours per drive unit.
- d. Test each drive by using actual control signal for remote and local operation.
- e. Test each drive alarm function.
- f. Perform other tests recommended by equipment manufacturer.

B. Manufacturer Services:

1. Unloading and Installation: Manufacturer's factory-trained representative shall be present during unloading of equipment and installation at equipment's final location. Representative shall train installing personnel in advance in the proper handling and rigging of equipment. Services by manufacturer's representative under this paragraph shall be at least three eight-hour days at the Site.
2. Post-installation Check: Manufacturer's factory-trained representative shall check and approve the installed equipment before initial operation. Manufacturer shall calibrate, set and program low-voltage variable frequency drives provided. Services by manufacturer's representative under this paragraph shall be at least three eight-hour days at the Site.
3. Manufacturer's factory-trained representative shall adjust the system to final settings as specified in Article 3.5 of this Section.
4. Manufacturer's factory-trained representative shall test the system as specified in Paragraph 3.3.A of this Section. Representative shall operate and test the system in presence of ENGINEER and verify that equipment is in conformance with the Contract Documents. Services by manufacturer's representative under this paragraph shall be at least three eight-hour days at the Site.
5. Representative shall revisit the Site as often as necessary until all deficiencies are corrected, prior to readiness for final payment.
6. Provide services of manufacturer's factory-trained representatives to correct defective Work within 72 hours of notification by OWNER during the correction period specified in the General Conditions as may be amended by the Supplementary Conditions.
7. Replacement parts or equipment provided during the correction period shall be equal to or better than original.
8. Training: Provide services of qualified factory trained specialists from manufacturer to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of equipment. Training requirements, duration of instruction, and other qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.

3.4 ADJUSTING

- A. Immediately prior to Substantial Completion, when testing is acceptably completed and low-voltage variable frequency drives are operating, manufacturer's representative shall return to the Site and make final adjustments as required to each variable frequency drive furnished under this Section.

++ END OF SECTION ++

SECTION 26 29 33

CONTROL STATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install control stations, including pushbuttons, selector switches, and other control stations elements.

B. Coordination:

1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before control stations Work.

C. Related Sections:

1. Section 26 05 05, General Provisions for Electrical Systems.
2. Section 26 05 29, Hangers and Supports for Electrical Systems.
3. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. NEMA ICS 2, Controllers, Contactors and Overload Relays Rated 600 Volts.
2. NEMA ICS 5, Industrial Control and Systems: Control-Circuits and Pilot Devices.
3. NEMA ICS 6, Industrial Control and Systems Enclosures.
4. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
5. UL 508, Industrial Control Equipment.

1.3 QUALITY ASSURANCE

A. Component Supply and Compatibility:

1. Obtain all control stations furnished under this Section from a single control station manufacturer.
2. Components shall be suitable for the specified application and shall be integrated into the overall assembly by control station manufacturer.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
 - a. Listing of control stations to be furnished with their location, rating, and NEMA enclosure type for each.

2. Product Data:
 - a. Manufacturer's technical information and specifications for control stations proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Control Stations:

1. Manufacturers: Provide products of one of the following:
 - a. Cutler-Hammer.
 - b. General Electric Company.
 - c. Allen Bradley Company.
 - d. Square-D Company.
 - e. Or equal.
2. Type: 30.5 mm industrial, heavy duty, oil-tight construction with clearly-marked legend plates.
3. Emergency Stop or Lockout Stop: Lockout stop pushbuttons shall be two-position, push-pull type with maintained contact and mushroom head. Provide control stations with padlocking attachment and legend plate reading "PUSH-TO-STOP, PULL-TO-START".
4. Pushbuttons: Momentary or maintained types, NEMA A600 contact rating.
5. Selector Switches: Rotary type with round or oval handles and positioning device to securely hold switch in selected position for maintained type and for spring return from left, right, or both left and right to maintained position.
6. Control stations shall comply with NEMA ICS 2, NEMA ICS 5, and UL 508, and shall bear the UL label.
7. Indicating Lights: 120 VAC push-to-test. Lens color shall be in accordance with Section 26 05 53, Identification for Electrical Systems.
8. Enclosures: As required for area classifications specified in Section 26 05 05, General Provisions for Electrical Systems, and complying with NEMA 250 and NEMA ICS 6.
9. Identification: Identify enclosures in accordance with Section 26 05 53, Identification for Electrical Systems. Devices shall include front-mounted nameplates identifying function and equipment controlled, if not readily apparent.

B. Custom Control Stations:

1. Control Station for submersible pumps shall be custom.
2. Control Stations shall be enclosed in NEMA type enclosures as required for area classifications specified in Section 26 05 05.
3. Contractor shall field install vendor-provided pump protector controller in the Control Stations.
 - a. Provide power supplies as required.
4. Pilon device shall be type: 30.5 mm industrial, heavy duty, oil-tight construction with clearly-marked legend plates.

- a. Emergency Stop or Lockout Stop: Lockout stop pushbuttons shall be two-position, push-pull type with maintained contact and mushroom head. Provide control stations with padlocking attachment and legend plate reading "PUSH-TO-STOP, PULL-TO-START".
 - b. Pushbuttons: Momentary or maintained types, NEMA A600 contact rating.
 - c. Selector Switches: Rotary type with round or oval handles and positioning device to securely hold switch in selected position for maintained type and for spring return from left, right, or both left and right to maintained position.
 - d. Control stations shall bear a UL label.
 - e. Indicating Lights: 120 VAC push-to-test. Lens color shall be in accordance with Section 26 05 53, Identification for Electrical Systems.
5. Identification: Identify enclosures in accordance with Section 26 05 53, Identification for Electrical Systems. Devices shall include front-mounted nameplates identifying function and equipment controlled, if not readily apparent.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install equipment as shown and indicated, and provide sufficient access and working space for ready and safe operation and maintenance.
- B. Securely fasten equipment to walls or other surfaces on which equipment is mounted. Provide independent supports where no wall or other surface exists, in accordance with Section 26 05 29, Hangers and Supports for Electrical Systems.

++ END OF SECTION ++

SECTION 26 29 36

LOW-VOLTAGE MANUAL MOTOR STARTERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install low-voltage manual motor starters.
- B. Related Sections:
 - 1. Section 26 05 05, General Provisions for Electrical Systems.
 - 2. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. NEMA ICS 2-110, General Standards for Manual and Magnetic Controllers.
 - 2. UL 508, Industrial Control Equipment

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
 - 1. NEC Article 430, Motors, Motor Circuits, and Controllers.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Listing of low-voltage manual motor starters to be furnished, with identification of location of each, NEMA enclosure type, and equipment to be controlled.
 - 2. Product Data:
 - a. Manufacturer's technical information for low-voltage manual motor starters proposed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Provide products of one of the following:
 - 1. Cutler-Hammer.
 - 2. General Electric Company.
 - 3. Allen Bradley Company.

4. Square-D.
5. Or equal.

2.2 MATERIALS

- A. Low-Voltage Manual Motor Starters:
 1. Type: Toggle-operated, horsepower-rated, with thermal overload protection.
 - a. Where shown or indicated on the Drawings, provide manual motor starters rated 600-volt, three-pole, 20-amp without overload protection for use as disconnects.
 2. Provide starters rated for 600-volt, three-pole; 240-volt, two-pole; or 120-volt, single-pole with amperage and horsepower rating as required for load to be controlled.
 3. Enclosure: As required for area classifications specified in Section 26 05 05, General Provisions for Electrical Systems.
 4. Identification: Identify starters in accordance with Section 26 05 53, Identification for Electrical Systems. Identify per the equipment controlled.
 5. Starter shall comply with NEMA ICS 2-110 and UL 508.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install equipment so that sufficient access and working space is provided for ready and safe operation and maintenance.
- B. Securely fasten equipment to walls or other surfaces on which equipment is to be mounted. Provide suitable 1/4-inch spacers so that enclosure is not installed directly against walls. Provide independent supports where no wall or surface capable of supporting equipment exists.
- C. Install in conformance with Laws and Regulations, the Contract Documents, and manufacturer recommendations.

++ END OF SECTION ++

SECTION 26 32 13

12.47KV ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals as shown specified and required to furnish and install standby power generator system with appurtenances for a complete and operational system.
2. The following generator system(s) are included in this Section:
 - a. Two (2) 2000 KW, 2500 KVA, 0.8 power factor, 12470 volts, 3 phase, 4 wires, engine generator, located in outdoor walk-in weatherproof sound attenuated enclosure.
 - b. Two (2) neutral grounding resistors.
 - c. One (1) 2000 KW, 12470 volts, 3 phase, 3 wires resistive load bank.
 - d. One (1) generator protection and paralleling and switchgear control panel.

B. Coordination:

1. Review installation procedures under other Sections and coordinate installation of items that must be installed with or before engine generator Work.

C. Related Sections:

1. Section 05 05 33, Anchor Systems.
2. Section 26 05 13, Medium Voltage Cables
3. Section 26 05 19, Low-Voltage Electrical Power Conductors and Cables
4. Section 26 05 33.13, Rigid Conduits.
5. Section 26 13 26, Medium-Voltage Metal Clad Switchgear.
6. Section 26 24 16, Panelboards
7. Section 40 61 13, Process Control Systems General Provisions.

1.2 REFERENCES

A. Standards referenced in this section are:

1. International Standards Organization (ISO), ISO 8528, Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets.
2. ISO 9001, Quality Management Systems – Requirements.
3. NEMA MG-1, Motors and Generators.
4. NFPA 30, Flammable and Combustible Liquids Code.
5. NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.
6. NFPA 70E, Electrical Safety in the Workplace.
7. NFPA 110, Standard for Emergency and Standby Power Systems.
8. UL 142, Steel Aboveground Tanks for Flammable and Combustible Liquids.
9. UL 508, Safety Standard for Industrial Control Equipment.

- 10 UL 2200, Standard for Safety Stationary Engine Generator Assemblies (rated 600 volts or less)

1.3 QUALITY ASSURANCE

- A. Qualifications:
 1. Manufacturer:
 - a. Shall have minimum of five years of experience of producing substantially similar equipment to that specified and shall document at least five installations in satisfactory operation for at least five years.
 - b. Shall possess valid ISO 9001 certification.
 - c. Supplier shall have complete parts and service facilities, factory-trained service staff available for 24-hour emergency service and be authorized to administer the warranty for all components of engine generator systems.
- B. Component Supply and Compatibility:
 1. Obtain all equipment included in this Section regardless of component manufacturer from a single generator set manufacturer. Materials, equipment, and parts shall be new, of current production of a firm that manufactures the generator set as a matched system. Manufacturer shall have full responsibility for engine generator performance. Generator set manufacturer shall prepare or approve all Shop Drawings and other submittals for all components furnished under this Section.
 2. Engine generator shall be factory-assembled and factory-tested. Verify in the factory that system is free from electrical and mechanical defects and conforms to the Contract Documents.
- C. Regulatory Requirements: Comply with applicable provisions of authorities having jurisdiction, including the following:
 1. Code of Federal Regulations (CFR), Title 40, Part 89, Control of Emissions from New and In-Use Nonroad Compression Ignition Engines, Subpart D Emission Test Equipment Provisions
 2. Local Ordinances: Systems shall conform to Laws and Regulations relative to noise control and emissions.
 3. Local and State Building Codes: Installations shall conform to applicable codes including requirements of local fire marshals.
 4. Permits: Obtain and pay for required permits, fees, and inspections by authorities having jurisdiction

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 1. Shop Drawings:
 - a. Installation drawings specific to the Project.
 - b. Bill of material for all equipment and spare parts.
 - c. Electrical wiring and interconnection diagrams with all external connections identified.
 - d. Control panel data shall include:

- 1) Description of control features.
 - 2) Operator panel control switches and functions.
 - 3) Alarm and status displays.
 - 4) Provisions for remote start signal and remote status and alarm.
 - 5) Compliance with UL 508.
- e. Enclosure data shall include the following:
- 1) Plan and elevation drawings showing overall dimensions, interior equipment arrangement, and working spaces.
 - 2) Construction details and hardware specifications.
 - 3) Exhaust piping and silencer mounting arrangement.
 - 4) Sound attenuation provisions and decibel levels.
- f. Fuel storage system data shall include:
- 1) Day tank and storage tank arrangements.
 - 2) Storage capacity and hours of operation at rated load and 3/4 load.
 - 3) Alarm devices.
 - 4) Construction details including secondary containment provisions for fuel tank.
 - 5) Piping arrangements and details.
 - 6) Compliance with UL 142 and local codes.
- g. Provide the following relative to installation:
- 1) Vibration isolators and anchor bolt requirements.
 - 2) Seismic restraint requirements.
 - 3) Provisions for fuel piping, electrical conduits, and other external connection requirements.
2. Product Data:
- a. Manufacturer's literature, specifications, engineering data sheets, and standard drawings, necessary to fully describe the engine generator sets and appurtenances and substantiate compliance with the Contract Documents. Information shall be annotated to clearly indicate ratings, features, and options specific to the Project.
 - b. Generator data shall include:
 - 1) Listed to UL 2200.
 - 2) Heat rejection to room
 - 3) Combustion air requirements.
 - 4) Factory painting specifications.
 - c. Engine data shall include:
 - 1) Fuel flow at rated load.
 - 2) Fuel consumption at 1/4, 1/2, 3/4, and full load.
 - 3) Engine Type: Naturally aspirated or turbocharged and after-cooled.
 - 4) Maximum exhaust backpressure.
 - 5) Silencer attenuation rating.
 - 6) Jacket water heater system.
 - 7) Gaseous emissions data measurements for hydrocarbons, carbon monoxide, particulate matter, and NOx conforming to 40 CFR 89, Subpart D.

- d. Alternator data shall include:
 - 1) Winding insulation class and temperature rise in accordance with NEMA MG-1-1.65
 - 2) Standby and continuous KW/KVA ratings.
 - 3) Motor starting KVA at 90 percent sustained voltage.
 - 4) Surge KW capacity.
 - 5) Machine reactances and time constants.
- e. Starting system data shall include:
 - 1) Battery system.
 - 2) Battery charger.
 - 3) Cycle cranking configuration.
- 3. Testing Procedures:
 - a. Source Quality Control Testing Procedures: For Units 501 kW and larger, provide factory testing procedures and dates at least thirty days prior to testing.
 - b. Site Quality Control Testing Procedures: Testing procedures, provided at least thirty days prior to scheduled start of testing.

B. Informational Submittals: Submit the following:

- 1. Manufacturer's Instructions:
 - a. Manufacturer's unloading, rigging, installing, testing, and startup instructions. Information shall be specific to and indicate options for the Project
- 2. Source Quality Control Submittals:
 - a. Provide factory testing results within seven days of completing factory test.
- 3. Site Quality Control Submittals:
 - a. Services to be performed by Supplier's representative, provided at least thirty days prior to start of Site testing.
 - b. Report on results of testing at the Site, provided within seven days of completion of testing.
- 4. Manufacturer Reports: Reports of visits to Site by Supplier's representative, including purpose of visit, problems encountered, and resolutions.
- 5. Qualifications Statements:
 - a. Manufacturer: When requested by ENGINEER, submit data documenting compliance with qualifications requirements of the Contract Documents.

C. Closeout Submittals:

- 1. Operation and Maintenance Manuals: Provide in accordance with Section 01 78 23, Operations and Maintenance Data. Include the following information:
 - a. Operating Instructions: Instructions for starting, stopping, protection of circuits, automatic controls, battery charging and safety considerations. Methods for adjusting speed, output voltage, and control timers.
 - b. Performance Parameters: Provide nominal values and acceptable limits for output voltage, frequency, load, engine temperature, and oil pressure. Include circuit drawings with component identifications for reference.

- c. Maintenance Instructions: Procedures for daily, weekly, monthly, and annual basis, or on an hours-run basis. Include guidance for selecting fuel oil, lubricating oil, use of water treatment additives, and anti-freeze.
2. PLC Programming Documentation: Provide electronic files of the PLC programming on a flash drive.
3. Warranty Documentation.

D. Maintenance Materials:

1. Provide the following spare parts for each generator set:
 - a. Two sets of primary and secondary fuel filters.
 - b. Two sets of air filters.
 - c. Three circuit fuses of each size and type used.
 - d. Two sets of lube oil filters.
 - e. Two sets of fan belts and fuel hoses.
 - f. One engine starting motor.
 - g. Two control relays of each type.
 - h. One of each type of input/output module or card used.
 - i. One replacement power supply for each type and size used.
2. Furnish list of additional recommended spare parts for operating period of one year. Describe each part, quantity recommended, and current unit price.
3. Package spare parts in suitable containers bearing labels clearly indicating contents and equipment with which they are to be used.

1.5 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive OWNER of other rights or remedies OWNER may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by CONTRACTOR under the Contract Documents. Obligations of CONTRACTOR under the Contract Documents shall not be limited by provisions of the specified special warranty.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Delivery:
 1. Cover all generator air and exhaust openings with vapor inhibiting and water repellent material.
 2. Deliver anchorage devices that are to be embedded in cast-in-place concrete in ample time to prevent delaying the Work.
 3. Inspect equipment for shipping damage or loose parts upon delivery. Check for evidence of water that may have entered equipment during transit.
 4. Notify ENGINEER of loss or damage to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.
- B. Handle equipment in accordance with manufacturer's instructions. Furnish at least one copy of instructions with equipment at time of shipment.

- C. Storage:
 - 1. Store equipment in a clean, dry location with controls for uniform temperature and humidity. Protect equipment with coverings and maintain environmental controls.
 - 2. Store materials for easy access for inspection and identification. Keep all materials off the ground, using pallets, platforms or other supports. Protect equipment from corrosion and deterioration.

1.7 PREVENTIVE MAINTENANCE SERVICE PLAN

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals required to provide all Manufacturer's recommended preventive maintenance from the period when the equipment is delivered to the project site until date of Substantial Completion. The maintenance shall follow the Manufacturer's recommended plan and be performed by the Manufacturer's trained technicians every three months, at a minimum.
- B. CONTRACTOR shall provide a Preventive Maintenance Service Plan to the OWNER for a period of three years after date of Substantial Completion. During this period, the Manufacturer's trained technicians shall provide all labor, materials, equipment and incidentals required to perform all Manufacturer's recommended preventive maintenance. The maintenance shall follow the Manufacturer's recommended plan and be performed quarterly, at a minimum.
- C. The following services shall be provided at a minimum for Preventive Maintenance Service Plan:
 - 1. Perform visual inspection and fluid sampling every six months.
 - a. Inspect the generator exterior for signs of rust and degradation of paint
 - b. Sample both Oil and Coolant.
 - 2. Replace the Oil and Fuel filter every 12 months.
 - 3. Run generator on full load using the load bank every 12 months.
 - 4. At the end of the third year, perform an Oil change.

