



ADDENDUM NO. 01

To: Prospective Bidders & Plan Holders

From: Craig A. Johnson, P.E.
Crist Engineers, Inc.

Date: June 7, 2023

Project: Gulpha Basin Pump Station Improvements
Hot Springs, Arkansas

Bid Date: June 26, 2023

Bid Time: 2:00 PM

Location: Hot Springs Purchasing Office
324 Malvern Avenue
Hot Springs, Arkansas 71901

The BIDDER shall properly acknowledge Addendum No. 01 as required in Article 3 of Document 004100 on the Bid Form as confirmation that the BIDDER has examined the following Addenda and the related changes to the Contract Documents. Lack of proper acknowledgement on the Bid Form may deem a bid non-responsive.

The Contract Documents dated May 31, 2023, are hereby amended as follows:





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IMPORTANT REMINDERS:

The bid opening for this project is 2:00 PM, June 26, 2023.

Please reference Section 002113 - Instructions to Bidders, provided in the contract documents for information required for the bid submission.

CLARIFICATIONS:

None This Addendum

BID DOCUMENTS:

None This Addendum

SPECIFICATIONS:

1. Division 26 Electrical

- A. Division 26 Electrical Specifications were inadvertently omitted from the issued set of Bid Documents. Add the following specifications to the contract documents attached hereto:

DIVISION 26 – ELECTRICAL

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260600	Grounding and Bonding	6
260700	Hangers and Supports	5
261230	600-Volt or Less Wires and Cables.....	11
261250	Fiber Optic Cable and Appurtenances	12
261300	Conduits.....	15
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264120	Low Voltage Molded Case Circuit Breakers.....	4
264130	Low Voltage Insulated Case Circuit Breakers.....	5
264410	Group Mounted Circuit Breaker Switchboards	8
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264810	Generator (Owner Procured Equipment)	17
264820	Automatic Transfer Switch (Owner Procured Equipment).....	9
265100	Lighting LED Luminaires.....	7
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DRAWINGS:

None This Addendum

END ADDENDUM NO. 01

SECTION 260500

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. General requirements applicable to all Electrical Work.
2. General requirements for electrical submittals.
3. Interfaces to equipment, instruments, and other components:
4. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
5. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - b. Submit all such changes and additions to the Engineer for acceptance.
6. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
 - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
7. Loop drawings:
 - a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
 - 1) Conduit numbers and associated signal(s) contained within each conduit.
 - 2) Wire numbers.
 - 3) Equipment terminal numbers.
 - 4) Junction boxes and signal(s) contained within each junction box.
 - 5) Equipment power sources, and associated circuit numbers.
 - 6) As-built drawings detailing wiring.

- B. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
 2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.
 3. Owner is not responsible for any additional costs due to the failure of Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.
- C. Contract Documents:
1. General:
 - a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
 2. Specifications:
 - a. The General and Supplementary Conditions of the Contract Documents govern the Work.
 - b. These requirements are in addition to all General Requirements.
 3. Contract Drawings:
 - a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
 - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
 - c. The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
 - d. The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
 - e. Installation details:
 - 1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
 - 2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.
 4. Schematic diagrams:

- a. All controls are shown de-energized.
- b. Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
- c. Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
- d. Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
- e. Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

1.2 REFERENCES

A. Code compliance:

- 1. As specified in the section for Regulatory Requirements.
The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
- 2. The standards listed are hereby incorporated into this Section.
 - a. American National Standards Institute (ANSI).
 - b. American Society of Civil Engineers (ASCE):
 - c. ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
 - d. ASTM International (ASTM).
 - e. Illuminating Engineering Society (IES).
 - f. Institute of Electrical and Electronics Engineers (IEEE).
 - g. Insulated Cable Engineers Association (ICEA).
 - h. International Code Council (ICC):
 - i. International Code Council Evaluation Service (ICC-ES).
 - j. AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
 - k. International Society of Automation (ISA).
 - l. National Electrical Manufacturers Association (NEMA):
 - m. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - n. National Fire Protection Association (NFPA):
 - o. 70 - National Electrical Code (NEC).
 - p. National Institute of Standards and Technology (NIST).
 - q. Underwriters' Laboratories, Inc. (UL).
 - r. Compliance with laws and regulations: As specified in Document 00700 - General Conditions.

1.3 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:

1. IEEE.
2. NETA.
3. IES.
4. ISA.
5. NEC.
6. NEMA.
7. NFPA.
8. NIST.
9. Specific definitions:
10. FAT: Factory acceptance test.
11. LCS: Local Control Station
12. ICSC: Instrumentation and controls subcontractor.
13. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
14. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
15. PCIS: Process control and instrumentation system.
16. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
17. Space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
18. Spare: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
19. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
20. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.4 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:

- a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
 2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
 3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
 4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.
 5. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
 - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
 - b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
 - c. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
 - 1) As specified in the Contract Documents.
- B. Operating facility:
1. The Facility is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
 - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
 - b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
 - c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
 - d. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
 - e. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.5 SUBMITTALS

A. General:

1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
2. Furnish the submittals required by each section in the Electrical Specifications.
3. Adhere to the wiring numbering scheme specified in the section for Identification for Electrical Systems throughout the Project:
4. Uniquely number each wire.
5. Wire numbers must appear on all Equipment Drawings.
6. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

B. Seismic requirements:

1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Specifications.
2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare, and submit the following:
 - a. Statement of seismic qualification, and special seismic certification:
 - 1) "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in the section for Regulatory Requirements, including the requirements of ASCE 7, Chapter 13.
 - 2) "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with $I_p = 1.5$." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
 - b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
 - c. Anchoring design calculations and details:
 - 1) Submit project-specific drawings and supporting calculations, prepared, and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of the section for Seismic Design Criteria.
 - 2) Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
 - d. Temporary or moveable equipment.
 - 1) Equipment anchored to the structure and having a total weight of 20 pounds or less.
 - 2) Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.

C. Submittal organization:

1. First page:
 - a. Specification section reference.
 - b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
 - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
 - d. Place for Contractor's review stamp and comments.
2. Next pages:
 - a. Provide confirmation of specification compliance:
 - 1) Specification section: Include with each submittal a copy of the relevant specification section.
 - 2) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
 - 3) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
 - b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
 - 1) In the order that the comments or questions were presented throughout the submittal.
 - 2) Referenced by index section and page number on which the comment appeared.
 - c. Acceptable responses to Engineer's comments are either:
 - 1) Engineer's comment or change is accepted and appropriate changes are made.
 - 2) Explain why comment is not accepted or requested change is not made.
 - 3) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
 - d. Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
 - e. No further review by the Engineer will be performed until a response for previous comments has been received.
3. Remaining pages:
 - a. Actual submittal data:
 - 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
 - 2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

D. Submittal requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.

3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
4. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
5. Submit copies of shop drawings, and product data:
 - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
 - a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
7. Exceptions to Specifications and Drawings:
 - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
 - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
 - c. Acceptance of any exception is at the sole discretion of the Engineer.
 - d. Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
 - e. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
8. Specific submittal requirements:
 - a. Shop drawings:
 - 1) Required for materials and equipment listed in this and other sections.
 - 2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
 - 3) Shop drawings requirements:
 - a) Front, side, and rear elevations, and top and bottom views, showing all dimensions.
 - b) Locations of conduit entrances and access plates.
 - c) Component layout and identification.
 - d) Schematic and wiring diagrams with wire numbers and terminal identification.
 - e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.