1.8 SYSTEM OPERATION DESCRIPTION

- A. The control system shall permit automatic and manual starting, stopping, paralleling and exercising of the generators with each other and NYSEG utility supply. System operation shall include the following:
 - 1. Automatic closed transition transfer and re-transfer via the normally offline generator main breaker 52-SM2 and the normally online NYSEG main breaker 52-SM1. During the closed transition transfer and re-transfer period, the controls shall provide soft loading and unloading for bump-less load transfer of the generators.
 - 2. Manual and Automatic paralleling of the two generators.
 - 3. Exercising of generators.
 - 4. Automatic and Manual remote operations and monitoring of the following breakers:

- a. 52-SM1
 - b. 52-SM2
 - c. 52-FA1
 - d. 52-FA2
 - e. 52-FA3
 - f. 52-FA4
 - g. 52-TIEA
 - h. 52-TIEB
 - i. 52-FB1
 - j. 52-FB2
 - k. 52-FB3
 - l. 52-FB4
 - m. 52-G1
 - n. 52-G2
 - o. 52-LB
5. PLC shall have inputs for the following breaker status signals and inputs shall be used to determine the status and availability of sources and feeder breakers.
- a. Opened
 - b. Closed
 - c. Racked Out
 - d. Racked In
 - e. Relay Trip
 - f. Relay Fault
 - g. Trip Coil Health
 - h. Lockout Coil Health
 - i. Loss of Control Voltage
 - j. Breaker in Test Position
 - k. Breaker in Normal Position
 - l. Breaker in Remote
 - m. Breaker in Local
6. PLC shall have the following discrete outputs signals to SCADA system.
- a. PLC Fault
 - b. System Disagree Alarm (common alarm)
 - c. G1 Low Fuel
 - d. G1 Low Battery
 - e. G1 Fault
 - f. G1 Running
 - g. G1 Stopped
 - h. G1 E-Stop
 - i. G2 Low Fuel
 - j. G2 Low Battery
 - k. G2 Fault
 - l. G2 Running
 - m. G2 Stopped
 - n. G2 E-Stop
 - o. Load Bank Online
 - p. Load Bank Fault

- B. A master three position, Auto-Off-Manual, switch (system master switch) shall govern the operation of the power generating system.
 - 1. Generator operation shall be based upon a four position, Off-Auto-Run-Exercise switch for each generator.
 - 2. Each main, tie and feeder breaker operation shall be based on the system master switch.
 - 3. System re-transfer mode shall be based upon a two position Open Transition - Closed Transition selector switch.

- C. The system shall be provided with the following modes of operation:
 - 1. Auto Standby Mode
 - 2. Auto Exercise Mode
 - 3. Manual Mode

- D. The system shall function in accordance with the control devices shown on the Drawings and provide additional devices as required for proper operation. The system controls shall operate in conjunction with the medium switchgear and breaker controls shown on the Drawings.

- E. Automatic Standby Mode, system master switch and generator switches in auto:
 - 1. If associated breaker selector switches for either main breaker 52-SM1 and 52-SM2 are in local mode:
 - a. Activate a system disagree alarm denoting main breaker is in local mode when system is in Automatic Standby Mode, and prevent control system for operating automatically.
 - 2. If associated breaker selector switches for either generator breaker 52-G1 and 52-G2 are in local mode, and prevent control system for operating automatically:
 - a. Activate a system disagree alarm denoting generator breaker is in local mode when system is in Automatic Standby Mode.
 - 3. Transfer to standby: Upon detection of a loss of normal voltage on the NYSEG supply, the PLC controls shall initiate the following operation:
 - a. Open the switchgear main breaker 52-SM1 and start both generators after an adjustable time delay, 0-300 seconds.
 - b. When the generators are started, automatically parallel each generator to each other and onto the generator switchgear bus by closing breakers 52-G1 and 52-G2.
 - c. If tie breakers 52-TIEA and 52-TIEB are closed.
 - 1) Open the following feeder breakers one at a time if the feeder breaker selector switch is in remote mode:
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - e) 52-FB1
 - f) 52-FB2
 - g) 52-FB3
 - h) 52-FB4

- 2) Close 52-SM2
- 3) Close the following breakers one at a time if the associated breaker selector switch is in remote mode. The sequence of breakers and time intervals shall be adjustable.
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - e) 52-FB1
 - f) 52-FB2
 - g) 52-FB3
 - h) 52-FB4
- d. If tie breakers 52-TIEA and/or 52-TIEB are opened and if the associated breaker selector switches are in remote mode.
 - 1) Close tie breakers and operate feeder breakers as mentioned in the step above.
- e. If tie breakers 52-TIEA or 52-TIEB are opened and the associated breaker selector switch is in local mode:
 - 1) Activate a system disagree alarm denoting tie breakers are opened and in local mode.
 - 2) Open the following breakers one at a time if the breaker selector switch is in remote mode.
 - a) 52-FB1
 - b) 52-FB2
 - c) 52-FB3
 - d) 52-FB4
 - 3) Close Breaker 52-SM2.
 - 4) Close following breakers one at a time if the associated breaker selector switch is in remote mode. The sequence of breakers and time intervals shall be adjustable.
 - a) 52-FB1
 - b) 52-FB2
 - c) 52-FB3
 - d) 52-FB4
- f. The load sensing control shall be active under this mode unless the load control is selected off.
 - 1) The load sensing control shall automatically walk off or walk on a generator based upon the bus load.
 - 2) The load sensing control shall automatically close load bank breaker 52-LB and bring the load bank online whenever the system detects that the generators are under loaded. System shall automatically adjust the load bank resistance to optimize the generator loading. The system shall automatically open the load bank breaker 52-LB whenever sufficient plant load is detected.
4. Re-transfer to normal, Closed Transition Mode:
 - a. If breakers 52-SM1, 52-SM2, 52-TIEA and 52-TIEB selector switches are not in remote mode, system shall abort Closed Transition sequence.

- 1) Activate a system disagree alarm denoting required breakers are in local mode.
- 2) Upon system confirming all required breaker selector switches are returned to remote mode, re-initiate Closed Transition sequence.
- b. Upon detection of the return of the normal voltage on the NYSEG supply, and after adjustable time delay, the PLC control shall initiate the following closed transition re-transfer:
 - 1) Enable device 25 MLC for the L1 line after an adjustable time delay (0-300 seconds) to auto synchronize and close the switchgear main breaker 52-SM1.
 - 2) Close main breaker 52-SM1.
 - a) The paralleling of utility and generators shall not exceed 100ms.
 - 3) Open 52-SM2
 - a) Subsequent to the Open command, confirm the status of breaker 52-SM2. If the breaker status remains Closed after 6 cycles, the system shall Open both tie breakers and activate a system disagree alarm denoting breaker 52-SM2 failed to open.
 - 4) Open breakers 52-G1 and 52-G2, and Stop the generators after an adjustable delay, 0-300 seconds.
5. Re-transfer to normal, Open Transition Mode: Upon detection of the return of the normal voltage on the NYSEG supply, and after adjustable time delay, the PLC control shall initiate the following operation after adjustable time delay:
 - a. If tie breakers 52-TIEA and 52-TIEB are closed and if the associated breaker selector switches in remote mode.
 - 1) Open following breakers one at a time if the associated breaker selector switch is in remote mode:
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - 2) Open 52-TIEA or 52-TIEB
 - 3) Close 52-SM1
 - 4) Close following breakers one at a time if the associated breaker selector switch is in remote mode:
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - 5) Open following breakers one at a time if the associated breaker selector switch is in remote mode:
 - a) 52-FB1
 - b) 52-FB2
 - c) 52-FB3
 - d) 52-FB4
 - 6) Open 52-SM2
 - 7) Close 52-TIE and/or 52-TIEB

- 8) Close following breakers one at a time if the associated breaker selector switch is in remote mode:
 - a) 52-FB1
 - b) 52-FB2
 - c) 52-FB3
 - d) 52-FB4
- b. If tie breakers 52-TIEA and/or 52-TIEB are opened and if the associated breaker selector switches in remote mode
 - 1) Open following breakers one at a time if the associated breaker selector switch is in remote mode.
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - 2) Close 52-SM1
 - 3) Close following breakers one at a time if the associated breaker selector switch is in remote mode:
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - 4) Open following breakers one at a time if the associated breaker selector switch is in remote mode:
 - a) 52-FB1
 - b) 52-FB2
 - c) 52-FB3
 - d) 52-FB4
 - 5) Open 52-SM2
 - 6) Close 52-TIE and/or 52-TIEB
 - 7) Close following breakers one at a time if the associated breaker selector switch is in remote mode:
 - a) 52-FB1
 - b) 52-FB2
 - c) 52-FB3
 - d) 52-FB4
- c. If tie breakers 52-TIEA and 52-TIEB are closed and the associated breaker selector switches in Local mode.
 - 1) Activate a system disagree alarm denoting tie breakers are closed and in manual mode.
 - 2) Open following breakers one at a time if the associated breaker selector switch is in remote mode.
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - e) 52-FB1
 - f) 52-FB2

- g) 52-FB3
 - h) 52-FB4
 - 3) Open 52-SM2
 - 4) Close 52-SM1
 - 5) Close following breakers one at a time if the associated breaker selector switch is in remote mode.
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - e) 52-FB1
 - f) 52-FB2
 - g) 52-FB3
 - h) 52-FB4
 - d. If tie breakers 52-TIEA and 52-TIEB are Open and the associated breaker selector switches in local mode.
 - 1) Activate a system disagree alarm denoting tie breakers are open and in manual mode.
 - 2) Open following breakers one at a time if the associated breaker selector switch is in remote mode.
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - 3) Close 52-SM1
 - 4) Close following breakers one at a time if the associated breaker selector switch is in remote mode:
 - a) 52-FA1
 - b) 52-FA2
 - c) 52-FA3
 - d) 52-FA4
 - 5) Open 52-SM2
 - e. Open breaker 52-G1 and 52-G2, and Stop the generators after an adjustable delay, 0-5 minutes.
- F. Exercise Mode, system master switch in Auto and generator switch in exercise mode:
- 1. The exercise mode shall be activated when manually initiated by the operator by placing the generator switches in the exercise position and a start pushbutton is activated.
 - 2. Transfer to exercise operation: When the exercise mode is initiated, the PLC control shall start the selected generator and initiate the following if the tie breakers 52-TIEA and 52-TIEB are closed:
 - a. When the generators are started, automatically parallel each generator to each other and to the dead bus by closing breakers 52-G1 and 52-G2, and then to the Utility by closing breaker 52-SM2.

- b. When the generators are online, soft load each generator to the maximum level, tracking the bus load. The paralleling of utility and generators shall not exceed 100ms.
- c. Unload the NYSEG supply line. After time delay, open the main breaker, 52-SM1.
 - 1) Subsequent to the Open command, confirm the status of breaker 52-SM1. If the breaker status remains Closed after 6 cycles, the system shall Open SM2 and activate a system disagree alarm denoting breaker 52-SM1 failed to open.
 - a) Subsequent to the 52-SM2 Open command, confirm the status of breaker 52-SM2. If the breaker status remains Closed after 6 cycles, the system shall Open both tie breakers and activate a system disagree alarm denoting breaker 52-SM2 failed to open.
- 3. If the Tie breakers 52-TIEA and 52-TIEB are open, the PLC control shall start the selected generators and parallel the generators to the dead bus.
- 4. The load sensing control shall be active under this mode unless the load control is selected off.
 - a. The load sensing control shall automatically walk off and walk on a generator based upon the bus load.
 - b. The load sensing control shall automatically Close Load bank breaker 52-LB and bring the load bank online whenever the system detects that the generators are underloaded. The system shall automatically adjust the load bank resistance to optimize the generator loading. The system shall automatically Open the Load bank breaker 52-LB whenever there is sufficient plant load is detected.
- 5. Re-transfer to normal: When the operator activates the exercise mode stop pushbutton the PLC control shall initiate re-transfer to normal, after an adjustable delay, 0 to 1 minute:
 - a. If the Tie circuit breakers 52-TIEA and 52-TEIB are closed, the re-transfer under this mode shall be closed transition re-transfer in a similar fashion as previously described under the standby mode re-transfer to normal.
 - b. If the tie circuit breakers 52-TIEA and 52-TEIB are open, the re-transfer under this mode shall open transition re-transfer in a similar fashion as previously described under the standby mode re-transfer to normal open transition.

G. Manual Mode, system master switch in Manual:

- 1. The generator start and synchronizing shall be manual by the operator.
- 2. Manual mode operation the standby generators shall be capable of operating manually isolated from the NYSEG.
 - a. The manual mode shall be enabled when the system master switch located at the generator system control panel is placed in manual position. Under manual mode the system controls shall be from dedicated devices totally independent from the PLC, allowing operation should the PLC be out of service.
 - b. In manual mode each generator shall be started by the operator when the generator switches are placed in the run position. The first generator started shall be manually connected to the generator switchgear dead bus

via breaker operation. The second generator shall be manually paralleled with the first generator via the local controls (e.g., synchroscope, potentiometer, etc.) and then manually connected to the generator switchgear bus via breaker operation.

- c. In manual mode the operator shall be able to exercise each generator individually on the load bank.
- d. Closing operation of the switchgear breakers shall be manual by the operator from the OIT located at the Generator Protection and Switchgear Paralleling Control Panel.
 - 1) Provide programming logic in breakers 52-SM1, 52-SM2 , 52-TIEA and 52-TIEB close commands to prohibit closed transition of sources.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. Quantity and ratings of the systems shall be as indicated in Paragraph 1.1.A.2 of this Section.
- B. Generators shall be rated for standby operation for duration of normal utility outage as defined by ISO 8528 for limited time operation. Generators shall be capable of operating for up to 500 hours per year, of which maximum of 300 hours is continuous running, and no overload is allowed.
- C. Generator assemblies shall be UL 2200-listed, control panels shall be UL 508-listed and above-ground fuel tanks shall be UL 142-listed.
- D. Generators shall be rated for the specified KW, without overload, at the following Site conditions:
 - 1. Maximum Ambient Temperature: 40 degrees C.
 - 2. Altitude: 1000ft feet above mean sea level.

2.2 MANUFACTURERS

- A. Provide generator systems of one of the following:
 - 1. Caterpillar
 - 2. Cummins
 - 3. Or equal.

2.3 ENGINE

- A. Engine Type: Four-cycle compression ignition, water cooled diesel 1800 RPM. Two-cycle engines are not acceptable.
- B. Engine Construction:
 - 1. Steel-backed bearings.
 - 2. Crank Case: Reinforced cast iron.

3. Crank Shaft: Forged alloy steel with hardened journals, finished and dynamically balanced.
4. Cylinder Head: Cast iron.
5. Pistons: Aluminum alloy with chrome faced rings.
6. Replaceable cylinder liners and valve seat inserts for engines rated over 200 horsepower.
7. Single-block construction. Bolted, multiple blocks are not acceptable.

C. Cooling System:

1. Radiator: Engine-mounted with engine-driven blower fan capable of cooling the engine under full load conditions in an ambient temperature of 104 degrees F without de-rating.
2. Thermostatic valve in jacket water outlet between radiator and engine to maintain proper jacket water temperature. Engine-driven pump to circulate water through cooling system.
3. Coolant: Fill system with 50 percent solution of ethylene glycol.
4. Coolant water temperature gauge.
5. High engine temperature shutdown.
6. Loss of coolant shutdown.
7. Fan guard.
8. Radiator face duct connection.
9. Engine coolant heaters, thermostatically controlled, capable of keeping jacket water at temperature not less than 90 degrees F in compliance with NFPA 110. Coolant heaters shall operate at 480 volts, three phase. House contactor for controlling heater in NEMA 4X stainless steel enclosure mounted on unit.

D. Lubrication System: Positive displacement, mechanical, full pressure lube pump, full flow and bypass lubrication filters with replaceable spin-on canister elements, oil drain line with valves and dipstick oil level indicator.

E. Fuel System: Suitable for operation on No. 2 diesel fuel oil. System to include primary and secondary fuel filters, fuel/water separator, fuel priming pump, flexible fuel lines and fuel pressure gauge.

F. Governor: Electronic system to provide automatic isochronous frequency regulation. System dynamic capabilities to be controlled as function of engine temperature for fast stable operation at varying engine operating conditions. System to actively control fuel rate and excitation. Fuel rate to be regulated as function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous states.

G. Fuel Oil Sub-base Tank

1. Construction: Heavy-gage steel primary tank, and welded steel secondary containment sized to contain 110 percent of primary tank capacity. Rust inhibitor coating inside and prime- and finish-coated outside, color to match generator set exterior paint. Primary tank capacity in gallons shall be sufficient for 48 hours of run time at 2000 KW.
2. Comply with the following:

- a. UL142-listed and labeled.
- b. NFPA 30, NFPA 37, and NFPA 110.
- 3. Fittings: NPT for fuel supply and return; two-inch diameter NPT for normal vent, manual fill and level alarm; NPT for emergency vents, level gauge, basin drain, and leak detection alarm.
- 4. Fuel level gauge and leak detector switch with alarm lights and contacts for remote annunciation of low fuel level and leak detection.
- 5. Mushroom-type cap and screen for normal vent openings and pressure relief-type caps for emergency vent openings.
- 6. Manufacturers: Provide sub-base tank of one of the following:
 - a. Pryco, Inc.
 - b. Tramont Corp.
 - c. Or equal.

H. Air Supply/Exhaust Systems:

- 1. Heavy duty air cleaner with service indicator.
- 2. Flexible stainless steel exhaust connector.
- 3. Critical grade silencer with condensate drain ports.
- 4. Schedule 40 stainless steel piping. Insulate indoor piping to limit surface temperature to 50 degrees C.

I. Air Emissions:

- 1. Comply with United States Environmental Protection Agency (USEPA) standards for non-road engines and with state and local requirements.
- 2. Submit emissions data measurements for hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM) and oxides of nitrogen (NOx) conforming to USEPA test procedures. Include USEPA not-to-exceed requirements for each pollutant.

J. Starting System: DC system complete with engine mounted batteries, locally mounted charger and connecting cables between batteries and engine and between charger and batteries.

- 1. Batteries: Lead-acid or calcium/lead antimony, engine cranking type, rated in accordance with engine manufacturer's requirements for minimum of three 15-second cranking cycles at firing speeds without recharging, and to accommodate DC power requirements of control panel and other accessories requiring DC power.
- 2. Battery racks, cables, connectors, and disconnect switch.
- 3. Engine-mounted battery charging alternator and solid state voltage regulator.
- 4. Battery Charger:
 - a. UL-listed, voltage regulated and equipped with float, taper and equalize charge settings.
 - b. Analog DC ammeter and voltmeter; 12-hour equalize timer; AC and DC fuses.
 - c. Loss of AC power, low battery voltage and high battery voltage alarm lights and contacts for remote annunciation; power on light.