- f) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
 - g) Weight.
 - h) Finish.
 - b. Nameplates:
 - 1) As specified in the section for Identification for Electrical Systems.
 - 2) Temperature limitations, as applicable.
 - c. Product data:
 - 1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
 - 2) Include:
 - a) Catalog cuts.
 - b) Bulletins.
 - c) Brochures.
 - d) Quality photocopies of applicable pages from these documents.
 - e) Identify on the data sheets the Project name, applicable specification section, and paragraph.
 - f) Identify model number and options for the actual equipment being furnished.
 - g) Neatly cross out options that do not apply or equipment not intended to be supplied.
 - h) Detailed sequence of operation for all equipment or systems.
- E. Operation and maintenance manuals:
 - 1. As specified in the section for Operation and Maintenance Data.
 - 2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.
- F. Material and equipment schedules:
 - 1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
 - 2. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- G. Schedule of values:
 - 1. In addition to completing all items referred to in the schedule of values, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.
- H. Roof penetrations:

1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.
- I. Record Documents:
1. Provide Record Documents of all Electrical Drawings.
 2. Record Drawing requirements:
 - a. Update Record Drawings weekly.
 - b. Record Drawings must be fully updated as a condition of the monthly progress payments.
 - c. Submit Record Drawings upon completion of the Work for final review.
 - d. Clearly and neatly show all changes including the following:
 - 1) All existing pipe, conduit, wire, instruments, or other structures encountered or uncovered during construction.
 3. Shop drawings:
 - a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
 - b. Provide as-built shop drawings for all electrical equipment on 11-inch by 17-inch paper.
 - c. Size all drawings to be readable and legible on 11-17-inch media.
 - d. Provide electronic copies of these documents on CD-ROM or DVD disks in PDF format.
 4. Review and corrections:
 - a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
 - b. Promptly correct and re-submit record documents returned for correction.
- J. Test reports:
1. Include the following:
 - a. A description of the test.
 - b. List of equipment used.
 - c. Name of the person conducting the test.
 - d. Date and time the test was conducted.
 - e. All raw data collected.
 - f. Calculated results.
 2. Each report signed by the person responsible for the test.
 3. Additional requirements for field acceptance test reports are specified in the section for Field Electrical Acceptance Tests.
- K. Calculations:
1. Where required by specific Electrical Specifications:
 - a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.6 QUALITY ASSURANCE

- A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the section for Product Requirements.
- B. Shipping precautions:
 - 1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
 - 2. Place dehumidifiers, when required, inside the polyethylene coverings.
 - 3. Skid-mount the equipment for final transport.
 - 4. Provide lifting rings for moving without removing protective covering.
 - 5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- C. Delivery and inspection:
 - 1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.
- D. Special instructions:
 - 1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

1.8 PROJECT OR SITE CONDITIONS

- A. Site conditions:
 - 1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
 - 2. Seismic load resistance:
 - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Specifications.
 - 3. Wind load resistance:
 - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Specifications.
 - 4. Altitude, temperature, and humidity:
 - a. As specified in Specifications.
 - b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
 - c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:

- d. Provide all power conduits wiring for these devices (e.g., heaters, fans, etc.) whether indicated on the Drawings or not.
5. Outdoor installations:
- a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
 - b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation, and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
 - c. Provide all wiring necessary to power these devices.
 - d. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
 - 1) NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
 - 2) NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
 - 3) NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.
 - 4) NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
 - 5) NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in the section for Hazardous Classified Area Construction.
6. Plant area Electrical Work requirements:
- a. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Indoor Conditioned Spaces	NEMA 1	Galvanized rigid steel	C	Stainless steel
Above lay-in ceilings	NEMA 1	EMT	C	Stainless steel
Indoor Non-Conditioned Spaces	NEMA 1	Galvanized rigid steel	C	Stainless steel

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Below Grade/Vault	NEMA 3R	Galvanized rigid steel	X	Stainless steel
Outdoor	NEMA 3R	Galvanized rigid steel	W	Stainless steel
Classified Areas	NEMA Type 7	Galvanized rigid steel	H	Stainless steel

Modify exposed conduit runs as specified in the section for Conduits.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:

1. Testing requirements are specified in the section for Field Electrical Acceptance Tests and other sections.

B. Pre-submittal conference:

1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire Project, equipment, control philosophy, schedules, and submittal requirements.
2. Contractor, electrical subcontractor, all suppliers, and individual equipment manufacturers furnishing major pieces of equipment must attend.

C. Factory acceptance testing (FAT):

1. Where FAT is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
2. Indicate the desired dates for inspection and testing.
3. Schedule the FAT after approval of the FAT procedures submittal:
 - a. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
 - b. Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

1.11 WARRANTY

A. Warrant the Electrical Work as specified in General Conditions:

B. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

- ##### A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:

- B. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.
- 1.13 OWNER'S INSTRUCTIONS (NOT USED)
- 1.14 MAINTENANCE
- A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
 - B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.
- B. Allowable manufacturers are specified in individual Electrical Specifications.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in General Conditions.
- C. Stainless steel:
 - 1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
 - 2. Provide exposed screws of the same alloys.
 - 3. Provide finished material free of any burrs or sharp edges.
 - 4. Use only stainless-steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
 - 5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
 - 6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT (NOT USED)

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES (NOT USED)

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. The electrical subcontractor is encouraged to visit the site to examine the premises completely before bidding.
- B. **Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.**
- C. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.
- D. Comply with pre-bid conference requirements as specified in Instructions to Bidders.

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

- A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
- B. Verify all dimensions indicated on the Drawings:
 - 1. Actual field conditions govern all final installed locations, distances, and levels.
- C. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
- D. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
- E. Provide a complete electrical system:
 - 1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.
 - 2. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- F. Cutting and patching:
 - 1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
 - 2. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting, or piercing:
 - 3. Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:

- a. Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
 - b. Use tone-locate system or X-ray to ensure that area is clear of obstructions.
 - c. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
- 4. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
 - a. 3M: CP 25WB+: Caulk.
 - b. 3M: Fire Barrier: Putty.
- 5. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
 - a. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.
 - b. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
 - c. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
 - d. Adjust equipment locations as necessary to avoid any obstruction or interferences.
 - e. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
 - f. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
- G. Earthwork and concrete:
 - 1. Install all trenching, shoring, concrete, backfilling, grading, and resurfacing associated with the Electrical Work:
 - a. Requirements as specified in the Contract Documents.
- H. Roof penetrations:
 - 1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.
- I. Terminations:
 - 1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.
- J. Miscellaneous installation requirements:
 - 1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in General Conditions.
 - 2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
 - 3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
 - 4. Circuits of different service voltage:

- a. Voltage and service levels:
 - b. Medium voltage: greater than 1.0 kV.
 - c. Low voltage: 120 V to 480 V.
 - d. Instrumentation: Less than 50 VDC.
 - e. Install different service voltage circuits in separate raceways, and junction boxes.
- 5. In manholes, install all cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.
- 6. Labeling:
- K. Equipment tie-downs:
 - 1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
 - 2. **ALL CONTROL PANELS MUST BE PERMANENTLY MOUNTED AND TIED DOWN TO STRUCTURES IN ACCORDANCE WITH THE PROJECT SEISMIC CRITERIA.**
- 3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 RE-INSTALLATION (NOT USED)
- 3.7 FIELD QUALITY CONTROL
 - A. Inspection:
 - 1. Provide any assistance necessary to support inspection activities.
 - 2. Engineer inspections may include, but are not limited to, the following:
 - 3. Inspect equipment and materials for physical damage.
 - 4. Inspect installation for compliance with the Drawings and Specifications.
 - 5. Inspect installation for obstructions and adequate clearances around equipment.
 - 6. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - 7. Inspect equipment nameplate data to verify compliance with design requirements.
 - 8. Inspect raceway installation for quality workmanship and adequate support.
 - 9. Inspect cable terminations.
 - 10. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in the section for Field Electrical Acceptance Tests.
 - B. Field acceptance testing (Functional Testing):
 - 1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
 - 2. Perform the field acceptance tests as specified in the section for Field Electrical Acceptance Tests.
 - 3. Record results of the required tests along with the date of test:
 - 4. Use conduit identification numbers to indicate portion of circuit tested.
 - C. Workmanship:

1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
2. Neatly coil and label spare wiring lengths.
3. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.8 ADJUSTING (NOT USED)

3.9 CLEANING

- A. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.
- B. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:
- C. Use of compressors or air blowers for cleaning is not acceptable.
- D. As specified in other sections of the Contract Documents.

3.10 PROTECTION

- A. Protect all Work from damage or degradation until Substantial Completion.
- B. Maintain all surfaces to be painted in a clean and smooth condition.

3.11 SCHEDULES (NOT USED)

END OF SECTION

SECTION 260600
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Grounding materials and requirements.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical.
- B. ASTM International (ASTM):
 - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 467 - Ground and Bonding Equipment.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.4 SUBMITTALS

- A. Furnish submittals as specified in the Submittal Procedures section and the Common Work Results for Electrical section.
- B. Product data:
 - 1. Catalog cut sheets.

1.5 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. All grounding components and materials shall be UL listed and labeled.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

- 1.7 PROJECT/SITE CONDITIONS (NOT USED)
- 1.8 SEQUENCING (NOT USED)
- 1.9 SCHEDULING (NOT USED)
- 1.10 WARRANTY
 - A. As specified in the Common Work Results for Electrical.
- 1.11 SYSTEM START-UP
 - A. As specified in the Common Work Results for Electrical section.
- 1.12 OWNER'S INSTRUCTIONS (NOT USED)
- 1.13 MAINTENANCE (NOT USED)

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Exothermic connectors: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Burndy.
 - 4. Thomas & Betts.
- B. Ground rods: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Nehring.
 - 4. Thomas & Betts.
- C. Ground cable: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Nehring.
 - 4. Southwire.
- D. Precast ground well boxes: One of the following or equal:
 - 1. Brooks Products, 3-RT Valve Box.
 - 2. Christy Concrete Products, G12 Valve Box.

2.2 SYSTEM DESCRIPTION

- A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.
- B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
 - 1. Grounding electrodes.
 - 2. Bonding jumpers.
 - 3. Ground connections.

- C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
- D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950 - Field Electrical Acceptance Tests, shall be:
 - 1. 5 ohms or less for industrial systems.

2.3 EXISTING PRODUCTS (NOT USED)

2.4 MATERIALS

- A. Ground rod:
 - 1. Minimum: 3/4-inch diameter, 10 feet long.
 - 2. Uniform 10 mil covering of electrolytic copper metallicity bonded to a rigid steel core:
 - a. The copper-to-steel bond shall be corrosion resistant.
 - 3. In accordance with UL 467.
 - 4. Sectional type joined by threaded copper alloy couplings.
 - 5. Fit the top of the rod with a threaded coupling and steel-driving stud.
- B. Ground cable:
 - 1. Requirements:
 - a. Soft drawn (annealed).
 - b. Concentric lay, coarse stranded in accordance with ASTM B8.
 - 2. Size is as indicated on the Drawings, but not less than required by the NEC.
- C. Exothermic welds:
 - 1. Current carrying capacity equal to that of the conductor.
 - 2. Permanent molecular bond that cannot loosen or corrode over time.
 - 3. Will not deteriorate with age.
 - 4. Use low emission welds for indoor installations.
- D. Equipment grounding conductors:
 - 1. Conductors shall be the same type and insulation as the load circuit conductors:
 - a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
 - 2. Minimum size in accordance with the NEC.
- E. Grounding electrode conductors:
 - 1. Minimum size in accordance with the NEC.
- F. Main bonding jumpers and bonding jumpers:
 - 1. Minimum size in accordance with the NEC.

2.5 MANUFACTURED UNITS (NOT USED)

2.6 EQUIPMENT (NOT USED)

2.7 COMPONENTS (NOT USED)

2.8 ACCESSORIES

- A. Precast ground well boxes:
 - 1. Minimum 10-inch interior diameter.
 - 2. Traffic-rated cast iron cover.

3. Permanent "GROUND" marking on cover.

2.9 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
 1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
 2. Provide a separate grounding conductor in each individual raceway for parallel feeders.
- C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
 1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.
- D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
 1. Individually bond these raceways to the ground bus in the equipment.
- E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.
- F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.
- G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.
- H. Duct bank ground system:
 1. Provide a bare copper grounding conductor the entire length of each duct bank.
 2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.
- I. Grounding at service (600 V or Less):
 1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

- J. Ground connections:
1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using exothermic welds as indicated on the Drawings, UL listed, and labeled for the application.
 2. Make ground connections in accordance with the manufacturer's instructions.
- K. Grounding electrode system:
1. Ground ring:
 - a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
 - b. Ground ring conductor shall be in direct contact with the earth.
 - c. Minimum burial depth 36 inches or as indicated on the Drawings.
 - d. Re-compact disturbed soils to original density in 6-inch lifts.
 2. Ground rods:
 - a. Locations as indicated on the Drawings.
 - b. Length of rods forming an individual ground array shall be equal in length.
 - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
 3. Metal underground water pipe:
 - a. Bond metal underground domestic water pipe to grounding electrode system.
 4. Metal frame of building or structure:
 - a. Bond metal frame of building or structure to grounding electrode system.
 5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
 6. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.
 7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.
- L. Shield grounding:
1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
 2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
 3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
 4. Terminate the signal cable shield on a dedicated grounding terminal block.
- M. Where indicated on the Drawings, install ground rods in precast ground wells.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING (NOT USED)