2.4 ALTERNATOR

- A. Construction: Synchronous generator, four-pole, 2/3 pitch, revolving field, self-ventilated, drip-proof construction, single bearing, dynamically balanced rotor with amortisseur windings to minimize voltage deviations and heating effects under unbalanced load conditions. Rotor directly connected to engine flywheel housing to ensure permanent alignment.
- B. Winding Insulation Systems: Class H in accordance with NEMA MG-1. Temperature rise not to exceed 105 degrees C over 40 degrees C ambient at rated load. Epoxy coating for fungus resistance and abrasion protection.
- C. Excitation System: Brushless construction. Excitation support system, permanent magnet type, to sustain 300 percent rated current for up to 10 seconds under short circuit conditions. Provide surge suppressors to protect against voltage spikes.
- D. Voltage Regulator: Automatic solid state system to maintain generator output voltage within plus or minus 0.5 percent from no load to full load. Control voltage buildup, provide volts per Hertz regulation, protect from over-excitation, limit voltage overshoot on startup, and be environmentally sealed.
- E. Provide anti-condensation heater to maintain temperature approximately five degrees Fahrenheit above ambient when generator is idle.

2.5 GENERATOR CONTROL PANEL

- A. Controls shall be in accordance with NFPA 110, Level 1, and control panel shall conform to the following:
 - 1. Install control panel on vibration isolators with controls, instruments, lights, and devices necessary to manually and automatically start, stop, monitor, and protect the generator.
 - 2. Controls shall be UL 508-listed and microprocessor-based with programmable adjustments. Control power from starting battery system. Panel shall include the following:
 - a. Emergency stop pushbutton.
 - b. Adjustable cycle cranking.
 - c. KW, KVA, KVAR, and power factor meters.
 - d. Engine coolant temperature readout.
 - e. Engine oil pressure readout.
 - f. Running time readout.
 - g. RPM meter.
 - h. Cool down timer.
 - 3. Readouts and dry contact outputs shall be provided as required by NFPA 110, Level 1.
 - 4. Provide output dry contacts for remote monitoring and control for the following:

- a. Generator running
 - b. Generator common warning alarm.
 - c. Generator common shutdown alarm.
 - d. Low day tank fuel if day tank is used (warning alarm).
 - e. Low main tank fuel (warning alarm).
 - f. Liquid leak in containments areas, including tank, double walled piping, and other fuel supply components (warning alarm).
5. Reset Control: Manual or remote restarts are not allowed and alarm lamps shall remain in alarm state until manual reset is accomplished even if alarm condition has been corrected.
 6. Provide control panel anti-condensation space heater.

2.6 ENCLOSURE

- A. Provide engine-generator system with outdoor weatherproof walk-in sound attenuated enclosure where indicated in Paragraph 1.1.A.2 of this Section.
- B. Walk-in enclosures shall be custom built for proper access to all components within enclosure. Working space shall comply with NFPA 70, 70E, OSHA, and Laws and Regulations.
 1. Construction: Pre-painted aluminum stressed skid construction consisting of the following:
 - a. Roof: One-piece roof sheet, 0.040-inch thick, 3003 aluminum alloy with extruded aluminum recessed side and end rails and I-beams, 6061-T6 alloy.
 - b. Side and End Walls: Panels, 0.050-inch thick, 5052 H-34 aluminum sheet, fastened with rivets spaced three inches on center, with extruded aluminum post sections on 2.0-foot centers.
 - c. Floor and Under-frame: Two 6-inch wide flange I-beam longitudinal skids with 10-gage steel cross members on 12-inch centers. Cross members to be overlaid with 3/4-inch tongue and groove exterior fir plywood subfloor surfaced with 1/8-thick diamond plate steel.
 - d. Door and Frame: Aluminum frame and personnel door fully gasketed to form weather-tight seal.
 2. Provide louvers sized as required for sufficient engine combustion and radiator cooling. Louvers shall be motorized and of aluminum construction riveted into steel frame forming rigid, water-resistant assembly.
 3. Finishing: Complete enclosure shall be prime-coated with two coats of zinc-chromate and finished-painted with two coats of enamel. Color of finish paint will be selected by ENGINEER from manufacturer's standard colors.
 4. Enclosure shall be wired with the following equipment:
 - a. 480V, 3 Phase, 3 wire load center panelboard with circuit breakers for all power requirements generator jacket heater, ventilation fans and enclosure unit heaters.
 - b. 480V-208/120V, 15 KVA Transformer.
 - c. 120/208-volt, three-phase load center panelboard with circuit breakers for all power requirements including lighting, convenience receptacle, battery charger, day tank, generator space heater, ventilation fans and engine jacket water heater.

- d. LED Vapor-tight lighting fixtures within the enclosure with snap switch at entrance door. Provide LED wallpack light fixtures with integral photocells at each exterior door, over fuel port, front and back.
 - e. Interior and exterior duplex convenience receptacles. Exterior receptacles shall be GFI type with while in use weather proof covers.
 - f. Battery-powered emergency lighting fixture positioned to light engine starting controls. Battery-powered emergency led exit signs at each doors.
 - g. Ventilation fans to operate when temperature exceeds 40 degrees C.
- C. Sound Attenuation: Engine-generator enclosure shall be sound-attenuated to reduce noise level to 75 dBA at a point seven meters from engine-generator in free air environment, while operating at full load.

2.7 LOAD BANKS

- A. Provide load banks as shown or indicated on the Drawings. Load banks shall be UL-listed.
- B. Load banks shall be continuous time rated, resistive type, voltage, and number of phases matched to engine generator provided.
- C. The duty cycle shall be continuous and the load bank shall operate in an ambient temperature of -28°C to 49°C (-20°F to 120°F).
- D. Material and Construction
- 1. The load bank shall be constructed of heavy gauge aluminized steel per ASTM A463.
 - 2. The main input load bus, load step relays, fuses and blower/control relays shall be located within the load bank enclosure. A thermostatically controlled heater shall be located within the control section to protect control devices from the effects of moisture and condensation
 - 3. The load bank shall be outdoor weatherproof construction. All exterior fasteners shall be stainless steel. The load bank shall include forklift channels in the base for lifting.
 - 4. Intake openings shall be designed to prevent objects greater than 0.50" diameter from entering the unit. The exhaust hood shall be designed to prevent rain/moisture from entering the unit. The load bank exhaust hood shall be aluminum.
- E. Resistive Load Elements
- 1. Load elements shall be helically wound chromium alloy rated to operate at approximately ½ of maximum continuous rating of wire. Elements must be fully supported across the entire length within the air stream by segmented ceramic insulators on stainless steel rods. Element supports shall be designed to prevent a short circuit to adjacent elements or to ground.
 - 2. The overall tolerance of the load bank shall be -0% to +5% kW at rated voltage. A -5%, +5% rating allows the load bank to deliver less than rated kW and shall not be used. The load bank must deliver full rated kW at rated voltage.

F. Cooling

1. The load bank shall be cooled by integral TEFC motor(s) which is direct coupled to the cooling fan blade. The fan motor must be electrically protected against overload using a motor overload device and short circuit protector.
2. The fan blade is to be an airfoil design constructed from aluminum or non-corroding material.

G. Protective Devices

1. A differential pressure switch(s) shall be provided to detect air loss (one for each stack). The switch(s) shall be electrically interlocked with the load application controls to prevent load from being applied if cooling air is not present.
2. An over-temperature switch shall be provided to sense the load bank exhaust in each stack. The switch shall be electrically interlocked with the load application controls to prevent load from being applied in the event of an over temperature condition.
3. To provide for major fault protection, branch fuses shall be provided on all three phases of switched load steps above 50kW. Branch fuses shall be current limiting type with an interrupting rating of 200K A.I.C.
4. The exterior of the load bank shall have appropriate warning/caution statements on access panels.

H. Control Systems

1. Provide an integral control panel to control the load bank locally and remotely. The control panel enclosure shall be rated NEMA 4X and 316 stainless steel. The control panel shall be designed to accept an external power input rated for 480 VAC, 30A, 3PH, 60 Hz. Provide a rotary style, main power disconnect. Provide CPTs and power supplies as required.
2. A microprocessor based module with industrial connectors and LED status display shall be installed in the load bank. The module shall connect with Voltage and Current Transformers to obtain real time monitoring of the load bank at a sampling rate of at least 28.8 kHz. The module shall have large flash memory, which allows remote upgrading and space for configuration data and calibration maps. Non-volatile RAM provides 500 event history log time stamped by on-board real time clock.
3. Usage counters shall provide information on individual contactor operation, element run times, overall power-on time, load-on time and kWh. Load monitoring checks each phase for faulty contactors, blown fuses or faulty elements. Faults are logged with visual indication via blinking stop lamp and warning code. Automatic detection senses the supply-on-test voltage, frequency, phase and phase rotation.
4. The module shall have a load correction facility, which shall compensate for any voltage drop on supply.
5. The module shall balance the usage of each load element to increase the life of the load bank.
6. An HMI Hand Held controller shall also be provided with a 10 meter cable for operator interface with all functionality faults and features. When carrying out full-load testing, one page will show the three-phase measurements of voltage

(V), frequency (Hz), current (A), power (both kW and kVA) and power factor (Cos ϕ).

7. Switchgear Interface: Load bank shall have provisions to interface with the switchgear critical power management system. This shall be done through Modbus Ethernet.
 - a. Remote I/O Interface shall be designed to provide control of load bank functions and monitoring of safety devices via a single Modbus Ethernet interface.
 - b. The remote I/O interface provides complete control and monitoring of the load bank and load steps, in addition to starting and stopping of the cooling fans and monitoring of the safety circuits.

I. Step-Down Transformer

1. The outdoor rated, dry type step down transformer shall be rated load bank capacity, three phase, 60 Hz, with a 12470V primary and 480/277VAC secondary. The transformer shall be fully rated for outdoor installation on a single skid with the load bank. Transformer and load bank shall include thermostatically controlled heater strip to minimize the effects of moisture and condensation

J. The windings shall be copper; rated temperature rise shall be 115°C with 220°C insulation class

K. Transformer Secondary protection shall be provided integral to the skid.

2.8 GROUNDING RESISTORS

A. Provide grounding resistors for neutral grounding of each generator as shown on the Drawings.

1. Grounding resistors shall be rated 400 amperes, 7200 volt line to neutral, 10 seconds. Temperature rating shall be suitable for 760 degrees C rise. Grounding resistors shall be designed and tested in accordance with IEEE-32 for neutral grounding devices.
2. The resistors shall consist of stainless steel stamped grid edge wound elements, double insulated with stainless steel terminals. The resistor frame and non-current carrying parts shall be zinc-plated steel.
3. The grounding resistors shall be complete with the following accessories:
 - a. Stand-off insulators, entrance bushings and terminals lugs with current transformer.
 - b. Stainless steel NEMA 3R enclosure for totally enclosing the components with access door.

2.9 CONTROL AND PROTECTION SYSTEM

A. General:

1. The Control and Protective System shall be equipped with all devices required for a complete system, including both automatic and manual paralleling meeting the requirements of NFPA 110, Level 1.

2. The generator system shall include the following panels:
 - a. Generator mounted local control panel, one for each unit.
 - b. Generator Protection and Switchgear Paralleling Control Panel consisting of separate generator cubicles, one cubicle for each generator and a master cubicle.
3. The generator system control panel shall be front access, steel construction, free-standing NEMA type 1. Each cubicle shall be arranged with inter wiring terminations.
4. The generator system control panel shall be constructed in accordance with the applicable requirements of Section 40 67 17, Process Control Panels and Hardware.
5. Output contacts shall be provided as required for the operational requirements specified and shall be 10 ampere at a minimum. Circuit breakers control contacts shall be rated as required for the make and break duty of the circuit breakers.
6. The control system shall operate in conjunction with the 15KV switchgears and the generators. System control functions shall be provided with suitable adjustable time delays to ensure stable operation of the system. Automatic generator sequencing shall be as required to accomplish the system operation specified under this section.

B. The system shall be provided with the following Control System Devices:

1. Speed Control and Load Sharing: A digital microprocessor based speed control and load sharing system with local operating communication network shall provide the means of control. The system shall share loads with an isolated multi-generator bus. System components shall include:
 - a. Device 25 MLC, master automatic synchronizers with load control for automatic generator speed, phase and voltage control. The device shall automatically control plant loading and unloading and power factor for bump-less load transfer during parallel operation with the utility. The device shall also include metering, protective, control and monitoring capability and shall be equipped with a keypad and graphical display accessible from the system control panel generator cubicles.
 - b. Device 65 MLS, master load sharing and speed control module for controlling engine speed and load in generator set applications.
 - c. Device 65, load sharing and speed governor controllers, for controlling engine speed and load. The speed control governor shall be suitable to operate with the automatic synchronizer and loading control and the engine mounted actuator and magnetic pickup. The controller shall also include power metering, protective, control and monitoring capability and shall be equipped with a keypad and graphical display accessible from the generator mounted control panel.
2. Device 90, Voltage Regulator: An electronic controller shall provide fast, accurate voltage control in addition to parallel compensation. The voltage regulator shall be suitable to operate with the permanent magnet generator and speed control and load sharing system.

3. Control Switches and Devices: The system control panel shall include the following discrete control switches and devices:
 - a. System Master control switch, Auto-Off-Manual.
 - b. Lamp test, horn silence and fault reset pushbuttons.
 - c. Voltage meter switch, one for each generator.
 - d. Current meter switch, one for each generator.
 - e. Synchronizing switch, one for each generator with removable key handle.
 - f. Four position generator control switch, Off-Auto-Run-Exercise, one for each generator.
 - g. Manual load sharing speed and voltage adjust potentiometers one for each generator.
 - h. Emergency stop pushbutton, turn to reset type with indicating light, one for each generator.
 - i. Elapsed time meter, one for each generator.
 4. Meters and Devices: The system control panel shall include the following discrete meters and devices. Meters shall be switchboard type, 1 percent accuracy, 4.5 inch size.
 - a. Voltage meter, one for each generator.
 - b. Current meter, one for each generator.
 - c. Frequency meter, one for each generator.
 - d. Wattmeter, one for each generator.
 - e. Synchroscope, one for each generator.
- C. Auxiliary Controls and Features: The system auxiliary controls and features shall include:
1. Dead bus control circuit to provide first-up, first-on generator operations and prevent more than one generator from simultaneously closing to a dead bus.
 2. Best battery circuitry and associated devices sufficient for operating the system controls from either of the two generator starting batteries. The best battery circuit shall also be provided with a regulated supply suitable to operate the controls from the switchgear battery system 125 VDC DC power source.
 3. Engine stop-start cranking and shutdown controls, plus the logic circuits necessary for operation of the engine.
 4. Voltage, frequency and watt sensing for control logic interlocking and load
 5. Automatic stop-start, sequencing and load control shall be controlled by a programmable logic controller, PLC for programming the operation of the generators. The controller shall be manufactured by Allen Bradley.
 6. Load sensing controls shall be sequenced to remove generators from service as load decreases and add generators as load increases. The load sensing controls shall include:
 - a. Adjustable time delays to avoid unnecessary stopping and starting of the generators.
 - b. A 15 minute adjustable time delay to activate the load sensing control upon start-up of the generators.
 - c. Shed controls to signal excessive load on the generator. The load shed operation can be disabled by from the load control switch.
 - d. Shed bus frequency monitor to sense a drop in bus frequency of approximately two cycles below nominal. Immediately upon a bus under

frequency all available generator sets confirmed not running shall be programmed into operation. Should the bus under frequency remain below the set point, for an adjustable time period, and then the load shed alarm shall be activated. If bus frequency does not recover within another adjustable time period, then the load shed alarm shall remain activated and require manual reset.

7. 19-inch touch-screen programmable operator interface terminal at the system control panel. The touch screen terminal shall be flush mounted on the front of the control panel. The touch screen terminal shall be provided with all necessary hardware, cables and software to allow operator access to the generator system information including monitoring, system status, control and annunciation. The screen shall be also capable to display graphically the generators and the electrical distribution system one-line diagrams. The touch screen shall communicate digitally to the generator system devices include all switches and gateways as required to properly display the information specified.

D. System Status and Annunciation: The system status and annunciation shall include local status and annunciation at each generator mounted control panel and remotely at the system control panel.

1. Local status and annunciation at each generator shall include:
 - a. Generator Running.
 - b. Low Lube Oil Pressure: Fault with shutdown.
 - c. Pre-Low Lube Oil Pressure: Alarm.
 - d. Charger Common: Alarm.
 - e. Fail to Start: Fault with shutdown.
 - f. Pre-High Engine Temperature: Alarm.
 - g. High Engine Temperature: Fault with shutdown.
 - h. Low Engine Temperature: Alarm.
 - i. Over-speed: Fault with shutdown.
 - j. Over-crank: Fault with shutdown.
 - k. Low Coolant Level: Alarm.
 - l. Day Tank Levels, Low and High: Alarms.
 - m. Day Tank Leak Detection: Alarm.
 - n. Emergency Stop Activated: Fault with shutdown.
 - o. Generator Control Not in Auto: Alarm.
2. Remote status and annunciation at the system panel shall include:
 - a. All specified local status and annunciation from each generator local control panel.
 - b. Breaker open and close status for all switchgear breakers.
 - c. Switchgear Breaker Trip: Alarm.
 - d. Switchgear Breaker Trouble: Alarm.
 - e. Processor Malfunction: Alarm.
 - f. Bus Under Frequency: Alarm.
 - g. Load Shed: Alarm.
 - h. System Operation, Standby Mode: Status.
 - i. System Operation, Exerciser Mode: Status.
 - j. Master Control Not in Auto: Alarm.
 - k. NYSEG Supply Line Loss of Voltage: Status.

- l. Switchgear Battery System Malfunction: Alarm.
 - m. Fail to synchronize: Alarm.
 - n. Generator System Supplying Load: Status.
 - o. Breaker Disagree: Alarm.
3. The system status and annunciation information at each local generator panel shall be communicated digitally over the generator system data highway to the system panel.
 4. All system status and annunciation information in its entirety shall be communicated digitally from the PLC over the Plant data highway. The PLC digital communication shall be Ethernet protocol.

E. Device Identification:

1. Provide control wiring and device identification for each control cubicle.
 - a. Identify all control conductors with permanent type wire markers. Each wire shall be identified by a unique number and shall be attached to the wire at each termination point.
 - b. all control devices with permanent type markers. Each device shall be identified by a unique number and shall be attached to each device.
 - c. The numbering system for each wire and control device shall be identified on the wiring diagrams and shall reflect the actual designations used in the work.