3.8 FIELD QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.9 ADJUSTING

- A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
 - 1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 260700
HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Mounting and supporting electrical equipment and components.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. ASTM International (ASTM):
 - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 3. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.4 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Demonstrate the following using generally accepted engineering methods:
 - a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
 - b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
 - 2. Design loading and anchoring requirements:
 - a. As indicated in the Building Code unless otherwise specified.
 - b. Seismic loading requirements:
 - 1) Freestanding, suspended, or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in the Common Work Results for Electrical section.
 - c. Wind loading requirements:
 - 1) All exterior equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in the Common Work Results for Electrical section.
 - d. Minimum safety factor against overturning: 1.5.
 - e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.
- B. Performance requirements:
 - 1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Submittal Procedures section and the Common Work Results for Electrical section.
- B. Product data:
 - 1. Supports:
 - a. Materials.
 - b. Geometry.
 - c. Manufacturer.
 - 2. Hardware:
 - a. Materials.
 - b. Manufacturer.
- C. Shop drawings:
 - 1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
 - 2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, and wall supports for all equipment:
 - a. For free standing supports and wall supports supporting equipment weight in excess of 200 pounds:
 - 1) Stamped by a professional engineer licensed in the state where the Project is being constructed.
 - b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
 - 3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.
- D. Installation instructions:
 - 1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
 - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM STARTUP

- A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. One of the following or equal:
 - 1. Preformed channel:
 - a. Thomas & Betts.
 - b. Power-Strut.
 - c. Unistrut.
 - d. Cooper B-Line.
 - e. Robroy.
 - f. Tyco.
- B. Nonmetallic cable rack:
 - 1. Underground Devices Inc.
 - 2. Hubbell.
 - 3. Unistrut.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS

- A. Use materials appropriate for the area as specified in the Common Work Results for Electrical section.
- B. Preformed channel:
 - 1. Stainless steel:
 - a. Supports:
 - 1) In accordance with ASTM A240.
 - 2) ANSI Type 316 material.
 - b. Hardware:
 - 1) ANSI Type 316 material.
- C. Non-metallic cable rack:
 - 1. Consists of stanchions and cable support arms.
 - 2. Stanchions:
 - a. 50 percent glass reinforced nylon or other non-metallic material.
 - b. Capable of supporting multiple arms.
 - c. Recessed bolt mounting holes.
 - d. Length as required.
 - 3. Arms:
 - a. 50 percent glass reinforced nylon or other non-metallic material.
 - b. Size the arms based on the length and weight of the cable to be supported.
 - 4. Stainless steel mounting hardware.

2.4 MANUFACTURED UNITS (NOT USED)

- 2.5 EQUIPMENT (NOT USED)
- 2.6 COMPONENTS (NOT USED)
- 2.7 ACCESSORIES (NOT USED)
- 2.8 MIXES (NOT USED)
- 2.9 FABRICATION (NOT USED)
- 2.10 FINISHES (NOT USED)
- 2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 - EXECUTION

- 3.1 EXAMINATION (NOT USED)
- 3.2 PREPARATION (NOT USED)
- 3.3 INSTALLATION

A. As specified in the Common Work Results for Electrical section.

B. Preformed Channel:

- 1. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.
 - a. Provide the necessary sway bracing to keep trapeze type structures from swaying under seismic events or wind loading.
- 2. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
 - a. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.
- 3. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
 - a. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
 - b. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
 - c. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.
- 4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
 - 1) Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
- 5. Corrosion protection:
 - a. Isolate dissimilar metals, except where required for electrical continuity.
 - 1) Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
- 6. Raceway:
 - a. Furnish all racks and trapeze structures needed to support the raceway from the structure.
 - 1) Group raceway and position on racks to minimize crossovers.
 - 2) Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.
- 7. Anchoring methods:

- a. Solid concrete: Anchor bolts, anchor rods or post-installed anchors.
 - b. Metal surfaces: Machine screws or bolts.
 - c. Hollow masonry units: Post-installed anchors.
- 8. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.
- 9. Recoat or seal all drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.
- C. Non-metallic cable rack:
 - 1. Install the non-metallic cable rack in accordance with the manufacturer's recommendations.
 - 2. Provide at least 2 stanchions and 2 arms at each installation.
 - 3. Mount the cable rack so that the supported cable does not interfere with access to manhole or handhole and so that the supported cable does not lie on the floor.
 - 4. Do not exceed the cable manufacturer's minimum bending radius.
 - 5. Use nylon cable ties to secure the cable to the supports.
- 3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 RE-INSTALLATION (NOT USED)
- 3.7 COMMISSIONING (NOT USED)
- 3.8 FIELD QUALITY CONTROL
 - A. As specified in the Common Work Results for Electrical section.
- 3.9 ADJUSTING (NOT USED)
- 3.10 CLEANING (NOT USED)
- 3.11 PROTECTION
 - A. As specified in the Common Work Results for Electrical section.
- 3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 261230

600-VOLT OR LESS WIRES AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. 600 volt class or less wire and cable.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. ASTM International (ASTM):
 - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. CSA International (CSA).
- D. Insulated Cable Engineers Association (ICEA):
 - 1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - 2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
- E. National Fire Protection Association (NFPA):
 - 1. 72 - National Fire Alarm and Signaling Code.
 - 2. 101 - Life Safety Code.
- F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
 - 1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
 - 2. 569-B – Commercial Building Standards for Telecommunications Pathways and Spaces.
 - 3. 1005 – Industrial Cabling Standard.
- G. Underwriter's Laboratories Inc., (UL):
 - 1. 44 - Thermoset-Insulated Wires and Cables.
 - 2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - 3. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
 - 4. 1569 - Standard for Metal-Clad Cables.
 - 5. 2196 - Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.
 - 6. 2225 - Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

- B. Specific definitions and abbreviations:
 - 1. AWG: American wire gauge.
 - 2. BCCS: Bare copper-covered steel.
 - 3. CPE: Chlorinated polyethylene.
 - 4. FEP: Fluorinated ethylene propylene.
 - 5. FHDPE: Foam high-density polyethylene.
 - 6. FPE: Foam polyethylene.
 - 7. OD: Outside diameter.
 - 8. PVC: Polyvinyl chloride.
 - 9. XHHW: Cross-linked high heat water resistant insulated wire.
- C. Definitions of terms and other electrical considerations as set forth in the:
 - 1. ASTM.
 - 2. ICEA.

1.4 SYSTEM DESCRIPTION

- A. Furnish and install the complete wire and cable system.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Manufacturer of wire and cable.
 - 2. Insulation:
 - a. Type.
 - b. Voltage class.
 - 3. AWG size.
 - 4. Conductor material.
 - 5. Pulling compounds.
- C. Shop drawings:
 - 1. Show splice locations.
 - a. For each proposed splice location provide written justification describing why the splice is necessary.
- D. Test reports:
 - 1. Submit test reports for meg-ohm tests.
- E. Calculations:
 - 1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
 - a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
 - b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.

- B. All wires and cables shall be UL listed and labeled.
- 1.7 DELIVERY, STORAGE, AND HANDLING
 - A. As specified in the Common Work Results for Electrical section.
- 1.8 PROJECT OR SITE CONDITIONS (NOT USED)
- 1.9 SEQUENCING (NOT USED)
- 1.10 SCHEDULING (NOT USED)
- 1.11 WARRANTY
 - A. As specified in the Common Work Results for Electrical section.
- 1.12 SYSTEM START-UP
 - A. As specified in the Common Work Results for Electrical section.
- 1.13 OWNER'S INSTRUCTIONS (NOT USED)
- 1.14 MAINTENANCE (NOT USED)

PART 2 - PRODUCTS

- 2.1 MANUFACTURERS
 - A. One of the following or equal:
 - 1. 600 volt class wire and cable:
 - a. General Cable.
 - b. Okonite Co.
 - c. Southwire Co.
 - d. Service Wire.
 - 2. Instrumentation class wire and cable:
 - a. Alpha Wire Co.
 - b. Belden CDT.
 - c. General Cable.
 - d. Okonite Co.
 - e. Rockbestos Surprenant Cable Corp.
 - 3. Network cables:
 - a. General Cable.
 - b. Belden.
 - c. CommScope.
- 2.2 EXISTING PRODUCTS (NOT USED)
- 2.3 MATERIALS
 - A. Conductors:
 - 1. Copper in accordance with ASTM B3.

2.4 MANUFACTURED UNITS

A. General:

1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
2. Permanently mark each wire and cable with the following at 24-inch intervals:
 - a. AWG size.
 - b. Voltage rating.
 - c. Insulation type.
 - d. UL symbol.
 - e. Month and year of manufacture.
 - f. Manufacturer's name.
3. Identify and mark wire and cable as specified in the Identification for Electrical Systems section:
 - a. Use integral color insulation for #2 AWG and smaller wire.
 - b. Wrap colored tape around cable larger than #2 AWG.

B. 600 volt class wire and cable:

1. Provide AWG or kcmil sizes as indicated on the Drawings:
 - a. When not indicated on the Drawings, size wire as follows:
 - 1) In accordance with the NEC:
 - a) Use 75 degree Celsius ampacity ratings.
 - b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
 - 2) Provide #12 AWG minimum for power conductors.
 - 3) Provide #14 AWG minimum for control conductors.
2. Provide Class B stranding in accordance with ASTM B8:
 - a. Provide Class C stranding where extra flexibility is required.
3. Insulation:
 - a. XHHW-2.
 - b. 90 degree Celsius rating.
4. Multiconductor cables:
 - a. Number and size of conductors as indicated on the Drawings.
 - b. Individual conductors with XHHW-2 insulation.
 - c. Overall PVC jacket.
 - d. Tray cable rated.
 - e. Color-coding for control wire in accordance with ICEA Method 1, E-2 in accordance with NEMA WC 57/ICEA S-73-532.
 - f. Ground conductor: Insulated, green:
 - 1) Sized in accordance with NEC.

C. Instrumentation class cable:

1. Type TC.
2. Suitable for use in wet locations.
3. Voltage rating: 600 volts.
4. Temperature rating:
 - a. 90 degree Celsius rating in dry locations.
 - b. 75 degree Celsius rating in wet locations.
5. Conductors:
 - a. Insulation:
 - 1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.

- b. #16 AWG stranded and tinned.
 - c. Color code: ICEA Method 1:
 - 1) Pair: Black and white.
 - 2) Triad: Black, white and red.
 - 3) Multiple pairs or triads:
 - a) Color-coded and numbered.
 - 6. Drain wire:
 - a. #18 AWG.
 - b. Stranded, tinned.
 - 7. Jacket:
 - a. Flame retardant, moisture and sunlight resistant PVC.
 - b. Ripcord laid longitudinally under jacket to facilitate removal.
 - 8. Shielding:
 - a. Individual pair/triad:
 - 1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
 - b. Multiple pair or triad shielding:
 - 1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
 - 2) Completely isolate group shields from each other.
 - 3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
 - c. All shielding to be in contact with the drain wire.
- D. Network cables:
- 1. Category 5e:
 - a. General:
 - 1) Provide Cat 5e cables meeting the standards set by TIA/EIA-568-C.2 and verified by third-party testing laboratory.
 - b. Conductors:
 - 1) #24 AWG solid bare annealed copper.
 - c. Insulation:
 - 1) Polyolefin.
 - 2) 4 non-bonded twisted pair cables formed into a cable core.
 - d. Shielding: None.
 - e. Color code (T568B):
 - 1) Pair 1: White/blue stripe and blue.
 - 2) Pair 2: White/orange stripe and orange.
 - 3) Pair 3: White/green stripe and green.
 - 4) Pair 4: White/brown stripe and brown.
 - f. Outer jacket:
 - 1) PVC with ripcord.
 - g. Electrical characteristics
 - 1) Voltage rating: 600VAC.

2.5 EQUIPMENT (NOT USED)

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES

A. Wire ties:

1. One of the following or equal:
 - a. T&B, "Ty-Rap" cable ties.
 - b. Panduit, cable ties.
- B. Wire markers:
 1. As specified in the Identification for Electrical Systems section.
- 2.8 MIXES (NOT USED)
- 2.9 FABRICATION (NOT USED)
- 2.10 FINISHES (NOT USED)
- 2.11 SOURCE QUALITY CONTROL
 - A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.
 - B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

- 3.1 EXAMINATION (NOT USED)
- 3.2 PREPARATION (NOT USED)
- 3.3 INSTALLATION
 - A. As specified in the Common Work Results for Electrical section.
 - B. Color-coding:
 1. Color-coding shall be consistent throughout the facility.
 2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Single phase system: Black for 1 hot leg, red for the other.
 - e. Neutral: White.
 - f. High phase or wild leg: Orange.
 - g. Equipment ground: Green.
 3. The following color code shall be followed for all 480/277 volt systems:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray.
 - e. Equipment ground: Green.
 4. The following color code shall be followed for all 120 VAC control wiring:
 - a. Power: Red.
 - b. Neutral: White.
 5. The following color code shall be followed for all general purpose DC control circuits:
 - a. Grounded conductors: White with blue stripe.

- b. Ungrounded conductors: Blue.
 - 6. Switch legs shall be violet. 3-way switch runners shall be pink.
 - 7. Wires in intrinsically safe circuits shall be light blue.
 - 8. Wire colors shall be implemented in the following methods:
 - a. Wires manufactured of the desired color.
 - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
 - 1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.
- C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
 - 1. Install wires only in approved raceways.
 - 2. Do not install wire:
 - a. In incomplete conduit runs.
 - b. Until after the concrete work and plastering is completed.
- D. Properly coat wires and cables with pulling compound before pulling into conduits:
 - 1. For all #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
 - a. Ideal Products.
 - b. Polywater Products.
 - c. 3M Products.
 - d. Greenlee Products.
 - e. Or equal as recommended by cable manufacturer.
 - f. Do not use oil, grease, or similar substances.
- E. Cable pulling:
 - 1. Prevent mechanical damage to conductors during installation.
 - 2. For cables #1 AWG and smaller, install cables by hand.
 - 3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
 - 4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
 - 5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
 - 6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
 - a. Make splices in manholes or pull boxes only.
 - b. Leave sufficient slack to make proper connections.
- F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.
- G. Install and terminate all wire in accordance with manufacturer's recommendations.
- H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
 - 1. Do not lace wires in gutter or panel channel.
 - 2. Install all wire ties with a flush cutting wire tie installation tool:
 - a. Use a tool with an adjustable tension setting.
 - 3. Do not leave sharp edges on wire ties.