2.10 ACCESSORIES

A. Engine Generator Mounting:

1. Vibration Isolators: Steel springs in combination with rubber pads.
2. Vibration Isolation: Provide flexible connections between engine-generator set and fuel lines, exhaust system, electrical conduits, and other externally connected support systems.
3. Anchor Bolts: Type 316 stainless steel, conforming to Section 05 05 33, Anchor Systems.
4. Template shall be furnished by manufacturer for setting anchorages devices, pipe sleeves, and nuts for mounting spring-type isolators to concrete foundation. Provide bolts and nuts for bolting isolators to channel frame base of engine-generator set.

2.11 FINISHING

- A. Engine generator ferrous metal surfaces shall be prime-coated for corrosion protection and finish-painted in accordance with manufacturer's standard painting system.
- B. Color of finish paint to be selected by ENGINEER from manufacturer's standard colors.

2.12 SOURCE QUALITY CONTROL

A. Factory Tests

1. Following assembly, perform at the factory standard production tests to verify proper operation and performance. Tests shall include two-hour full load test.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine the conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install engine generator system in accordance with the Contract Documents, approved Shop Drawings, and manufacturer's recommendations.

3.3 SITE QUALITY CONTROL

- A. After installation, provide field testing and inspection of the engine generator system. Testing and inspection shall be in accordance with manufacturer's recommendations and be performed by manufacturer's factory-trained representatives. Manufacturer's representatives shall inform OWNER when the equipment has been correctly installed. Do not energize equipment without permission of OWNER.
- B. The engine generator and the control system representatives shall perform system checks and inspections before energizing equipment in accordance with each manufacturer standard procedures and recommendations. Adjust equipment as required for proper operation.
- C. The control system representatives shall perform calibration, settings, and programming of the system devices and controls.
- D. The engine-generator system shall be field tested in accordance with NFPA 110. Provide all equipment, including load banks to fully load each unit, fuel, lubricants and material required for field testing. When the testing is completed, at a time determined by Owner, fuel tanks shall be filled and lubricates shall be replaced.
- E. After the engine-generator system has been tested and is operational, a separate system test shall be conducted, at a time determined by Owner, to demonstrate operational performance. The system test shall be conducted by the engine generator and the control system representatives and witnessed by the Owner. The engine-generator system shall be operated, including both manual and automatic modes. The automatic sequencing for each mode and auxiliary features shall also be demonstrated. The plant load shall be used during the system tests, including a two hour load test at the completion of the system testing.

- F. Manufacturer's Services: Provide qualified, factory-trained serviceman to perform the following:
1. Supervise unloading and installation of equipment.
 2. Instruct CONTRACTOR in the installation of equipment.
 3. Inspect and adjust equipment after installation and ensure that equipment operates properly.
 4. Instruct OWNER's personnel in operating and maintaining the equipment.
 5. Service representative shall make a minimum of 5 visits, with a minimum of 8 hours at the Site for each visit. First visit shall be for unloading supervision and instruction of CONTRACTOR in installing equipment; second visit shall be for assistance in installation of equipment; third visit shall be for checking completed installation and start-up of system; fourth visit shall be to instruct operations and maintenance personnel. Representative shall revisit the Site as often as necessary until installation is acceptable.

3.4 MANUFACTURER SERVICES

- A. Manufacturer Services:
1. Unloading and Installation: Manufacturer's factory-trained representative shall be present during unloading of the equipment and installation in the equipment's final location. Representative shall train installing personnel in advance in the proper handling and rigging of the equipment.
 2. Manufacturer's factory-trained representatives shall test the system as specified in Article 3.3 of this Section. Representative shall operate and test the system in the presence of OWNER and verify that the equipment conforms to requirements.
 3. Representative shall revisit the Site as often as necessary until all deficiencies are corrected, prior to readiness for final payment.
 4. Provide services of manufacturer's factory-trained representatives to correct defective Work within 72 hours of notification by OWNER during the Correction Period specified in the General Conditions as amended by the Supplementary Conditions.
 5. Replacement parts or equipment installed during the Correction Period shall be equal to or better than the original.
- B. Training: Furnish services of qualified factory trained specialists from manufacturer to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of the products. Training requirements, duration of instruction, and other qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
1. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.
 2. In addition to training requirements specified in Section 01 79 23, Instruction of Operations and Maintenance Personnel provide the following:
 - a. The Contractor shall retain the services of the Manufacturer's trained personnel to provide and perform standardized, structured training courses on site.

- b. On-site training shall make extensive use of the installed control system to ensure Plant personnel develop an enhanced understanding and level of comfort with the PMCS.
 - c. Submit training material for Engineers approval.
 - d. Operator Training
 - 1) Provide two 8-hour course covering the structure and the functions of the Generators and Control Systems and its components and devices.
 - 2) The course shall familiarize the Operator with the procedures for applying the control situations or scenarios and develop operator issue resolution capability.
 - 3) Training shall be provided in the following subjects:
 - a) System overview and capabilities
 - b) Graphic display configurations
 - c) System back-up and recovery
 - d) System start-up and shutdown procedures
 - e) Trouble-shooting
3. Training session shall be videotaped for future reference.

+ + END OF SECTION + +

SECTION 26 32 13.10

480V ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals as shown specified and required to furnish and install 480-volt standby power generator system with appurtenances for a complete and operational system.
2. The following generator system(s) are included in this Section:
 - a. 550 KW, 687.5 KVA, 0.8 power factor, 480/277 volts, 3-phase, 4 wires, Non-Walkin sound attenuated enclosure, engine generator, located at Lake Street.
 - b. 1200 Amp, 480V 3 Phase, 3-phase, 3 wire wall mounted generator docking station.

B. Coordination:

1. Review installation procedures under other Sections and coordinate installation of items that must be installed with or before engine generator Work.
2. Notify other contractors in advance of installing engine generator sets to provide other contractors with sufficient time for installing items included in their contracts that must be installed with or before engine generator Work.

C. Related Sections:

1. Section 05 05 33, Anchor Systems.

1.2 REFERENCES

A. Standards referenced in this section are:

1. International Standards Organization (ISO), ISO 8528, Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets.
2. ISO 9001, Quality Management Systems – Requirements.
3. NEMA MG-1, Motors and Generators.
4. NFPA 30, Flammable and Combustible Liquids Code.
5. NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.
6. NFPA 70E, Electrical Safety in the Workplace.
7. NFPA 110, Standard for Emergency and Standby Power Systems.
8. UL 50, Electrical Equipment Enclosure Testing.
9. UL 142, Steel Aboveground Tanks for Flammable and Combustible Liquids.
10. UL 508, Safety Standard for Industrial Control Equipment.
11. UL 2200, Standard for Safety Stationary Engine Generator Assemblies (rated 600 volts or less)

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturer:
 - a. Shall have minimum of five years of experience of producing substantially similar equipment to that specified and shall document at least five installations in satisfactory operation for at least five years.
 - b. Shall possess valid ISO 9001 certification.
 - c. Supplier shall have complete parts and service facilities, factory-trained service staff available for 24-hour emergency service, and be authorized to administer the warranty for all components of engine generator systems.
- B. Component Supply and Compatibility:
 - 1. Obtain all equipment included in this Section regardless of component manufacturer from a single generator set manufacturer. Materials, equipment, and parts shall be new, of current production of a firm that manufactures the generator set as a matched system. Manufacturer shall have full responsibility for engine generator performance. Generator set manufacturer shall prepare or approve all Shop Drawings and other submittals for all components furnished under this Section.
 - 2. Engine generator shall be factory-assembled and factory-tested . Verify in the factory that system is free from electrical and mechanical defects and conforms to the Contract Documents.
- C. Regulatory Requirements: Comply with applicable provisions of authorities having jurisdiction, including the following:
 - 1. Code of Federal Regulations (CFR), Title 40, Part 89, Control of Emissions from New and In-Use Nonroad Compression Ignition Engines, Subpart D Emission Test Equipment Provisions
 - 2. Local Ordinances: Systems shall conform to Laws and Regulations relative to noise control and emissions.
 - 3. Local and State Building Codes: Installations shall conform to applicable codes including requirements of local fire marshals.
 - 4. Permits: Obtain and pay for required permits, fees, and inspections by authorities having jurisdiction

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Installation drawings specific to the Project.
 - b. Bill of material for all equipment and spare parts.
 - c. Electrical wiring and interconnection diagrams with all external connections identified.
 - d. Control panel data shall include:
 - 1) Description of control features.
 - 2) Operator panel control switches and functions.

- 3) Alarm and status displays.
 - 4) Provisions for remote start signal and remote status and alarm.
 - 5) Compliance with UL 508.
 - e. Enclosure data shall include the following:
 - 1) Plan and elevation drawings showing overall dimensions, interior equipment arrangement, and working spaces.
 - 2) Construction details and hardware specifications.
 - 3) Exhaust piping and silencer mounting arrangement.
 - 4) Sound attenuation provisions and decibel levels.
 - f. Fuel storage system data shall include:
 - 1) Day tank and storage tank arrangements.
 - 2) Storage capacity and hours of operation at rated load and 3/4 load.
 - 3) Alarm devices.
 - 4) Construction details including secondary containment provisions for fuel tank.
 - 5) Piping arrangements and details.
 - 6) Compliance with UL 142 and local codes.
 - g. Provide the following relative to installation:
 - 1) Vibration isolators and anchor bolt requirements.
 - 2) Seismic restraint requirements.
 - 3) Provisions for fuel piping, electrical conduits, and other external connection requirements.
2. Product Data:
- a. Manufacturer's literature, specifications, engineering data sheets, and standard drawings, necessary to fully describe the engine generator sets and appurtenances, and substantiate compliance with the Contract Documents. Information shall be annotated to clearly indicate ratings, features, and options specific to the Project.
 - b. Generator data shall include:
 - 1) Listed to UL 2200.
 - 2) Heat rejection to room
 - 3) Combustion air requirements.
 - 4) Factory painting specifications.
 - c. Engine data shall include:
 - 1) Fuel flow at rated load.
 - 2) Fuel consumption at 1/4, 1/2, 3/4, and full load.
 - 3) Engine Type: Naturally aspirated or turbocharged and after-cooled.
 - 4) Maximum exhaust backpressure.
 - 5) Silencer attenuation rating.
 - 6) Jacket water heater system.
 - 7) Gaseous emissions data measurements for hydrocarbons, carbon monoxide, particulate matter, and NOx conforming to 40 CFR 89, Subpart D.
 - d. Alternator data shall include:
 - 1) Winding insulation class and temperature rise in accordance with NEMA MG-1-1.65
 - 2) Standby and continuous KW/KVA ratings.

- 3) Motor starting KVA at 90 percent sustained voltage.
 - 4) Surge KW capacity.
 - 5) Machine reactances and time constants.
 - e. Starting system data shall include:
 - 1) Battery system.
 - 2) Battery charger.
 - 3) Cycle cranking configuration.
 - 3. Testing Procedures:
 - a. Source Quality Control Testing Procedures: Provide factory testing procedures and dates at least thirty days prior to testing.
 - b. Site Quality Control Testing Procedures: Testing procedures, provided at least thirty days prior to scheduled start of testing.
- B. Informational Submittals: Submit the following:
- 1. Manufacturer's Instructions:
 - a. Manufacturer's unloading, rigging, installing, testing, and startup instructions. Information shall be specific to and indicate options for the Project
 - 2. Source Quality Control Submittals:
 - a. Provide factory testing results within seven days of completing factory test.
 - 3. Site Quality Control Submittals:
 - a. Services to be performed by Supplier's representative, provided at least thirty days prior to start of Site testing.
 - b. Report on results of testing at the Site, provided within seven days of completion of testing.
 - 4. Manufacturer Reports: Reports of visits to Site by Supplier's representative, including purpose of visit, problems encountered, and resolutions.
 - 5. Qualifications Statements:
 - a. Manufacturer: When requested by ENGINEER, submit data documenting compliance with qualifications requirements of the Contract Documents.
- C. Closeout Submittals:
- 1. Operation and Maintenance Manuals: Provide in accordance with Section 01 78 23, Operations and Maintenance Data. Include the following information:
 - a. Operating Instructions: Instructions for starting, stopping, protection of circuits, automatic controls, battery charging and safety considerations. Methods for adjusting speed, output voltage, and control timers.
 - b. Performance Parameters: Provide nominal values and acceptable limits for output voltage, frequency, load, engine temperature, and oil pressure. Include circuit drawings with component identifications for reference.
 - c. Maintenance Instructions: Procedures for daily, weekly, monthly, and annual basis, or on an hours-run basis. Include guidance for selecting fuel oil, lubricating oil, use of water treatment additives, and anti-freeze.
 - 2. Warranty Documentation.

- D. Maintenance Materials:
1. Provide the following spare parts for each generator set:
 - a. Two sets of primary and secondary fuel filters.
 - b. One set of air filters.
 - c. Two control circuit fuses of each size used.
 - d. Two sets of lube oil filters.
 - e. One set of fan belts.

1.5 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive OWNER of other rights or remedies OWNER may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by CONTRACTOR under the Contract Documents. Obligations of CONTRACTOR under the Contract Documents shall not be limited by provisions of the specified special warranty.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Delivery:
1. Cover all generator air and exhaust openings with vapor inhibiting and water repellent material.
 2. Deliver anchorage devices that are to be embedded in cast-in-place concrete in ample time to prevent delaying the Work.
 3. Inspect equipment for shipping damage or loose parts upon delivery. Check for evidence of water that may have entered equipment during transit.
 4. Notify ENGINEER of loss or damage to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.
- B. Handle equipment in accordance with manufacturer's instructions. Furnish at least one copy of instructions with equipment at time of shipment.
- C. Storage:
1. Store equipment in a clean, dry location with controls for uniform temperature and humidity. Protect equipment with coverings and maintain environmental controls.
 2. Store materials for easy access for inspection and identification. Keep all materials off the ground, using pallets, platforms or other supports. Protect equipment from corrosion and deterioration.

PART 2 - PART 2 – PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. Quantity and ratings of the systems shall be as indicated in Paragraph 1.1.A.2 of this Section.

- B. Generators shall be rated for standby operation for duration of normal utility outage as defined by ISO 8528 for limited time operation. Generators shall be capable of operating for up to 500 hours per year, of which maximum of 300 hours is continuous running, and no overload is allowed.
- C. Generator assemblies shall be UL 2200-listed, control panels shall be UL 508-listed and above-ground fuel tanks shall be UL 142-listed.
- D. Generators shall be rated for the specified KW, without overload, at the following Site conditions:
 - 1. Maximum Ambient Temperature: 40 degrees C.
 - 2. Altitude: 1000 feet above mean sea level.

2.2 MANUFACTURERS

- A. Provide generator systems of one of the following:
 - 1. Caterpillar
 - 2. Cummins/ONAN
 - 3. Or equal.

2.3 ENGINE

- A. Engine Type: Four-cycle compression ignition, water cooled diesel 1800 RPM. Two-cycle engines are not acceptable.
- B. Engine Construction:
 - 1. Steel-backed bearings.
 - 2. Crank Case: Reinforced cast iron.
 - 3. Crank Shaft: Forged alloy steel with hardened journals, finished and dynamically balanced.
 - 4. Cylinder Head: Cast iron.
 - 5. Pistons: Aluminum alloy with chrome faced rings.
 - 6. Replaceable cylinder liners and valve seat inserts for engines rated over 200 horsepower.
 - 7. Single-block construction. Bolted, multiple blocks are not acceptable.
- C. Cooling System:
 - 1. Radiator: Engine-mounted with engine-driven blower fan capable of cooling the engine under full load conditions in an ambient temperature of 104 degrees F without de-rating.
 - 2. Thermostatic valve in jacket water outlet between radiator and engine to maintain proper jacket water temperature. Engine-driven pump to circulate water through cooling system.
 - 3. Coolant: Fill system with 50 percent solution of ethylene glycol.
 - 4. Coolant water temperature gauge.
 - 5. High engine temperature shutdown.
 - 6. Loss of coolant shutdown.
 - 7. Fan guard.

8. Radiator face duct connection.
 9. Engine coolant heaters, thermostatically controlled, capable of keeping jacket water at temperature not less than 90 degrees F in compliance with NFPA
 10. Coolant heaters shall operate at 208 volts, single phase. House contactor for controlling heater in NEMA 4X stainless steel enclosure mounted on unit.
- D. Lubrication System: Positive displacement, mechanical, full pressure lube pump, full flow and bypass lubrication filters with replaceable spin-on canister elements, oil drain line with valves and dipstick oil level indicator.
- E. Fuel System: Suitable for operation on No. 2 diesel fuel oil. System to include primary and secondary fuel filters, fuel/water separator, fuel priming pump, flexible fuel lines and fuel pressure gauge.
- F. Governor: Electronic system to provide automatic isochronous frequency regulation. System dynamic capabilities to be controlled as function of engine temperature for fast stable operation at varying engine operating conditions. System to actively control fuel rate and excitation. Fuel rate to be regulated as function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous states.
- G. Fuel Oil Sub-base Tank
1. Construction: Heavy-gage steel primary tank, 48 hour capacity, and welded steel secondary containment sized to contain 110 percent of primary tank capacity. Rust inhibitor coating inside and prime- and finish-coated outside, color to match generator set exterior paint.
 2. Comply with the following:
 - a. UL142-listed and labeled.
 - b. NFPA 30, NFPA 37, and NFPA 110.
 3. Fittings: NPT for fuel supply and return; two-inch diameter NPT for normal vent, manual fill and level alarm; NPT for emergency vents, level gauge, basin drain, and leak detection alarm.
 4. Fuel level gauge and leak detector switch with alarm lights and contacts for remote annunciation of low fuel level and leak detection.
 5. Mushroom-type cap and screen for normal vent openings and pressure relief-type caps for emergency vent openings.
 6. Manufacturers: Provide sub-base tank of one of the following:
 - a. Pryco, Inc.
 - b. Tramont Corp.
 - c. Or equal.
- H. Air Supply/Exhaust Systems:
1. Heavy duty air cleaner with service indicator.
 2. Flexible stainless steel exhaust connector.
 3. Critical grade silencer with condensate drain ports.
 4. Schedule 40 stainless steel piping. Insulate indoor piping to limit surface temperature to 50 degrees C.

- I. Air Emissions:
 - 1. Comply with United States Environmental Protection Agency (USEPA) standards for non-road engines and with state and local requirements.
 - 2. Submit emissions data measurements for hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM) and oxides of nitrogen (NOx) conforming to USEPA test procedures. Include USEPA not-to-exceed requirements for each pollutant.

- J. Starting System: DC system complete with engine mounted batteries, locally mounted charger and connecting cables between batteries and engine and between charger and batteries.
 - 1. Batteries: Lead-acid or calcium/lead antimony, engine cranking type, rated in accordance with engine manufacturer's requirements for minimum of three 15-second cranking cycles at firing speeds without recharging, and to accommodate DC power requirements of control panel and other accessories requiring DC power.
 - 2. Battery racks, cables, connectors, and disconnect switch.
 - 3. Engine-mounted battery charging alternator and solid state voltage regulator.
 - 4. Battery Charger:
 - a. UL-listed, voltage regulated and equipped with float, taper and equalize charge settings.
 - b. Analog DC ammeter and voltmeter; 12-hour equalize timer; AC and DC fuses.
 - c. Loss of AC power, low battery voltage and high battery voltage alarm lights and contacts for remote annunciation; power on light.

2.4 ALTERNATOR

- A. Construction: Synchronous generator, four-pole, 2/3 pitch, revolving field, self ventilated, drip-proof construction, single bearing, dynamically balanced rotor with amortisseur windings to minimize voltage deviations and heating effects under unbalanced load conditions. Rotor directly connected to engine flywheel housing to ensure permanent alignment.

- B. Winding Insulation Systems: Class H in accordance with NEMA MG-1. Temperature rise not to exceed 130 degrees C over 40 degrees C ambient at rated load. Epoxy coating for fungus resistance and abrasion protection.

- C. Excitation System: Brushless construction. Excitation support system, permanent magnet type, to sustain 300 percent rated current for up to 10 seconds under short circuit conditions. Provide surge suppressors to protect against voltage spikes.

- D. Voltage Regulator: Automatic solid state system to maintain generator output voltage within plus or minus 0.5 percent from no load to full load. Control voltage buildup, provide volts per Hertz regulation, protect from over-excitation, limit voltage overshoot on startup, and be environmentally sealed.

- E. Provide anti-condensation heater to maintain temperature approximately five degrees Fahrenheit above ambient when generator is idle.

2.5 CONTROL PANEL

- A. Controls shall be in accordance with NFPA 110, Level 1, and control panel shall conform to the following:
 - 1. Install control panel on vibration isolators with controls, instruments, lights, and devices necessary to manually and automatically start, stop, monitor, and protect the generator.
 - 2. Controls shall be UL 508-listed and microprocessor-based with programmable adjustments. Control power from starting battery system. Panel shall include the following:
 - a. Emergency stop pushbutton.
 - b. Adjustable cycle cranking.
 - c. KW, KVA, KVAR, and power factor meters.
 - d. Engine coolant temperature readout.
 - e. Engine oil pressure readout.
 - f. Running time readout.
 - g. RPM meter.
 - h. Cool down timer.
 - 3. Readouts and dry contact outputs shall be provided as required by NFPA 110, Level 1.
 - 4. Provide output dry contacts for remote monitoring and control for the following:
 - a. Generator running
 - b. Generator common warning alarm.
 - c. Generator common shutdown alarm.
 - d. Low day tank fuel if day tank is used (warning alarm).
 - e. Low main tank fuel (warning alarm).
 - f. Liquid leak in containments areas, including tank, double walled piping, and other fuel supply components (warning alarm).
 - 5. Reset Control: Manual or remote restarts are not allowed, and alarm lamps shall remain in alarm state until manual reset is accomplished even if alarm condition has been corrected.
 - 6. Provide control panel anti-condensation space heater.

2.6 CIRCUIT BREAKERS

- A. General: Provide main and exciter circuit breakers, sized for protecting the engine-generator.
- B. Type: UL-listed, molded case with interchangeable electromechanical trip unit for sizes 225-amp and larger. Provide NEMA 1 enclosed units and mount on engine generator.

2.7 ENCLOSURE

- A. Provide engine-generator system with outdoor weatherproof enclosure where indicated in Paragraph 1.1.A.2 of this Section.
- B. Non-walk-in enclosure shall be constructed of minimum 14-gauge, reinforced sheet steel and shall attach directly to engine-generator base or sub-base fuel tank. Enclosure shall be factory assembled structure with key-lockable access doors for performing normal maintenance operations. Hardware and fasteners shall be stainless steel. Lube oil and coolant drains shall be extended to exterior of enclosure and terminated with drain valves, capped with pipe nipples on flanged connections.
- C. Sound Attenuation: Engine-generator enclosure shall be sound-attenuated to reduce noise level to 70 dBA at a point seven meters from engine-generator in free air environment, while operating at full load.
 - 1. Contractor shall provide access platforms with stairs and railing as required to access the generator. Platform design shall per design parameters as listed on general notes of structural drawings and per latest applicable building code

2.8 ACCESSORIES

- A. Engine Generator Mounting:
 - 1. Vibration Isolators: Steel springs in combination with rubber pads.
 - 2. Vibration Isolation: Provide flexible connections between engine-generator set and fuel lines, exhaust system, electrical conduits, and other externally connected support systems.
 - 3. Anchor Bolts: Type 316 stainless steel, conforming to Section 05 05 33, Anchor Systems.
 - 4. Template shall be furnished by manufacturer for setting anchorages devices, pipe sleeves, and nuts for mounting spring-type isolators to concrete foundation. Provide bolts and nuts for bolting isolators to channel frame base of engine-generator set.

2.9 GENERATOR DOCKING STATION

- A. Enclosure
 - 1. NEMA 3R Rain-Tight Enclosure
 - 2. Pad-lockable front door shall include a hinged access plate at the bottom for entry of temporary cabling that prevents unauthorized tampering while in use.
 - 3. NEMA 3R Integrity shall be maintained while temporary cabling is connected during use
 - 4. Front and Side shall be accessible for maintenance
 - 5. Top, Side, and Bottom shall be accessible for permanent cabling
- B. Bussing
 - 1. Material: Silver-plated Copper
 - 2. Bond equipment ground bus to box enclosure.

3. Provide insulated ground bus for system grounding.
- C. Temporary generator connectors shall be Camlok style mounted on gland plate.
 1. Camlok shall be 16 Series model and color coded according to system voltage requirements.
 2. Camlok connections shall be Bus Bar Style.
 3. Camlok connection shall be protected against accidental contact while not in use.
- D. Permanent connections shall be factory installed broad range set-screw mechanical type, located behind a physical barrier.
- E. Docking station shall have 65KAIC short circuit & withstand rating.

2.10 FINISHING

- A. Engine generator ferrous metal surfaces shall be prime-coated for corrosion protection and finish-painted in accordance with manufacturer's standard painting system.
- B. Color of finish paint to be selected by ENGINEER from manufacturer's standard colors.

2.11 SOURCE QUALITY CONTROL

- A. Factory Tests
 1. Following assembly, perform at the factory standard production tests to verify proper operation and performance. Tests shall include two-hour load test.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine the conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install engine generator system in accordance with the Contract Documents, approved Shop Drawings, and manufacturer's recommendations.

3.3 SITE QUALITY CONTROL

- A. Site Testing: Test engine-generator set in accordance with NFPA 110. Provide all materials and equipment, including load banks, fuel, lubricants and material required for Site testing. Completely fill fuel tank at conclusion of testing.

- B. Manufacturer's Services: Provide qualified, factory-trained serviceman to perform the following:
1. Supervise unloading and installation of equipment.
 2. Instruct CONTRACTOR in the installation of equipment.
 3. Inspect and adjust equipment after installation and ensure that equipment operates properly.
 4. Instruct OWNER's personnel in operating and maintaining the equipment.
 5. Service representative shall make a minimum of 4 visits, with a minimum of 8 hours at the Site for each visit. First visit shall be for unloading supervision and instruction of CONTRACTOR in installing equipment; second visit shall be for assistance in installation of equipment; third visit shall be for checking completed installation and start-up of system; fourth visit shall be to instruct operations and maintenance personnel. Representative shall revisit the Site as often as necessary until installation is acceptable.

++ END OF SECTION ++

SECTION 26 33 53

STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SCOPE

- A. The uninterruptible power supplies required under this Section shall be single or three-phase, continuous online, double-conversion, solid-state types.
- B. Maintenance bypass: A wall-mountable maintenance bypass shall provide for supplying the load directly from the AC utility supply, while the UPS is isolated for maintenance or repair.

1.2 RELATED SECTIONS

- A. Section 26 05 26, Grounding and Bonding for Electrical Systems
- B. Section 26 05 53, Identification for Electrical Systems

1.3 REFERENCES

- A. Definitions
 - 1. PWM – Pulse Width Modulated.
 - 2. IGBT – Insulated Gate Bipolar Transistor
- B. Reference Standards. UPS shall comply with the latest applicable provisions and recommendations of the following:
 - 1. ANSI C84.1
 - 2. IEEE C62.41
 - 3. IEEE C62.45
 - 4. UL 1449
 - 5. UL 1778

1.4 DESCRIPTION

- A. General
 - 1. The UPS shall consist of a converter, an inverter, a precision float battery charger, a sealed, maintenance-free battery, and a bypass switch housed in a self-contained, compact package.
 - 2. Each UPS shall provide the following operations:
 - a. Under normal conditions, the critical load shall be continuously supplied by the inverter.
 - 1) The inverter shall power the load while regulating both the voltage and the frequency.

- 2) The converter shall derive power from the AC source and shall supply DC power to the inverter. Simultaneously, the batteries shall be charged.
- b. When AC line power fails or goes out of tolerance, the battery source shall automatically supply the inverter via the DC link bus.
 - 1) There shall be no break in the output to the load, voltage, or frequency during the transfer from the normal AC line supply to the battery supply or from the battery supply back to the AC line supply.
 - 2) Upon restoration of the AC supply the battery charger shall automatically recommence charging the battery.
- c. In the UPS position, the bypass switch shall connect the conditioned output to the load.
- d. In the line position, the bypass switch shall cause the AC input line to be directly connected to the load.
- e. Each UPS shall have active voltage regulation to enable the UPS to maintain its output voltage and frequency with varying input sources.
- f. Each UPS shall be computer load compatible suitable for the demands of computer type loads including power factor corrected, switch-mode and linear power supplies.
- g. Power ratings, nominal input and output voltages, phases and frequency shall be as shown on the Contract Drawings.

B. Operating Criteria:

1. The uninterruptible power supply's operating criteria shall be in accordance with the following:
 - a. Ambient temperature range - 0 degrees C to 40 degrees C.
 - b. Operational humidity – up to 95 percent non-condensing.
 - c. Maximum altitude - 3,000 feet above sea level
 - d. Altitude correction - 1-degree C per 1,000 feet.
 - e. Voltage regulation - plus or minus 3 percent with input voltages plus fifteen to minus twenty percent of nominal.
 - f. Overload capability
 - 1) 150 percent surge and 125 percent for 10 minutes operating online
 - 2) 150 percent surge and 110 percent on the inverter.
 - g. Nominal frequency - 60 hertz
 - h. Adjustable tracking limits of .01 to 3 hertz.
 - i. THD – less than 5 percent at rated load.
 - j. Efficiency - 85 percent minimum.

C. Protection: The uninterruptible power supply shall have protective functions in accordance with the following.

1. Lightning and surge protection shall provide 2,000 to 1 spike attenuation.
2. Noise rejection shall provide common mode greater than 120 dB and normal mode greater than 60 dB.
3. Breakers shall provide overcurrent protection for DC and battery charger circuits.

1.5 QUALITY ASSURANCE

A. General

1. The UPS shall be designed, built and tested in accordance with the latest applicable editions of ANSI, IEEE, NEMA, UL, and NFPA.
2. The UPS shall be UL listed.
3. The UPS shall provide a reliable source of isolated, regulated uninterruptible power with no break in AC output power during a complete or partial interruption of incoming line power.
4. The UPS manufacturer shall have 10 or more years of experience in the design and be regularly engaged in manufacturing, and servicing equipment for installations of the type and size specified under this Section.
5. The UPS manufacturer shall use a shop test facility that has qualified, experienced technicians, for all shop tests.

B. Field Tests:

1. The UPS shall be field-tested.
2. Field testing shall be performed in accordance with the requirements specified under this Section
3. Retain the services of the UPS manufacturer for field service.
4. Field service shall be in accordance with the requirements specified under this Section.

1.6 SUBMITTALS

A. Contractor shall submit Shop Drawings and material specifications for the approval of the Engineer. Submittals shall include, but not be limited to:

1. Manufacturer's catalog cuts and technical information required to demonstrate compliance with the specific requirements and to show all physical features and enclosure dimensions.
2. A completed materials list showing all items proposed for use.
3. Control and wiring diagrams with construction details of enclosures.
4. Single-line diagrams
5. Three-line diagrams.
6. Technical specifications.
7. Construction details of enclosures.
8. Description of the shop and field-testing methods, procedures, and apparatus with calibration dates shall be submitted. Testing methods and procedures shall be submitted at least 90 days in advance prior to the conformation of witness testing dates and actual testing.

B. Reports:

1. Shop test and field test reports shall be submitted.
2. Manufacturer's site visit and acceptance testing reports shall be submitted.

C. Operation and maintenance

1. Operation and Maintenance manuals shall be submitted in accordance with this Section and the Specifications.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. The UPS equipment shall be delivered, stored, and handled in accordance with this Section, the Specifications and the manufacturer's recommendations and the following:
 - 1. UPS equipment shall be inspected for shipping damage or loose parts when received.
 - 2. Evidence of water which may have entered equipment during transit shall be checked.
 - 3. UPS equipment shall be lifted, rolled or jacked into locations shown on the Contract Drawings.
 - 4. UPS equipment shall be stored in a clean, dry location in which a uniform temperature is maintained.
 - 5. UPS equipment shall be protected in storage with suitable covering and air circulation maintained to ensure the equipment is kept dry and free from condensation.
 - 6. Where dampness or condensation may be encountered, heaters shall be provided for equipment to prevent moisture damage.

1.8 SPARE PARTS, SPECIAL TOOLS, AND SUPPLIES

- A. The spare parts shall be listed in an index and packed in containers suitable for long-term storage, bearing labels clearly designating the manufacturer's part number with complete information for use and reordering.
- B. Spare parts shall be furnished and shall include one set for every four systems installed per power rating. Each spare part set shall consist of the manufacturer's complete line of recommended spare parts inventory and shall include at a minimum the following:
 - 1. One set of fuses shall be provided of each size and type used.
 - 2. One set of boards including interface, connection, fuse, display, driver, power supply with accessories shall be provided.
 - 3. One set of modules including static switch assembly with accessories shall be provided.
 - 4. One set of current monitor boards and contactor including convertor, inverter, I/O and DC with accessories shall be provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. UPS/s shall be as manufactured by:
 - 1. Schneider Electric;
 - 2. Eaton;
 - 3. Or approved equal.

2.2 MATERIALS / EQUIPMENT

- A. The UPS section shall comprise components organized in a modular manner to facilitate easy replacement of components.
- B. Converter module
 - 1. The rectifier/charger shall convert the incoming AC power to a regulated DC output for supplying the inverter and for charging the battery.
 - 2. The rectifier/charger shall be PWM design, using IGBTs.
 - 3. The rectifier/charger module power factor under normal conditions shall be not less than 0.99
 - 4. The IGBTs shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their specified ratings.
- C. Inverter module
 - 1. The inverter shall comprise IGBT PWM design with high-speed switching.
 - 2. The inverter shall be capable of proving the required voltage and frequency while operating from the rectifier or the battery.
 - 3. The IGBTs shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their specified ratings.
- D. Static Bypass
 - 1. The static bypass shall comprise fully rated, continuous duty, naturally commutated static switches and facilitating high-speed transfers.
 - 2. The static bypass shall feature the following:
 - a. No break in output voltage and frequency.
 - b. Transfers complete in less than 2 cycles.
 - c. Transfers to bypass shall be automatically initiated for the following conditions:
 - 1) Output overload beyond the setting period time out.
 - 2) Bus voltage out of limits.
 - 3) Internal over temperature setting period time out.
 - 4) Battery approaching discharge
 - 5) Convertor or inverter failure
 - d. Transfers to bypass shall be inhibited for the following conditions:
 - 1) Bypass voltage out of limits
 - 2) Bypass frequency out of limits
 - 3) Bypass out of synchronization
 - 4) Phase rotation error.
 - e. Uninterrupted automatic re-transfers shall take place whenever the inverter is capable of assuming the load.
 - f. Uninterrupted automatic re-transfers shall be inhibited for the following conditions:
 - 1) When transfer is manually initiated.
 - 2) In the event of multiple transfer/retransfer cycles the control circuit shall limit cycling to 3 cycles in any ten-minute period. At the end of the third transfer the control shall lock the load on bypass and initiate an alarm.

3) Converter or inverter failure.

E. Batteries

1. Batteries shall be enclosed in the UPS cabinet or a separate cabinet when necessary.
2. Batteries shall be sealed maintenance free lead-calcium types.
3. Batteries shall be capable of maintaining the 110% of the rated load for 30 minutes.
4. Batteries shall be capable of a minimum of 200 complete full load discharge cycles when operated and maintained within specifications.
5. A DC breaker shall provide protection for the batteries.
6. UPS shall be capable of monitoring and alarming an open DC breaker.

F. Controls and Indicators

1. Microprocessor controlled circuitry
 - a. Fully automatic control of the UPS shall be provided through the use of a microprocessor controlled operating control system
 - b. Start-up and transfers shall be automatic functions, and shall not require operator intervention.
2. Front Panel Display
 - a. The UPS control panel shall be a touch sensitive, backlit LCD front panel that includes LED indicators for basic UPS status. The LCD display shall a minimum be configured the following sections:
 - 1) Home Screen
 - a) Show UPS status of output voltage, battery time remaining, and current alarms on all screens.
 - b) Show load level, average efficiency and power consumption in kW.
 - c) Show a system mimic diagram or menu showing power path, operating mode and active events.
 - 2) Control Section
 - a) Provide touch sensitive control buttons with confirming prompt, to at minimum
 - b) Turn UPS on or off.
 - c) Transfer to or from bypass.
 - d) Enable or disable the battery charger
 - e) Initiate a battery test.
 - 3) Metering Section
 - a) The metering section shall show voltages, currents, temperatures, kW, kVA and pf for the UPS input, output and bypass.
 - 4) Log Section
 - a) The log section shall show active alarms, alarm history, events, status changes and commands.
 - b) The period interval at which information is displayed shall be adjustable.