- I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
 - 1. Use ring type lugs if box lugs are not available on the equipment.
- J. Lighting circuits:
 - 1. Each circuit shall have a dedicated neutral.
- K. Splices:
 - 1. Provide continuous circuits from origin to termination whenever possible:
 - a. Obtain Engineer's approval prior to making any splices.
 - 2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
 - 3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
 - a. Splice box NEMA rating requirements as specified in the Common Work Results for Electrical section.
 - b. Make splices in labeled junction boxes for power conductors.
 - c. Make splices for control and instrument conductors in terminal boxes:
 - 1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
 - 4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
 - 5. Clearly label junction and terminal boxes containing splices with the word "SPICE LOCATED WITHIN".
 - 6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
 - 7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
 - a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
 - 8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
 - a. A heat shrink insulating system listed for submersible applications.
 - b. Or an epoxy resin splicing kit.
- L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.
- M. Instrumentation class cable:
 - 1. Install instrumentation class cables in separate raceway systems from power cables:
 - a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
 - b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
 - 2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
 - 3. Shield grounding requirements as specified in the Grounding and Bonding section.
- N. Copper Ethernet cables:
 - 1. Comply with TIA/EIA-568-C.2.
 - 2. Pathways:

- a. For initial installation, the maximum fill capacity for pathways (i.e. conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
 - b. Conduit should be run in the most direct route possible with no more than two 90 degree bends between pull boxes and serve no more than 3 outlet boxes.
- 3. Cable bend radius:
 - a. Proper cable bend radius control must be maintained throughout the pathways. The bend radius needs to be at a minimum 10 times the cable diameter.
- 4. Cable pulling:
 - a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
 - b. The maximum pulling tension is not to exceed manufacturer recommendations. Cable installation should not in any way deform the cable jacket.
 - c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- 5. Cable management:
 - a. Organize and manage cables for quick and easy moves, adds and changes.
- 6. Testing:
 - a. All cables and termination hardware shall be 100 percent tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements of TIA/EIA-568-C.1 Section 11.
 - 1) All pairs of each installed cable shall be verified prior to system acceptance.
 - 2) Any defect in the cabling system installation including but not limited to cable, connectors, feed through couplers, patch panels, and connector blocks shall be repaired or replaced in order to ensure 100 percent useable conductors in all cables installed.
 - b. All twisted-pair copper cable links shall be tested for compliance to the requirements in TIA/EIA/568-C.2 for the appropriate Category of cabling installed.
 - c. All cables shall be tested in accordance with the contract documents, TIA/EIA standards, and best industry practice.
 - d. The field test equipment shall meet the requirements of TIA/EIA-568-C. The appropriate level III tester shall be used to verify Category 6 cabling.
 - e. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA/EIA-568-C.1.
 - f. Visually inspect cable placement, cable termination, grounding and bonding, equipment and labeling of all components.
 - g. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors.
 - 1) Test operation of shorting bars in connection blocks.
 - 2) Test cables after termination but not cross-connection.
 - a) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C.2.
 - (1) Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex.
 - (2) Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- 7. Separation from EMI sources:

- a. Comply with TIA/EIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches
 - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
 - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
 - e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
- O. Multi-conductor cable:
- 1. Where cable is not routed in conduit with a separate ground conductor, use 1 conductor in the cable as a ground conductor:
 - a) Use an internal ground conductor, if it is no smaller than as indicated on the Drawings and in accordance with NEC requirements for equipment ground conductor size.
 - b) Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with one of the full-sized conductors serving as ground.
- P. Armored cable:
- 1. Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with 1 of the full-sized conductors serving as ground.
 - 2. The cable armor is not acceptable as a ground conductor.
 - 3. Where armored cable terminates at a device, switchboard, panel, etc., use armored cable connector.
 - 4. Where armored cable run continues in conduit, strip jacket and armor for portions in conduit, and terminate cable and jacket with an armored cable connector threaded into a coupling or conduit box.
- Q. Telephone cable:
- 1. Install telephone cables in dedicated metallic raceways, including raceways in duct banks, manholes, and pull boxes.
- R. Fire alarm cable:
- 1. Install fire alarm cable in dedicated metallic raceways as indicated on the Drawings.
- S. Signal cable:

1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.
- T. Submersible cable in wet wells:
1. Provide Kellem's grip or stainless-steel wire mesh to support cable weight and avoid stress on insulation.
- U. Wiring allowances:
1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
 2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.
- 3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 RE-INSTALLATION (NOT USED)
- 3.7 COMMISSIONING
- 3.8 FIELD QUALITY CONTROL
- A. As specified in the Common Work Results for Electrical section.
- B. Grounding:
1. As specified in the Grounding and Bonding section.
- 3.9 ADJUSTING (NOT USED)
- 3.10 CLEANING (NOT USED)
- 3.11 PROTECTION
- A. As specified in the Common Work Results for Electrical section.
- 3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 261250

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Fiber optic cable.
 - 2. Fiber splices and terminations.
 - 3. Accessories.
- B. Furnish a complete fiber optic network as indicated on the Drawings.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. Bellcore Standards:
 - 1. GR-409, "Generic Requirements for Indoor Fiber."
- C. Electronic Industry Association (EIA) 455B "Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components":
 - 1. FOTP-25 - Impact testing of Fiber Optic Cables and Cable Assemblies.
 - 2. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test.
 - 3. FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables.
 - 4. FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable.
 - 5. FOTP-104 - Fiber Optic Cable Cyclic Flexing Test.
 - 6. FOTP-181 - Lightning Damage Susceptibility Test for Fiber Optic Cables with Metallic Components.
- D. Insulated Cable Engineer's Association (ICEA):
 - 1. S-83-596, "Optic Fiber Premises Distribution Cables."
 - 2. S-87-640, "Optic Fiber Outside Plant Communications Cable."
 - 3. S-104-696, "Indoor-Outdoor Optic Fiber Cable."
- E. TIA/EIA Standards:
 - 1. 598 - "Optical Fiber Cable Color Coding."
 - 2. 11801 – Information technology – Generic cabling for customer premises.
- F. Underwriters Laboratories, Inc. (UL):
 - 1. 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
 - 2. 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section and the Common Work Results for Process Control and Instrumentation Systems section.

- B. Specific definition:
 - 1. N/Cm: Newtons per centimeter.
 - 2. OTLS: Optical Loss Test Set (Tier 1 test).
 - 3. OTDR: Optical Time Domain Reflectometer (Tier 2 test).

1.4 SYSTEM DESCRIPTION (NOT USED)

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Complete manufacturer's brochures that identify materials and options.
 - 2. Completed data sheets, including catalog number and source for determining catalog number.
 - 3. Manufacturer's installation instructions.
 - 4. Include the following:
 - a. Manufacturer's data on testing equipment used on this project.
 - b. Manufacturer's specifications and data sheets for all fiber types.
 - c. Manufacturer's specifications and data sheets for all connectors, bulkheads, splicing kits, breakout devices, and appurtenances used connecting and terminating the fiber spans.
 - 5. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the NIST.
 - 6. Manufacturer's test procedures and quality assurance procedures:
 - a. After review, the Engineer may require that additional tests be performed before installation.
- C. Shop drawings:
 - 1. Interconnection cabling diagrams for the complete system including every fiber in each cable.
 - 2. Drawings indicating the locations of all pull boxes including pull box identifiers and lengths.
 - 3. Submit optical power budget calculations for all fiber segments. Include the following:
 - a. Minimum transmit power of active devices.
 - b. Minimum receive sensitivity.
 - c. Available power, in dBm.
 - d. Loss for each segment in dBm, including cable attenuation and connector losses. Use manufacturer's data for cable attenuation, at the wavelength to be used. Assume 0.5 dB per connector.
 - e. Demonstrate that remaining power budget at each receiver is equal to or greater than 3.0 dBm.
- D. Installation instructions:
 - 1. Submit a cable pulling and splicing work plan a minimum of 45 days before the planned initiation of cable pulling. The cable pulling and splicing work plan must be approved a minimum of 15 days before pulling cable. Include the following:
 - a. Pull tension calculations.
 - b. Detailed description of pull operation methods for all conduit runs.
 - c. Tools and equipment to be used for cable installation and testing.
 - d. Physical location of equipment setup and type.
 - e. Exact locations of splice points.
 - f. Safety and manual assist cable-pulling operations.
 - g. Detailed schedule for pulling and testing cables.
 - h. The name and qualifications of the supervisory personnel directly responsible for the installation of the conduit system.