- 5) Settings Section
 - a) The settings section shall permit the adjustment of all ranges and discrete data points of the UPS such as
 - (1) Date and time
 - (2) Alarm designation
 - (3) Communications parameters
 - (4) UPS name
 - (5) Display language
 - (6) Passwords
- 3. Indicators
 - a. The colors for UPS alarm and event indicators shall be as follows:
 - 1) Red – The power source is supplying power to the rectifier/charger and the inverter is powering the load.
 - 2) Amber and Horn – An alarm condition has been detected.
 - 3) Blue – The UPS has transferred and is in the bypass state.
 - 4) Green – The power source has failed and the UPS battery is supplying the inverter which in turn is powering the load.

G. Interface Panel

- 1. A signal and communication interface panel located behind protective covers shall be provided and equipped with the following:
 - a. 4 Form C dry contact capable of relaying alarm and status conditions either as NO or NC signals.
 - b. Auxiliary contacts from the DC breaker
 - c. One host USB connector.
 - d. One device USB connector
 - e. One RS 232 port
 - f. One Modbus port

H. Maintenance bypass

- 1. Provide wall-mounted bypass switch with three modes of operation with make before break, transitions
 - a. Normal Mode: Load powered via UPS.
 - b. Bypass Mode : Load powered via the mains supply.
 - c. Test Mode: Load powered via the mains supply and UPS Isolated.
- 2. Bypass switches shall be UL listed.

I. Enclosure

- 1. Enclosures shall be provided in accordance with NEMA requirements as follows:
 - a. For dry, dusty locations, enclosures shall meet NEMA 12 requirements
 - b. For wet and corrosive locations, enclosures shall meet NEMA 4X requirements.
 - c. NEMA 4X enclosures shall be fabricated from 316 stainless steel
 - d. For hazardous locations UPS power shall be fed through intrinsically safe barriers from non-hazardous locations.
- 2. UPSs shall be designed for forced air cooling.

3. Cooling air shall be drawn in through the front of the unit and exhausted through the top.
4. All serviceable subassemblies shall be modular and capable of being replaced from the front of the UPS

2.3 SOURCE QUALITY CONTROL / SHOP TESTS

A. Certified Shop Tests:

1. Shop testing shall be performed on each UPS at the manufacturer's plant prior to shipment.
2. Shop test shall be in accordance with the latest revisions of IEEE and ANSI and shall demonstrate that the equipment tested conforms to the requirements specified.
3. The Contractor shall provide a shop test report. The report shall identify the tests performed and the results obtained.
4. UPS shop tests shall include the following:
 - a. Physical inspection shall be performed including verification of tightness of all connections and connections of wiring harnesses to and from individual modules and boards.
 - b. Functional tests which shall be the manufacturer's standard and include the following:
 - 1) Verification of the calibration of all UPS instrumentation
 - 2) Verification of all alarm and protections settings
 - 3) Verification of the operation of all modes of the UPS and the trouble free switchover from one mode to the next.
 - 4) A steady state load test verifying all input and output voltages, currents, frequency and balance among the phases at 0, 50 and 100% load.
 - 5) Monitoring current and voltage harmonics during the steady state load test and verification that harmonics are within stated limits.
 - 6) A transient load response test to verify voltage, current and frequency remain with specified limits when load acceptance and rejection is varied as follows
 - a) 0% to 50% to 0%
 - b) 25% to 75% to 25%
 - c) 50% to 100% to 50%
 - 7) A battery-rundown test

PART 3 - EXECUTION

3.1 INSTALLATION

- A. UPS equipment shall be installed in accordance with manufacturer's instructions and recommendations.
- B. UPS equipment shall be installed so that sufficient access and working space is provided for ready and safe operation and maintenance.

- C. UPS equipment shall be installed so that sufficient working space is provided for to ensure adequate ventilation and cooling.
- D. Where applicable UPS equipment shall be installed on concrete pads at locations shown on the Contract Drawings.
- E. Where applicable steel channels shall be provided for support of UPS equipment.
- F. UPS equipment shall be securely mounted to mounting surface/s with anchor bolts.
- G. Anchor UPS to satisfy the specified seismic requirements in accordance with the anchorage details.

3.2 FIELD TESTING / QUALITY CONTROL

A. Field Tests

1. After installation, UPS shall be field tested for operation and conformance.
2. The Contractor shall perform field tests in accordance with this Section and Specifications.
3. The field tests shall be witnessed by the Engineer and certified by the Contractor.
4. UPS testing shall be performed by the manufacturer's representative, prior to energizing equipment.
5. Equipment shall not be energized without the permission of the Engineer.
6. The testing shall be in accordance with the recommendations of the manufacturer's representative and shall consist at a minimum of the following:
 - a. Verification of the calibration of all UPS instrumentation
 - b. Verification of all alarm and protections settings
 - c. Verification of the operation of all modes of the UPS and the trouble free switchover from one mode to the next.
 - d. A steady state load test verifying all input and output voltages, currents, frequency and balance among the phases at 0, 50 and 100% load.
 - e. Monitoring current and voltage harmonics during the steady state load test and verify that harmonics are within stated limits.
 - f. A transient load response test to verify voltage, current and frequency remain with specified limits when load acceptance and rejection is varied as follows
 - 1) 0% to 50% to 0%
 - 2) 25% to 75% to 25%
 - 3) 50% to 100% to 50%
 - g. A battery-rundown test

B. Manufacturer's Field Services

1. The Contractor shall provide the services of a qualified manufacturer's service representative who shall adequately supervise and assist in the installation of the UPS, check the UPS installation before it is placed into operation, assist in the performance of field tests, observe and assist initial operations and train

the Contractor and the Owners operations and maintenance staff in the care, operation and maintenance of the UPS.

2. The Contractor shall provide a field report from the manufacturer's representative for each visit to the site. The report shall include complete information on time, schedule, tasks performed, persons contacted, problems corrected, tests results, training, instruction and all other pertinent information.

++ END OF SECTION ++

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install automatic transfer switches.

B. Related Sections:

1. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. IEEE 472, Guide for Surge Withstand Capability Tests.
2. IEEE 446, Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.
3. IEEE C62.41, Recommended Practice for Surge Voltages in Low Voltage AC Power Circuits.
4. NEMA ICS1 109, Tests and Procedures.
5. NEMA ICS10, AC Automatic Transfer Switches.
6. UL 1008, Transfer Switch Equipment.
7. UL 508, Industrial Control Equipment
8. UL 61010B-1 (previously UL 3111-1), Electrical Measuring and Test Equipment; Part 1: General Requirements.
9. ANSI C37.90a, Surge Withstand Capability Test (formerly IEEE Standard 472-1974) – Ring Wave Test.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. NEC Article 702, Optional Standby Systems.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
 - a. Listing of transfer switches to be provided, including ratings and location of each.
 - b. Equipment dimensions, and construction details of enclosures with conduit entry locations.

2. Product Data:
 - a. Manufacturer's technical information for products proposed, including catalog cut sheets.
 3. Test Procedures:
 - a. At least thirty days prior to actual factory and field testing, submit proposed testing procedures, methods and apparatus.
- B. Informational Submittals:
1. Source Quality Control Submittals:
 - a. Submit reports of completed factory tests, including test results and procedures used for testing.
 2. Field Quality Control Submittals:
 - a. Submit reports of completed field tests, including test results and procedures used for testing.
 3. Supplier Instructions:
 - a. Manufacturer's written instructions for transporting, handling, storing, and installing the products.
 4. Supplier Reports:
 - a. Written report of each visit to Site by supplier's service representative.
- C. Closeout Submittals
1. Operation and Maintenance Data:
 - a. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation, and spare parts information.
 - b. Manuals shall include record drawings of control schematics, including point-to-point wiring diagrams.
 - c. Furnish operation and maintenance manuals per Section 01 78 23, Operations and Maintenance Data.
- D. Maintenance Material Submittals: Furnish the following:
1. Spare Parts and Extra Stock Materials: Provide as specified in this Section.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to the Site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices to be embedded in cast-in-place concrete in time to prevent delay of the Work.
- B. Shipping sections shall be designed to be shipped by truck, rail, and ship. Indoor sections shall be bolted to skids.
- C. Equipment shall be equipped to be handled by crane. Where cranes are not available equipment shall be suitable for skidding in place on rollers using jacks to raise and lower the sections.
- D. Comply with Section 01 65 00, Product Delivery Requirements, and Section 01 66 00, Product Storage and Handling Requirements.

1.6 MAINTENANCE

A. Spare Parts and Extra Stock Materials:

1. Furnish, tag, and box for shipment and long term storage the following spare parts for each switch:

Item	Quantity per Switch
a. Control relay	Two of each type used
b. Pilot light	Two per ten of each type used
c. Fuses	Two set of each type and size used

2. Furnish a list of additional recommended spare parts for an operating period of one year. Describe each part, quantity recommended, and current unit price of each.
3. Package spare parts in suitable containers bearing labels clearly indicating contents and equipment with which they are to be used. Deliver spare parts at same time as switchgear.

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

- A. Provide automatic transfer switches as specified for transferring loads from one power source to another.

2.2 MANUFACTURERS

- A. Manufacturers: Provide products of one of the following:
 1. Eaton.
 2. ASCO Power Technologies.
 3. Or equal.

2.3 SWITCH

- A. Ratings:
 1. Switches shall be capable of switching all classes of loads and rated for continuous duty when installed in a non-ventilated enclosure.
 2. Switches shall be rated with continuous ampere rating, number of poles and voltage as shown on Drawings.
 3. Switches shall be rated to withstand the magnitude of fault current available without welding of contacts in compliance with ANSI C37.90a and IEEE C62.41.
- B. Standards and Performance:
 1. Switches shall comply with UL Standard 1008, NEMA Standard ICS10, and applicable requirements of NEC Article 700, IEEE 446, IEEE C62.41, UL 508,

and UL 61010B-1. Switches shall be UL labeled with performance meeting or exceed the following:

- a. Temperature Rise: Measurements shall be made after overload and endurance tests.
- b. Withstand: UL listed to withstand magnitude of fault current available at switch terminals when coordinated with respective protective devices shown on Drawings at an X/R ratio of 6.6 or less. Main contacts shall not trip open or weld when subjected to fault currents.
 - 1) As a condition for approval, manufacturer of automatic transfer switches shall verify that switches are listed by Underwriters Laboratories, Inc., Standard UL-1008 with three-cycle short circuit closing and withstand as follows:

RMS Symmetrical Amperes at 480 VAC	
Amperes	3 Cycle Closing & Withstand
100 to 400	65,000
600 to 800	65,000
1000 to 1200	85,000
1600 to 4000	100,000

- 2) During three-cycle closing and withstand tests, there shall be no contact welding or damage. Three-cycle tests shall be performed without using current limiting fuses, and oscillograph traces across main contacts shall be furnished to verify that contact separation has not occurred, and there is contact continuity across all phases after completion of testing. Test procedures shall be in accordance with UL-1008, and testing shall be certified by UL.
- 3) When conducting temperature rise tests to UL-1008, Supplier shall include post-endurance temperature rise tests to verify ability of transfer switch to carry full rated current after completing overload and endurance tests.

- c. Dielectric: Measurements shall be made at 1960 VAC RMS minimum following the withstand current rating test.
- d. Transient Withstand: Control panel shall pass the voltage surge withstand test per IEEE Standard 472 and voltage impulse withstand test per NEMA ICS1 109.

C. Construction:

- 1. Switch shall be double throw actuated by non-fused, momentarily energized operating mechanism(s).
- 2. Accomplish mechanical locking of main contacts in each direction without aid of latching solenoids, toggle mechanisms, or gear arrangements.
- 3. An overload or short-circuit shall not cause switch to go to a neutral position.
- 4. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.

5. Switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.
6. Main contacts shall be silver-tungsten composition. Switches shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.
7. Inspection of contacts shall be possible from front of switch without disassembly of operating linkages and without disconnecting power conductors. Switches rated 600 amps and higher shall have front-removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors or bus bars.
8. Transfer switch shall be equipped with a safe manual operator designed to prevent injury to operating personnel. Manual operator shall provide same contact-to-contact transfer speed as electrical operator to prevent a flash-over from switching main contacts slowly. Manual operation shall be safe even if electrical operator becomes energized and shall not require prior disconnection of operators or control wiring. Safe manual transfer shall be possible under all load conditions, energized or non-energized. Manual operator shall be an external type, operable through door of transfer switch enclosure. Operating personnel shall not be required to open transfer switch door to facilitate manual transfer. Manual operator shall be functional at all times, regardless of switch position or status. Manually initiated electrical operation does not meet intent of this requirement. Manual operator is not required on closed transition type switches.
9. Neutral Connections:
 - a. Switch shall include a solid neutral suitable for neutral conductors to be solidly connected. Provide neutral conductor plate with fully rated ALCU pressure connectors.
 - b. Provide switch with fully rated neutral transfer contacts.

D. Enclosure: Enclosed switches shall be NEMA 12 at minimum.

1. Standard and optional door-mounted switches and pilot lights shall be 30.5-mm industrial grade type or equivalent.
2. Provide door controls on a separate, removable plate that can be supplied loose for open type units.

E. Identification: Identify switches per Section 26 05 53, Identification for Electrical Systems.

2.4 TRANSFER SWITCHING FEATURES

- A. Delay Transition (Open): Unless otherwise shown, provide automatic delayed open transition transfer for each switch. Switch shall transfer load in delayed transition (break-before-make) mode. Transfer shall be accomplished with a user-defined interruption period in both directions adjustable from one second to five minutes in at least 15 increments.

- B. Closed Transition: When identified on drawings, provide automatic closed transition transfer for each switch. Switch shall transfer load without interruption (closed transition) by momentarily connecting both sources with overlapping contacts that operate only when both sources are present and acceptable. Maximum interconnection time shall be 100 milliseconds. Switch shall operate as a conventional break-before-make (open transition) switch when power source serving the load fails.
 - 1. Closed transition feature shall include suitable control to bring the generator supply into synchronism with power company supply and then soft load and unload generator accordingly.

2.5 SEQUENCE OF OPERATION

- A. When voltage on any phase of normal source is outside of specified parameters and after a programmable time delay period to allow for momentary dips, engine starting contacts shall close to start generating supply.
- B. Transfer switch shall transfer to emergency source when generating supply has reached specified voltage and frequency on all phases.
- C. In Open Transition switches, after restoration of normal supply on all phases to within specified parameters, an adjustable time delay shall delay retransfer to normal to assure stabilization of normal supply. After expiration of the time delay period, transfer switch shall retransfer to normal. Should emergency supply source fail during the time delay period, switch shall bypass time delay and automatically return to normal source. Provide an adjustable time delay between opening of closed contacts and closing of open contacts during transfers to allow loads to be demagnetized.
- D. In Closed Transition switches, after restoration of normal power on all phases to within specified parameters, an adjustable time delay shall delay retransfer to normal to assure stabilization of normal supply. After expiration of the time delay period, transfer switch shall retransfer to normal in a closed transition mode. Normal source contacts shall first close, followed by opening of emergency source contacts. Contact overlap time shall not exceed 100 milliseconds. If emergency power source should fail during time delay on retransfer period, transfer switch shall automatically return to normal source in an open transition mode.
- E. After retransfer to normal, engine generator shall be allowed to operate at no load for a programmable period to cool down.
- F. Should transfer to emergency source be initiated by test switch rather than an actual source failure, transfer from normal to emergency shall be as described above.

2.6 MICROPROCESSOR CONTROLLER

- A. Each switch shall include a microprocessor controller for operation of the switch. Equip controller with the following:
1. Provide controller's sensing and logic by a built-in microprocessor with ability to communicate through an optional ethernet communication module.
 2. Controller shall provide a minimum of five selectable nominal voltages. Voltage sensing shall be true RMS type and be accurate to plus/minus one percent of nominal voltage. Frequency sensing shall be accurate to plus/minus 0.2 percent. Controller shall be capable of operating over a temperature range of -20 to +60 degrees C and storage from -55 to +85 degrees C.
 3. Connect controller to transfer switch by an interconnecting wiring harness that shall include a keyed disconnect plug to enable controller to be disconnected from transfer switch for routine maintenance. Interfacing relays shall be industrial grade plug-in type with dust covers. Enclose controller with a protective cover. Mount controller internally but separately from transfer switch.
 4. Customer connections shall be wired to a common terminal block.
- B. Controller Display and Keypad:
1. Display and keypad shall be an integral part of controller for viewing available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through serial communications input port. The following parameters shall be adjustable:
 - a. Nominal line voltage and frequency
 - b. Single- or three-phase sensing
 - c. Operating parameter protection
 - d. Transfer operating mode configuration: Open transition, closed transition or delayed transition
 2. Instructions and controller settings shall be easily accessible, readable, and accomplished without using codes, calculations, or instruction manuals.
- C. Controller Voltage, Frequency and Phase Rotation Sensing:
1. Voltage and frequency on both the normal and emergency sources shall be continuously monitored, with the following pickup, dropout, and trip setting capabilities values shown as a percent nominal unless otherwise specified:

Parameter	Sources	Dropout/Trip	Pickup/Reset
Under-voltage	Normal and Emergency, three-phase	70 to 98%	85 to 100%
Over-voltage	Normal and Emergency, three-phase	102 to 115%	2% below trip
Under-frequency	Normal and Emergency	85 to 98%	90 to 100%
Over-frequency	Normal and Emergency	102 to 110%	2% below trip
Voltage Unbalance	Normal and Emergency	5 to 20%	1% below dropout

2. Repetitive accuracy of all settings shall be within plus/minus 0.5 percent over an operating temperature range of -20 degrees C to +60 degrees C.

3. Voltage and frequency settings shall be field adjustable in one percent increments, either locally with the display and keypad or remotely via serial communications port access.
4. When activated by keypad or through serial port, controller shall be capable of sensing phase rotation of both normal and emergency sources. Source will be unacceptable if phase rotation is not preferred rotation selected (ABC or CBA).
5. Source status screens shall be provided for both normal and emergency to provide digital readout of voltage on all three phases, frequency, and phase rotation.

D. Controller Time Delays:

1. Provide controller with time delays below. Time delay settings shall be adjustable over a range of zero to 9999 seconds (factory set at three seconds) unless specified otherwise.
 - a. Normal source failure, for engine starting.
 - b. Transfer to emergency on availability of emergency source.
 - c. Emergency source failure, retransfer on availability of normal source.
 - d. Engine cool down following retransfer to normal.
 - e. Time delay to control contact transition time during open transition transfer to either source.
 - f. All timers can be bypassed via operation on processor's keypad.
2. Provide adjustable time-delay on retransfer to normal. Time delay shall be automatically bypassed if emergency source fails and normal source is acceptable.
3. Provide a time delay activated output signal to drive external relays for selective load disconnect control. Controller shall have the ability to activate an adjustable zero to five-minute time delay for one of the following modes:
 - a. Prior to transfer only.
 - b. Prior to and after transfer.
4. Time delay and sensing functions shall be field adjustable and operate with drift that does not exceed plus/minus one percent of set frequency, plus/minus two percent of set voltage, and plus/minus ten percent of set time delay, over the temperature range of -20 degrees C to +70 degrees C.
5. Time delays shall be adjustable in one-second increments, except extended parallel time, that shall be adjustable in 0.01-second increments.
6. Time delays shall be adjustable by using display and keypad or with a remote device connected to serial communications port. Time delay value displayed shall be time remaining until next event occurs.
7. For (open) delay transition transfer switches controller shall include the following built-in time delays for delayed transition operation:
 - a. Zero to five-minute time delay for load disconnect position for delayed transition operation.
8. For closed transition transfer switches, controller shall include the following built-in time delays
 - a. One to five minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.
 - b. 0.1 to 9.99 second time delay on an extended parallel condition of both power sources during closed transition operation.

2.7 ACCESSORY FEATURES:

- A. Provide each switch with the following:
1. A two-position maintained-type test switch for test/automatic/ modes. Test position shall simulate a normal source failure.
 2. A SPDT silver-tungsten contact, rated five amps at 30 VDC, for a low-voltage engine start signal. Start signal shall prevent dry cranking of engine by requiring generator set to reach proper output and run for duration of cool down setting regardless of whether normal source restores before load is transferred.
 3. Auxiliary contacts rated ten amps at 250 VAC, consisting of one contact, closed when switch is connected to normal source and one contact closed when switch is connected to emergency source.
 4. LED indicating lights (30.5 mm, industrial heavy duty, oil-tight, NEMA rated to match automatic transfer switch enclosure). One shall indicate when switch is connected to normal source (green) and one to indicate when the switch is connected to emergency source (red).
 5. LED indicating lights (30.5 mm, industrial heavy duty, oil-tight, NEMA rated to match automatic transfer switch enclosure), energized by controller outputs. Lights shall provide true source availability of normal and emergency sources as determined by voltage sensing trip and reset settings for each source.
 6. Provide the following built-in to controller, capable of being activated through keypad programming or serial port only when required by user:
 - a. Provide ability to select “commit/no commit to transfer” to determine whether load should be transferred to standby generator if normal source restores before generator is ready to accept load.
 - b. Provide terminals for a remote contact that opens to signal switch to transfer to emergency, and for remote contacts that open to inhibit transfer to emergency or retransfer to normal. Provide ability to activate both inhibit signals through keypad or serial port.
 - c. Controller shall be capable of accepting a normally open contact that will allow transfer switch to function in a non-automatic mode using an external control device.
 - d. Engine Exerciser: Controller shall provide an internal engine exerciser that allows user to program up to seven different exercise routines. For each routine, user shall be able to:
 - 1) Enable or disable routine.
 - 2) Enable or disable transfer of load during routine.
 - 3) Set start time.
 - 4) Time of day
 - 5) Day of week
 - 6) Week of month (first, second, third, fourth, last, alternate, and every)
 - 7) Set duration of run.
 - 8) At end of specified duration, switch shall transfer load back to normal and run generator for specified cool down period. A ten-year life battery that supplies power to real time clock in event of a power loss shall maintain time and date information.

7. System Status: Controller display shall include a “System Status” screen that shall be readily accessible from all points in the menu by a maximum of two key strokes. System status screen shall display a clear description of active operating sequence and switch position.
8. Self-Diagnostics: Controller shall contain a diagnostic screen for detecting system errors. Screen shall provide information on status input signals to controller that may be preventing completion of load transfer commands.
9. Communications Interface: Controller shall be capable of interfacing, through ethernet communication module. Standard software specific for transfer switch applications shall be available from transfer switch manufacturer. Software shall include monitoring, control, and setup of parameters.
10. Data Logging: Controller shall have ability to log data and to maintain last 99 events, even during total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory:
 - a. Event Logging
 - 1) Date and time and reason for transfer normal to emergency.
 - 2) Date and time and reason for transfer emergency to normal.
 - 3) Date and time emergency source available.
 - b. Statistical Data
 - 1) Total number of transfers.
 - 2) Last ten numbers of transfers due to source failure.
 - 3) Total number of hours both normal and emergency sources are available.
11. Terminate control wires with crimp lugs and identify with sleeve type markers. Provide suitable copper connector lugs for each service and load connections.

2.8 SOURCE QUALITY CONTROL

- A. Perform manufacturer’s standard factory tests that shall include:
 1. Physical inspection and checking of components.
 2. Mechanical operation and device functional tests.
 3. Control operation and functionality tests.
 4. Primary, control, and secondary wiring hi-pot tests.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which Work is to be performed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

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

- B. Install equipment in accordance with Contract Documents and manufacturer recommendations.
- C. Securely fasten equipment to floors, walls, or other surfaces on which equipment will be mounted. Install freestanding switches on raised concrete pad at locations shown on Drawings. Install in accordance with manufacturer's recommendations.

3.3 FIELD QUALITY CONTROL

- A. Perform field testing and inspection of each automatic transfer switch. Testing and inspection shall be in accordance with manufacturer's recommendations and be performed by manufacturer's factory-trained representative, who shall inform OWNER and ENGINEER when equipment has been correctly installed. Do not energize equipment without permission of OWNER.

3.4 MANUFACTURER SERVICES

- A. Manufacturer Services:
 - 1. Unloading and Installation: Manufacturer's factory-trained representative shall be present during unloading of equipment and installation at equipment's final location. In advance of installation, representative shall train installing personnel in proper handling and rigging of equipment, for at least two eight-hour days at the Site.
 - 2. Manufacturer's factory-trained representative shall test the system as specified in Article 3.3 of this Section. Representative shall operate and test system in the presence of ENGINEER and verify that equipment conforms to requirements. These services shall be at least two eight-hour days at the Site.
 - 3. Manufacturer's factory-trained representative shall adjust the system to initial settings specified in Article 2.6 of this Section.
 - 4. Representative shall revisit the Site as often as necessary until all deficiencies are corrected, prior to readiness for final payment.
 - 5. Provide services of manufacturer's factory-trained representatives to correct defective Work within 72 hours of notification by OWNER during the Correction Period specified in the General Conditions as amended by the Supplementary Conditions.
 - 6. Replacement parts or equipment installed during the Correction Period shall be equal to or better than the original.
- B. Training: Furnish services of qualified factory trained specialists from manufacturer to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of the products. Training requirements, duration of instruction, and other qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.

++ END OF SECTION ++

SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES GENERAL

1.1 DESCRIPTION:

- A. CONTRACTOR shall retain the services of a Certified LPS Installer to fully design and provide lightning protection system on the following buildings and structures consisting of air terminals, conductors, ground terminals, interconnection conductors, arresters, and other connectors or fittings required for a complete system.
 - 1. Regional WWTP at Milton Street
 - a. Electrical Distribution Building
 - b. ESD Lift Station
 - c. District 1 Lift Station
 - d. Trickling Filters and Trickling Filter Pump Station
 - e. Solids Contact Electrical
 - f. Solids Contact Tanks
 - g. Moving Bed Biofilm Reactor
 - h. Carbon Storage and Pumping
 - i. UV Building
 - j. Scum and Sludge Pump Station
 - k. Solids Handling Facility
 - l. Administration Building
 - 2. Lake Street WWTP
 - a. Electrical Building
 - b. Lake St Influent Facility
- B. The Certified LPS Installer shall furnish all labor, materials, equipment, services and incidentals necessary for the installation of a functional and complete LPS as specified herein.

1.2 REFERENCES:

- A. National Fire Protection Association (NFPA):
 - 1. 70: National Electrical Code (NEC).
 - 2. 780: Lightning Protection Code.
- B. Underwriters' Laboratories, Inc. (UL):
 - 1. 96: Lightning Protection Components.
 - 2. 96A: Installation Requirements for Lightning Protection Systems.

1.3 SUBMITTALS:

- A. Submit the following shop drawings in accordance with Section 01 33 00, Submittal Procedures.
- B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 05, General Provisions for Electrical Systems.

- C. 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.
- D. 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).
- E. Inspection and Maintenance: Provide a written recommended inspection and maintenance procedure, including periodicity of inspections.
- F. 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 downloads, roof cables, bonding leads and connections, air terminals, etc., and in the case where structural steel is used for downloads, the method and location of all roof and ground connections to the steel must be clearly detailed.

1.4 QUALITY ASSURANCE:

- A. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied.
- B. 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.
 - 2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment, field erection; coordination of piping, electrical and miscellaneous utility connection:
 - a. 5 person-days.
 - 3. Functional Testing: Calibrate, check alignment and perform a functional test with water. Tests to include all items specified.
 - a. 5 person-days.
 - 4. Performance Testing: Field performance test equipment specified.
 - a. 5 person-days.
 - 5. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.
 - a. 1 person-day.
 - 6. Service inspections during first two years of operation, for use at Owner's request, and exclusive of repair, malfunction or other troubleshooting service calls.
 - a. 3 person-day.

7. Credit to the Owner, all unused service person-days specified above, at the manufacturer's published field service rate.
 8. 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.
- C. Provide systems designed, furnished and installed by a Lightning Protection Contractor.
1. Provide a "Certificate of Compliance" for work performed after completion. The certificate should state that the following has been done:
 2. 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.
 3. The lightning protection system ground system has been tested and interconnected to the facility grounding system as required by NFPA 70.
 4. Record drawings have been turned over to the Owner or his representative.
- D. Use UL listed components.

1.5 REQUIREMENTS OF REGULATORY AGENCIES:

- A. Conform to UL 96 and 96A and NFPA 780.

1.6 DELIVERY, STORAGE AND HANDLING:

- A. Comply with the requirements specified in Section 01 66 00.
- 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.

1.7 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

2.1 MANUFACTURERS:

- A. Thompson Lightning Protection Company, St. Paul, MN.
- B. Heary Brothers Lightning Protection Company, Springville, NY.
- C. American Lightning Rod Co., Dover, NH.
- D. Or Equal

2.2 MATERIALS:

- A. All materials used in the installation shall be new and shall comply in weight, size and composition as required by UL 96A and NFPA 780
- B. All lightning protection system fittings shall be heavy duty type.
- C. All bolts, screws and hardware shall be stainless steel.
- D. Air Terminals and Accessories
 - 1. Air Terminals shall be not less than 18 inches long, not less than 5/8-inch in diameter and may be manufactured in separate parts if longer than 10 inches.
 - 2. Air terminals shall include a cast bronze point protector, stainless steel adapter and copper base.
 - 3. Air terminals shall be provided with an integral base support or shall have not less than five full threads of engagement with a separate attachment base mounted to the structure.
 - 4. If the Air terminal has internal threads the wall thickness shall be not less than 1/16 inch at the base of the threads.
 - 5. Air Terminals longer than 24 inches shall have bracing at half its height and listed for the purpose
 - 6. Air terminal bases are permitted to be stamped or cast construction.
 - a. Copper bases shall 0.061 minimum for copper material. If cast either copper or aluminum shall be at least 3/32 inches thick.
 - b. Air terminal base support must incorporate a connector fitting for connection of the lightning conductor.
 - c. The conductor contact area must be at least 1-1/2 inches on all sides of the cable
- E. Conductors
 - 1. Class I
 - a. Main conductors shall be stranded copper conductors and shall be at least 57,400 circular mils at 187 lbs per 1000 ft.
 - b. Secondary or bonding conductors minimum size shall be 26,240 cir. mils for copper.
 - 2. Class II
 - a. Main conductors; shall be not less than 115,000 cir. mils for copper conductor at 375 lbs per 1000 ft.
 - b. Secondary or bonding conductors minimum size shall be 26,240 cir. mils for copper.

- F. Grounding Electrodes
 - 1. Ground rod electrodes shall be copper-clad steel, a minimum 5/8" diameter and 10 feet long.
 - 2. Ground rods shall conform to the requirements of Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- G. Ground Cables:
 - 1. Ground cables shall be copper or aluminum where necessary to prevent dissimilar metal reaction.
 - 2. Ground cable stranding, number and size shall be suitable for the classification of the structure to be protected.
 - 3. All ground cable where exposed shall be corrosion resistant.
- H. Non-metallic conduit shall be schedule 80 PVC plastic, 90 degrees C rated, conforming to UL No. 651.
- I. Non-metallic fittings shall be of same material and manufacturer as base conduit. Cement shall be provided for joining fittings to the conduit and shall be the same manufacturer as the base conduit.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Air Terminals and Air Terminal Accessories
 - 1. Air terminals shall extend a minimum of ten inches above the object or area they are to protect.
 - 2. Air terminals shall be located at intervals not exceeding 20'-0" along ridges of pitched roofs and along the perimeter of flat or gently sloping roofs (flat or gently sloping roofs include roofs that have a pitch less than 3:12).
 - 3. Flat or gently sloping roofs exceeding 50'-0" in width shall be provided with additional air terminals located at intervals not exceeding 50'.
 - 4. Air terminals shall be located within two feet of the ends of ridges, roof edges and outside corners of protected areas.
 - 5. Air terminals shall be installed on stacks, flues, mechanical units and other objects not located within a zone of protection.
 - 6. Permanent metal objects on the structure having an exposed metal thickness 3/16" or greater may be substituted for air terminals and shall be connected to the lightning protection system as required by the specified standards using main size conductor and bonding plates having a minimum of 3 square inches of surface contact area.
 - 7. Air terminal bases shall be securely fastened to the structure in accordance with the specified standards.
 - a. Fasteners may include stainless steel screws, bolts, nails or anchors.
 - b. Adhesives shall only be used to complete other types of fasteners and shall be compatible with the fastener and structure material
 - c. Any protective sheets or pads that may be required by the roofing system manufacturer shall be furnished and installed by the Contractor.

8. Air terminal spacing exceeding these dimensions, shall be permitted so long as the area protected lies within a zone of protection.
9. Air terminals shall be installed for stacks, flues, mechanical equipment, and other objects, having a metal thickness of less than 3/16 of an inch, and not located within a zone of protection.
 - a. Permanent metal objects having a metal thickness 3/16 of an inch or greater shall be connected to the LPS in lieu Air Terminals by main size conductors and bonding plates having a minimum of 3 square inches of surface contact area.

B. Conductors and Accessories

1. Conductors shall provide a two way, horizontal or downward path from each strike or air terminal to connections to the lightning protection ground electrode system.
2. Down conductors shall be sized as Class I or Class II materials in accordance with the specified standards.
 - a. Down conductors where required shall be concealed in the exterior wall construction.
 - b. Class II conductors from a higher portion of a structure shall continue to connections to the lightning protection ground electrode system.
 - c. Down conductors shall be spaced at intervals averaging not more than 100 feet around the perimeter of the structure.
 - d. In no case shall a structure have fewer than two down conductors.
 - e. Where down conductors are installed exposed on the exterior of a structure and are subject to physical damage or displacement, guards shall be used to protect the conductor a minimum of 6 feet above grade.
 - f. Metallic guards shall be bonded at each end.
3. In the case of structural steel frame construction, down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals averaging not more than 100 feet around the perimeter of the structure.
 - a. Connections to the steel frame shall be made with bonding plates having area of a minimum of 8 square inches.
4. Conductors shall be installed free of excessive splices and sharp bends.
5. Conductor bends shall form an included angle of not less than 90 degrees nor have a radius of bend of less than 8 inches.
6. Conductors shall be secured to the structure at intervals not exceeding 3 feet.
 - a. Fasteners shall be of the same material or of a material equally resistant to corrosion as that of the conductor.
 - b. Any protective sheets or pads that may be required by the roofing system shall be furnished and installed by the Contractor.
7. Connector fittings shall be listed for the purpose and of the same material as the conductor or of electrolytically compatible materials.

C. Ground Electrodes and Accessories

1. Each down conductor shall terminate at a ground electrode dedicated to the LPS, or to a building or facility ground electrode system that consists of multiple ground electrodes that are interconnected with a ground ring

- conductor.
2. The down conductor shall be connected to the ground electrode by as exothermically welded connection.
 3. Ground rod electrodes shall be located a minimum of 2 feet below grade and shall be installed below the frost line where possible (excluding shallow topsoil conditions).
 4. Where it is not possible to drive ground rod electrodes because of bedrock or shallow topsoil conditions, ground plate electrodes, radial electrodes, ground ring electrodes, concrete- encased electrodes, or combinations of these may be used in accordance with NFPA 780.
 5. Where the structural steel framework is utilized as down conductors for the system, ground electrodes shall be connected to columns around the perimeter of the structure at intervals averaging not more than 60 feet apart.
 6. The grounding connection at the columns shall be made using either bonding plates having 8 square inches of surface contact area or by exothermically welded connections.

D. Common Bonding of Grounded Systems

1. Common bonding of all grounded systems within the building shall be ensured by interconnecting them to the LPS using main size conductor and fittings.
2. For structures exceeding 60 feet in height, the interconnection of the LPS ground electrodes and other grounded systems shall be in the form of a ground loop conductor.
3. These grounded systems to be interconnected shall include but are not limited to the electrical service, communication, and antenna system grounds as well as all underground metallic piping systems including water, gas, sewer, underground metallic conduits, etc.
4. Interconnection to service lines or conduits shall be made on the customer's side of the meter.
5. Ground Electrodes in test wells shall be bonded to the ground system by a bronze ground rod clamp having at least 1-1/2 inches of contact between the rod and the conductor, measured parallel to the axis of the rod.
6. The system shall be installed with common grounding by interconnecting ground mediums entering the building using main size conductors and fittings. Grounded metal bodies shall be bonded to the system using bonding connections and fittings. Ground conductors where installed in conduit, shall be non - metallic type.

E. Potential Equalization

1. Grounded metal bodies located within the required bonding distance as determined by the bonding distance formula in NFPA780 shall be bonded to the LPS using the required bonding conductors and connections.

F. Roof Penetrations

1. Roof penetrations required for down conductors or for connection to structural steel framework shall be made using thru-roof assemblies with solid riser bars or conduits and appropriate roof flashing.
2. Conductors shall not pass directly through the roof.
 - a. The Contractor shall furnish and install the materials required to properly seal all roof penetrations of the LPS components and any additional roofing materials or preparations required by the roofing manufacturer for lightning conductor runs to assure compatibility with the warranty for the roof including roof pads that may be required to protect the roof under each of the lightning protection components.

3.2 FIELD TESTING / QUALITY CONTROL

- A. The Contractor shall have the master installer or inspector perform field inspection of the lightning protection system at several stages during the installation in accordance with LPI requirements.
- B. Upon completion of the lightning protection system the Contractor shall arrange for a final inspection of the system. The final inspection shall be performed by the master installer or inspector in accordance with LPI requirements.