- i. Sample fiber optic cable test sheets.
 - j. All signed test sheet results.
- E. Operation and maintenance manuals:
 - 1. Compile completed test reports, instruction manuals, and manufacturer's information into the operating manuals and submitted in accordance with the Operation and Maintenance Data section.
- F. Test reports:
 - 1. Submit the results of all specified tests to the Engineer.
 - 2. Submit 3 copies of all test reports showing the results of all tests specified herein or in the Field Electrical Acceptance Tests section:
 - a. Test forms shall include the following information at a minimum:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Wavelength.
 - 5) Index of refraction.
 - 6) Cable identification.
 - 7) Fiber type.
 - 8) Fiber number.
 - 9) Fiber color.
 - 10) Result of the value of the tested parameter.
 - 3. Furnish hard copy and electronic copy for all OTDR traces.
 - 4. Submit certification that the fiber optic cable has passed each testing stage:
 - a. Submit separate documentation for each testing stage result.
- G. Record documents:
 - 1. Furnish updated electrical drawings, network diagrams, and fiber cable block diagrams at the end of construction and submit as Record Drawings.
- H. Calculations:
 - 1. Cable pulling calculations for all conduit runs:
 - a. Indicate on the submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Furnish all cable and appurtenances manufactured within 1 year of installation.
- C. Proof test all optical fibers by the fiber manufacturer at a minimum load of 50 kpsi.
- D. Provide 100 percent attenuation testing for all optical fibers:
 - 1. Include with each cable reel the attenuation of each fiber.
- E. Provide information on at least 5 successful fiber optic cable installations of comparable size and complexity in the past 3 years with name, address, and telephone number of facility owner, name of project with completion date, and type of conduit system and length of cable pulled.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

- B. Package the cable for shipment on wooden reels:
 - 1. Seal both ends of the cable to prevent the ingress of moisture.
 - 2. Place fiber cable assemblies on reels such that both cable ends are available for testing.
 - 3. Weatherproof cable reel markings shall include the following:
 - a. Manufacturer.
 - b. Date of manufacture.
 - c. Shipping date.
 - d. Cable identification.
 - e. Cable configuration/fiber count.
 - f. Cable length.
 - g. Gross weight.
 - h. Cable test date.
 - i. Handling instructions.
 - j. Direction to unreel.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING

- A. Testing:
 - 1. Perform testing of each fiber in each cable as follows:
 - a. At the factory before shipment.
 - b. At the project site upon delivery.
 - c. After installation, before breakout and terminations.
 - d. After installation is complete.
 - 2. Submit test reports following each set of tests as specified in this Section.
- B. Notify the Engineer and Owner a minimum of 15 days before post-installation testing.

1.10 SCHEDULING

- A. As specified in the Common Work Results for Electrical section.

1.11 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable manufacturers are indicated with each component type as listed in the remainder of this specification.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS

A. General fiber cable requirements:

1. Suitable for the installed environment.
2. Color-coded fibers according to EIA/TIA-598.
3. Color-coded buffer tubes according to EIA/TIA-598.
4. Furnish buffer tubes of a single layer nylon construction or of a material with similar mechanical performance.
5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
6. Apply binders with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes:
 - a. Provide binders that are:
 - 1) Non-hygroscopic.
 - 2) Non-wicking (or rendered so by the flooding compound).
 - 3) Dielectric with low shrinkage.
7. Provide a minimum of 1 ripcord under the cable sheath.
8. Provide the high tensile strength Aramid yarns, Kevlar, and/or fiberglass helically stranded evenly around the cable core:
 - a. No metallic elements whatsoever are allowed in non-armored cable.
9. The jacket or sheath shall be free of holes, splits, and blisters.
10. Mark the jacket or sheath with:
 - a. Manufacturer's name.
 - b. The words "Optical Cable".
 - c. Year of manufacture.
 - d. Sequential meter marks.
 - e. Repeat markings every 1-meter.
 - f. The actual length of the cable to be within 1 percent of the length marking.
 - g. The marking must be in a contrasting color to the cable jacket.
 - h. The height of the marking:
 - 1) Approximately 2.5 millimeters.
11. The shipping, storage, and operating temperature range of the cable shall be -40 degrees Celsius to +70 degrees Celsius.
12. General performance characteristics:
 - a. The rated tensile load of the cables:
 - 1) Indoor/outdoor:
 - a) Short term: 1,330 N.
 - b) Long term: 400 N.
 - b. Non-armored fiber optic cables: Compressive load withstand of 220 N/cm applied uniformly over the length of the cable.
 - c. Armored fiber optic cables: Compressive load withstand of 440 N/cm applied uniformly over the length of the cable.
 - d. The average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm for a cable subjected to this load:
 - 1) With no measurable increase in attenuation after load removal.
 - e. Test in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cable," except that the load must be applied at the rate of 3 millimeters to 20 millimeters per minute and maintained for 10 minutes.
 - f. Capable of withstanding 25 cycles of mechanical flexing at a rate of 30 within 1 cycles/minute.
 - g. The average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm at the completion of the test.

- h. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 millimeters constitutes failure.
 - i. Outer cable jacket cracking or splitting observed under 10X times magnification constitutes failure.
- B. Indoor/outdoor cable:
 - 1. Cable construction:
 - a. General:
 - 1) Cable type: Indoor/Outdoor - Flame retardant, low smoke, zero halogen, UV resistant.
 - 2) Fiber count: As indicated on the Drawings.
 - 3) Fiber type: As indicated on the Drawings.
 - 4) Buffer tube: Loose tube.
 - 5) Armoring: None.
 - 6) Waterproofing: Water blocking layer.
 - 7) Strength member:
 - a) Loose tube: Utilize a central, nonmetallic strength member with a coefficient of thermal expansion similar to the fibers as the central anti-buckling member.
 - 8) Approvals and listings: UL 1666 and UL 1685.
 - 9) Design and test criteria: In accordance with ICEA S-104-696.
 - b. Testing:
 - 1) All fibers in the cable:
 - a) Proof test of 100 kpsi.
 - b) Each optical fiber: Bellcore GR-409 strip force testing.
 - c) No gaps are allowed between the coating material and the buffer material visible under a 50-power microscope.
 - c. Outer jacket material:
 - 1) Linear low-density polyethylene.
 - 2) Meet all requirements of the NEC for use in all indoor/outdoor areas (excluding plenums) without being enclosed in conduit.
 - 3) Flame retardant OFNR riser rated conforming to UL 1666.
 - 4) Printed with all necessary UL marks and manufacturer identification.
 - 5) Sequential printing of footage in 2-foot increments.
 - 6) With a ripcord incorporated under the cable jacket.
- C. Single mode fibers:
 - 1. All fibers in the cable must be usable fibers and meet required specifications.
 - 2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
 - 3. Single mode fiber characteristics:
 - a. Category: OS2 compliant with ITU-G.657.A1.
 - b. Jacket color: Yellow
- D. Indoor/outdoor:
 - 1. Loose tube:
 - a. Corning Cable Systems, Freedm®.
 - b. CommScope, LazrSPEED/TerraSPEED.