++ END OF SECTION ++

SECTION 26 43 00

SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install surge protective devices (SPD).
2. SPDs furnished under this Section shall be ANSI/UL 1449 Type 2 integrating both surge suppression and high-frequency noise filtering suitable for use on low-voltage distribution systems.

B. Related Sections:

1. Section 26 05 05, General Provisions for Electrical Systems.
2. Section 26 11 16, Secondary Unit Substations.
3. Section 26 24 16, Panelboards.
4. Section 26 24 19, Motor Control Centers.

1.2 REFERENCES

A. Standards referenced in this Section are:

1. ANSI/UL 1449, Surge Protective Devices.
2. IEEE C62.11, Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV)
3. IEEE C62.41, Recommended Practice on Surge Voltages in Low-voltage AC Power Circuits.
4. IEEE C62.45, Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000 V and Less) AC Power Circuits.
5. UL 1283, Electromagnetic Interference Filters.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Shall have at least five years experience manufacturing and servicing products substantially similar to those required and shall be able to submit documentation of at least five installations in satisfactory operation for at least five years each.

B. Component Supply and Compatibility:

1. Obtain all products included in this Section regardless of component manufacturer from a single SPD manufacturer.
2. SPD manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.
3. Components shall be suitable for the specified service conditions and shall be integrated into overall assembly by SPD manufacturer.

- C. Regulatory Requirements: Comply with the following:
 - 1. NEC 110.9, Requirements for Electrical Installations, Interrupting Rating.
 - 2. NEC 240.21, Overcurrent Protection, Location in Circuit.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Electrical and mechanical drawings for each type of unit, showing electrical ratings, dimensions, mounting provisions, connection details, and layout diagrams.
 - b. Components list and nameplate schedule.
 - c. Summary sheets with schedules of equipment.
 - 2. Product Data:
 - a. Manufacturer's technical information, including catalog information.
 - b. Manufacturer's technical specifications with assembly and component ratings.
- B. Informational Submittals: Submit the following:
 - 1. Certifications:
 - a. Certification that SPD devices comply with standards referenced in this Section.
 - 2. Source Quality Control Submittals:
 - a. Report of results of testing and inspections performed at manufacturer's shop.
 - 3. Supplier Reports:
 - a. Submit written report of results of each visit to Site by Supplier's service technician, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
 - 4. Qualifications Statements:
 - a. Manufacture, when requested by ENGINEER.
- C. Closeout Submittals: Submit the Following
 - 1. Operations and Maintenance Data:
 - a. Submit in accordance with Section 01 78 23, Operations and Maintenance Data.
 - b. Include acceptable test reports, maintenance data and schedules, description of operation, wiring diagrams, and list of spare parts recommended for one year of operation with current price list.
 - 2. Warranty Documentation: Submit example warranty at time of shipment of the equipment. Include final warranty accepted by ENGINEER in the operations and maintenance manual for the equipment.

1.5 DELIVERY, STORAGE, AND HANDLING.

- A. Delivery:
 - 1. Upon delivery, check for evidence of water that may have entered equipment during transit.
- B. Storage:
 - 1. Store SPD equipment in a clean, dry location with controls for uniform temperature and humidity. Protect equipment with coverings and maintain environmental controls.
 - 2. Protect equipment from corrosion and deterioration.

1.6 WARRANTY

- A. General Warranty: The special warranty specified in this Article shall not deprive OWNER of other rights or remedies OWNER may otherwise have under the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by CONTRACTOR under the Contract Documents. The obligations of CONTRACTOR under the Contract Documents shall not be limited in any way by the provisions of the specified special warranty.
- B. Special Warranty on Materials and Equipment:
 - 1. Provide manufacturer's written warranty, running to the benefit of OWNER, agreeing to correct, or at option of OWNER, remove or replace materials or equipment specified in this Section found to be defective during a period of five years after the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Provide equipment of one of the following:
 - 1. General Electric.
 - 2. Schneider Electric/Square-D Company.
 - 3. Eaton/Cutler-Hammer.
 - 4. Or equal.

2.2 EQUIPMENT

- A. General:
 - 1. SPD shall be modular, high-energy, parallel design with fast-acting transient voltage suppression using metal oxide varistors. Equipment shall provide noise attenuation with electromagnetic interference filter.
 - 2. SPD shall comply with requirements of the following:
 - a. ANSI/UL 1449.
 - b. UL 1283.
 - c. IEEE C62.11, IEEE C62.41 and IEEE C62.45.

3. SPD shall be suitable for operation under the following environmental conditions:
 - a. Relative Humidity: Zero to 95 percent, non-condensing.
 - b. Frequency: 47 to 63 Hertz.
 - c. Temperature: Zero to 149 degrees F.
 4. SPD operating voltage and IEEE C62.41 and IEEE C62.45 Category A, B, and C application environments shall be suitable for the associated SPD location(s) shown or indicated on the Drawings.
 5. SPD shall be suitable for internal and external mounting. Where shown on the Drawings, SPD shall be factory-mounted and integrated into distribution equipment specified under the following Sections:
 - a. Section 26 11 16, Secondary Unit Substations.
 - b. Section 26 24 16, Panelboards.
 - c. Section 26 24 19, Motor Control Centers.
- B. SPD shall include a surge suppression path for each mode as required for the system configuration shown on the Drawings. Each mode shall be individually fused and equipped with thermal cutouts. SPD short-circuit rating shall be 200 kA. Protection modes shall include, to the extent applicable, the following:
1. Line-to-line.
 2. Line-to-neutral.
 3. Line-to-ground.
 4. Neutral-to-ground.
- C. SPD shall include electromagnetic interference/radio frequency interference (EMI/RFI) noise rejection filter with attenuation up to 30 dB from 10 kHz to 100 MHz.
- D. SPDs and components in the operating path shall have maximum continuous operating voltage greater than 115 percent of nominal system operating voltage.
- E. ANSI/UL 1449 minimum withstand rating shall be 20 kA per pole, and ANSI/UL 1449 voltage protection rating for SPD shall not exceed the following:

Modes	208Y/120	480Y/277
L-N,L-G, N-G	800	1200
L-L	1200	2000

- F. SPD surge capacity based upon IEEE C62.41 location category shall, as a minimum, be the following:

Category	Application	Per Phase	Per Mode
C	Service entrance	240 kA	120 kA
B	High exposure locations (distribution equipment)	160 kA	80 kA
A	Branch locations	120 kA	60 kA

2.3 ACCESSORIES

- A. Provide SPD equipped with the following accessories:
 - 1. Surge counter with display for indicating the number of surges detected.
 - 2. LED indicators for monitoring device status.
 - 3. Audible alarm and silence switch for indicating an inoperative condition.
 - 4. Dry contacts, "Form C", for remote annunciation of unit status.
 - 5. Indicators, counter, alarm, and silence switch shall be visible and accessible from front of the SPD. When SPD is integral to switchgear, motor control center, panelboard, or other equipment, indicators, counter, alarm, and silence switch shall be visible and accessible from front of the equipment in which the SPD is installed.

2.4 SOURCE QUALITY CONTROL

- A. Perform manufacturer's standard factory tests on equipment. Tests shall be in accordance with IEEE C62.45 and ANSI/UL 1449.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which materials and equipment will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install SPD at locations shown on the Drawings in accordance with equipment manufacturer's recommendations, Laws, and Regulations, and the Contract Documents.
- B. Conductor length between suppressor and connection point shall be as short and as straight as possible.

++ END OF SECTION ++

SECTION 26 50 00

LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install lighting fixtures and associated controls.
- B. Coordination:
 - 1. Coordinate location of fixtures with piping, ductwork, openings, and other systems and equipment and locate clear of interferences.
 - 2. Coordinate fixtures to be mounted in hung ceilings with the ceiling suspension system proposed.
- C. Related Sections:
 - 1. Section 26 05 05, General Provisions for Electrical Systems.
 - 2. Section 26 05 53, Identification for Electrical Systems.

1.2 REFERENCES

- A. Standards referenced in this Section are:
 - 1. UL 844, Luminaires for Use in Hazardous (Classified) Locations.
 - 2. UL 1598, Safety of Luminaires.
 - 3. IES LM-79, Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products
 - 4. IES LM-80, Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules
 - 5. IES TM-21, Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with the following:
 - 1. NEC Article 410, Luminaires, Lampholders, and Lamps.
- B. All luminaires shall be the products of lighting equipment manufacturers who have previously demonstrated, by performance and reputation, the ability to manufacture products of the quality specified and shall have a minimum of 5 years' experience manufacturing the luminaires specified. Such manufacturers must maintain an organization and manufacturing facility capable of actually manufacturing the specified luminaires.

- C. Luminaries over the range of operating voltage and temperature shall comply with the following:
 - 1. Minimum power factor of 0.95
 - 2. THD for both current and voltage of less than 10%
- D. Luminaries shall have integral UL Listed Class 2 drivers and ballasts.
- E. Luminaires shall have integral surge protective devices (SPD) to protect the luminaire from common mode transient peak voltages and transient peak currents
- F. Luminaires shall comply with DLC PR.
- G. Luminaires utilizing incandescent sources are not permitted.
- H. Luminaires shall utilize electronic or solid state drivers or ballasts where applicable.
- I. Fittings and other materials for special luminaires not definitely shown or specified shall be of approved material, make and quality and shall have a finish that will harmonize with other parts of the luminaires. Where suitable standard materials are not available such parts of the luminaires shall be specially manufactured.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Shop Drawings:
 - a. Schedule of light fixtures to be furnished, indicating fixture type and location for each.
 - b. Customized wiring diagrams.
 - 2. Product Data:
 - a. Manufacturer's technical information, specifications, standard wiring diagrams, and catalog cuts for lighting fixtures proposed.
 - b. Fixture construction details.
 - c. ETL photometric and isocandle curves for each fixture proposed.
 - d. Verification that recessed fixtures to be mounted in hung ceilings are compatible with ceiling suspension system proposed.
- B. Informational Submittals: Submit the following:
 - 1. Manufacturer's Instructions:
 - a. Instructions and recommendations for handling, storing, and protecting the equipment.
 - b. Installation instructions for the equipment, including setting drawings, templates, and directions and tolerances for installing anchorage devices.
- C. Maintenance Material Submittals: Submit the following:
 - 1. Spare Parts and Extra Stock Materials: Furnish spare parts for each type of unit required as indicated in Part 2 of this Section.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Delivery:
 - 1. Upon delivery, inspect equipment for evidence of water that may have entered equipment during transit.
- B. Storage:
 - 1. Store lighting fixtures, controls, related materials and equipment in clean, dry location with controls for uniform temperature and humidity. Protect materials and equipment with coverings and maintain environmental controls.
 - 2. Store materials and equipment for easy access for inspection and identification. Keep materials and equipment off ground, using pallets, platforms, or other supports. Protect materials and equipment from corrosion and deterioration.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Type: Lighting fixtures required shall be in accordance with the Lighting Fixture Schedule on the Drawings. Fixtures shall be complete with supports, ballasts, lamps, and incidentals, as required.
 - 1. Luminaires shall be provided with all necessary hangers, supports, conduit adaptors, reducers, hooks, brackets and other support hardware. All hardware shall have a protective, non-corrosive finish.
 - 2. Pendant mounted luminaires shall be suspended by means of an enclosed and gasketed cushion type hanger. The hanger shall be suitable to be mounted directly to the luminaire outlet box and shall provide a minimum of 8 degrees swing from the vertical. Stems shall be threaded rigid metal conduit, 1/2 inch minimum size. In corrosive areas stems shall be PVC coated.
 - 3. Where luminaires are subjected to moisture, or assembled of dissimilar metals, gaskets of approved material and thickness shall be provided.
 - 4. Luminaires shall be completely wired except where they will be directly connected to branch circuit wiring. The conductors shall be not less than No. 12 gauge, stranded, with approved heat resistant covering.
 - 5. Mounting heights of all luminaires shall be as shown on the Contract Drawings. For special types, the height shall be determined at the time of installation.
- B. Fixtures in hazardous locations shall be listed in accordance with UL 1598 and UL 844.
- C. Lamps:
 - 1. Lamps in association with their ballasts or drivers shall have voltage ratings suitable for the voltages shown on the Contract Drawings.
 - 2. The color temperature of lamps shall be such that the installed luminaire color temperature is as listed in this Section or shown on the Contract Drawings.
 - 3. LED lamps shall be in accordance with the following:
 - a. Comply with UL 8750
 - b. CRI of not less than 85

- c. Minimum efficacy of 140 lumens/watt
- d. Lamp L80 life of not less than 100,000 hours at 25 degrees C
- e. Maximum junction temperature of 150 degrees C
- f. Binning per ANSI C78.377 at 85 degrees C

D. LED Drivers:

- 1. LED drivers shall be matched to their lamps such that the luminaire supply voltage and its likely site variations shall produce a level of performance indicated in this Section and as shown on the Contract Drawings
- 2. LED Drivers in conjunction with the respective luminaire construction shall achieve the following:
 - a. Specified lumen output with variation from specified voltage of plus or minus 10%.
 - b. Rated life of not less than 100,000 hours.
 - c. THD of less than 10% across the specified voltage range and full power.
 - d. Power factor of not less than 95% and over the full range if dimming specified.
 - e. Consistent performance over the range of temperatures expected at the installation location either indoors or outdoors.
 - f. Cooling shall be achieved with static arrangements. Active cooling, thermal foldback or thermal sensing to achieve temperature control are not permitted.
- 3. Electrical connections between LED Drivers and all components of the luminaire shall be polarized and color coded to permit trouble free connection and reconnection. A connection diagram shall be imprinted on the Driver or the internal of the luminaire

E. Fixtures located in area identified as hazardous in Section 26 05 05, General Provisions for Electrical Systems, shall each be approved as a complete assembly, shall be clearly marked to indicate maximum wattage of lamps for which they are approved, and be protected against physical damage by suitable guards.

F. Hardware: Provide necessary hangers, supports, conduit adaptors, reducers, hooks, brackets, and other hardware required for safe fixture mounting. Hardware shall have protective, non-corrosive finish.

G. Outdoor Fixtures: Provide each fixture to be installed outdoors with cut-off lens to reduce the fixture's light pollution emissions.

H. Time Switch:

- 1. Type: Astronomic dial time switch with day-omitting device.
- 2. Products and Manufacturers: Provide of one of the following:
 - a. Z Series by Tork Time Controls, Inc.
 - b. Or equal.
- 3. Timing Motor: Heavy-duty, synchronous, self-starting, high torque, 120-volt or 277-volt, 60 Hertz, as shown on the Drawings.
- 4. Capacity: 40 amps per pole at 277 volts.

5. Dial: 24-hour rotation, with gear to provide one revolution per year that automatically raises the “ON” and “OFF” settings each day according to seasonal changes of sunset and sunrise.
6. Reserve Power: Spring driven reserve sufficient to operate time switch contacts for not less than 30 hours after power failure. On restoration of power, time switch shall transfer to synchronous motor drive and automatically rewind reserve.

I. Lighting Contactor and Controls:

1. Provide a lighting contactor and control system for control of each area where shown on the Drawings.
2. Product and Manufacturer: Provide products of one of the following:
 - a. Type SM03 by Square D Company.
 - b. Or equal.
3. System shall include:
 - a. Enclosure sized as required, complete with input control fuse and screw type terminal blocks rated 300-volt, 20-amp quantity for all circuits, unless indicated otherwise on the Drawings.
 - b. Single coil, electrically-operated, mechanically-held contactor. Contactor shall be rated 30-amp, 600-volt, with 120-volt operating coil, unless indicated otherwise on the Drawings. Number of poles shall be as shown on the Drawings. Provide multiple contactors when necessary.
 - c. Where lighting contactors are controlled by photocell, provide a 120-volt, two-pole control relay, enclosure mounted to convert the two-wire photocell control to three-wire control required by contactor. Control shall include a cover mounted on-off-auto selector switch for “manual” or “auto” selection of operation. In “auto” position, contactor shall respond to photocell.
 - d. Enclosure: As required for area classification per Section 26 05 05, General Provisions for Electrical Systems.
 - e. Identify panel in compliance with Section 26 0 53, Identification for Electrical Systems.

J. Photocell:

1. Products and Manufacturers: Provide one of the following:
 - a. 2100 Series by Tork Time Controls, Inc.
 - b. Or equal.
2. Cadmium sulfide hermetically-sealed cell, fully temperature compensated, with time delay of not less than 15 seconds to prevent false switching.
3. Built-in fail safe light level selector, adjustable within limits of two to 50 foot-candles and factory set at 25 foot-candles.

K. Motion/Occupancy Sensor:

1. Products and Manufacturers: Provide one of the following:
 - a. Leviton, Motion Sensor Field-of-View PR 150-1LW
 - b. Or equal.
2. Adjustable time delay interval of 15 seconds to 15 minutes.
3. Equipped with passive infrared (PIR) sensing technology.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. General:
 - 1. Fixture mounting heights and locations indicated on the Drawings are approximate and are subject to revision in the field where necessary to clear conflicts and obstructions.
 - 2. Mounting Heights: Mounting heights or elevations are to bottom of fixture or to centerline of device.
 - 3. Install fixtures in accordance with Laws and Regulations, the Contract Documents, and manufacturer instructions and recommendations.
 - 4. Mount fixtures so that sufficient access is available for ready and safe maintenance.
 - 5. Securely fasten equipment to walls or other surfaces on which equipment is mounted.
- B. Suspended Fixtures:
 - 1. Pendant-mount using 1/2-inch diameter conduit stems.
 - 2. Ground to outlet box.
 - 3. Attach mounting to building structure with expansion anchors.
 - 4. Fixtures shall not be dependent on the outlet box cover screws for support.
- C. Surface Mounted Fixtures:
 - 1. Attach to appropriate outlet box.
 - 2. Attach to surface using fasteners and sealing washers when mounting fixture in damp or wet locations.
- D. Boxes and Fixtures:
 - 1. For units mounted against masonry or concrete walls, provide suitable 1/4-inch spacers to prevent mounting back of box directly against wall.
 - 2. Bolt units rigidly to building with expansion anchors, toggle bolts, hangers, or Unistrut.
 - 3. Do not install boxes with open conduit holes.
 - 4. Cable each circuit and identify with tag.
- E. Re-lamp all fluorescent fixtures provided under this Contract with new lamps following Substantial Completion.
- F. Mount photocells as shown and adjust foot-candle setting for proper dusk and dawn photo-control. Provide wiring in conduit from photocell to controls.

G. Fixture Lowering System:

1. Hangers shall be plumb.
2. Provide adequate clearance between operating line and structural members, pipes, ducts, and other equipment and devices to avoid interference.
3. Conduit runs enclosing operating lines shall be straight with no offset bends.

++ END OF SECTION ++