2.5 EQUIPMENT (NOT USED)

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES

A. Patch cords:

1. General:

- c. Connector types to match supplied equipment and the patch panel terminations.
- d. Maximum length of patch cords: 25 feet.
- e. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
- f. Factory assembled and optically tested.
- g. Provide mode-conditioning cords for multimode fibers operating at 1310 nm.

2. Manufacturers: One of the following or equal:

- h. CommScope.
- i. Corning Cable Systems.

B. Fiber connectors:

- 1. As specified in the Control Systems: Network Materials and Equipment section.

C. Fiber optic identification/warning tags:

- 1. Black letters on orange or yellow background.
- 2. UV resistant polyethylene or other suitable material.
 - j. Manufacturers: The following or equal.
 - 1) Almetek.

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify the condition of the conduit system before installation of the fiber optic cable or inner duct.
- B. Pass a test mandrel through all fiber optic conduits prior to pulling fiber or installing inner duct.
 - 1. Run the mandrel in both directions.
- C. Examine all materials and equipment before installation and verify they are free from physical damage and defects.

3.2 PREPARATION

- A. Before fiber splicing terminating or testing activities, verify sufficient workspace is available to perform the activity without interferences from other trades.
- B. Pre-installation test:
 - 1. Conduct pre-installation tests on all fiber optic cable.
 - 2. Upon arrival at the site:
 - a. Inspect the cable and reel for damage.
 - b. Test all fibers with an optical time domain reflectometer (OTDR) for fiber integrity.
 - c. Verify that the fiber lengths are consistent with the cable manufacture.
 - d. Verify that all traces yield no point discontinuities.
 - 3. Complete test sequence and obtain approval from the Engineer of submitted test results before cable installation:
 - a. Replace any cable failing to meet the requirements of the required tests and test before installation.
 - 4. Submit copies of the test results to the Engineer within 5 days after the delivery to the site.

3.3 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Install fiber optic patch cords in open network trays or in dedicated conduits no longer than 25 feet in length.
- C. Install all fiber optic system components in accordance with the recommendations of the manufacturer.
- D. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the Engineer.
- E. Installation:
 - 1. Utilize personnel certified by the manufacturer with specific knowledge of the cable manufacturer's recommended procedures:
 - a. Schedule Engineer, 5 days before installation, to witness all cable installations.
 - 2. Properly attach the fiber optic cable's strength elements to a 600-pound breakaway swivel containing tension or shear pins using Kellums pulling grips that are a minimum of 18 inches long.
 - 3. Certify that cable tensile limits do not exceed cable pull tension and bend limits using tension monitoring devices.

4. Leave an extra loop of fiber optic cable in each pull box.
5. Conform with the cable manufacturer's specifications, practices, and the following requirements:
 - a. When power equipment is used to install fiber optic cables, use low speeds and do not exceed a rate of 30 meters per minute.
 - b. Do not exceed the tensile and bending limitation for fiber optic cables under any circumstances.
 - c. Use large diameter wheels, pulling sheaves, and cable guides to maintain the specified bending radius.
 - d. Use commercial dynamometers or load cells to monitor pulling tension.
 - e. A nonfreezing type of swivel inserted between the pulling line and cable pulling grip to prevent twisting under strain.
 - f. All cable to be installed using a breakaway swivel.
6. Apply to all conduits a lubricant at each conduit ingress and egress location during the pull operation:
 - a. Pour or pump lubricant into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1,000 feet of cable.
 - b. If the conduit is open at intermediate locations, then apply the appropriate proportion of lubricant at each opening.
 - c. Continuously lubricate the cable as it is being pulled by pouring or pumping the lubricant into the conduit at the feed location and at each intermediate location.
 - d. Station workers at each intermediate location as required.
 - e. Remove all excess lubricant that has collected.
 - f. Remove and clean the surrounding area after cable installation.
7. Install using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions:
 - a. Use pulling equipment with "slip-load" capability to allow the winch to maintain a constant pulling force without taking up the winch line.
 - b. Use pulling equipment equipped with a hydraulic bypass set so that a maximum tension of 600 pounds is not exceeded.
 - c. Use only equipment designed to prevent a preset pulling tension from being exceeded.
 - d. Fiber optic cable manufacturer to provide the pulling tension setpoint.
 - e. If during the pulling operation excessive tension is detected, cease all operations and notify the Engineer.
8. Position the cable reel at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system:
 - a. The use of a cable feeder is required, unless the cable is hand-pulled.
9. Supply all bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation:
 - a. The cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.
10. Minimize the use of snatch blocks and rollers to guide the cable into the conduit at the feed point:
 - a. Slack feed by hand the cable into the feed point and raceway without the use of rollers.
11. Tend the cable reel at all times and turn by hand to provide the required cable slack:
 - a. Under no circumstances shall the cable tension be allowed to turn the cable reel.
12. Use a rim roller, with a wheel radius greater than the minimum cable bending radius placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.
13. Perform a continuous thorough visual inspection for flaws, breaks, and abrasions in the cable sheath as the cable leaves the reel and maintain a slow pulling speed to permit this inspection.
14. Damage to the sheath or finish of the cable is cause for rejecting the cable:

15. Replace any cable damaged in any way during installation.
16. If the cable becomes damaged during installation, stop operations, and notify the Engineer immediately:
 - a. Engineer to determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.
17. Document all pulls by a graph which is annotated with the following information:
 - a. Reel number.
 - b. Pull point ID.
 - c. Date and time.
 - d. Explanations for abnormalities in readings or interruptions.
 - e. Sign-off by Contractor and Engineer.
18. Under no conditions shall the fiber optic cable be left exposed or unattended.
19. After the cables are installed and spliced:
 - a. Rack the cables.
 - b. Loosely secure in racked position with wire ties.
 - c. Attach imprinted plastic coated cloth identification/warning tags to each cable in at least 2 locations in each handhole/manhole.
20. Armored fiber optic cables containing metallic members shall be grounded in accordance with NEC.

F. Splices:

1. Submit all splice locations to the Engineer for approval before installation of the fiber cables.
2. Provide field splices in a splice tray located in a waterproof splice enclosure:
 - a. Manufacturers: The following or equal:
 - 2) Tyco/Raychem, FOSC style splice enclosure.
2. Loop the individual fibers a minimum of 1 full turn within the splice tray to avoid macro/micro bending.
3. After completion of cable terminations, neatly dress all cables.
4. Protect all splices with a thermal shrink sleeve.
5. Provide fusion type fiber optic cable splicing meeting the following requirements:
 - a. Joins multimode or single mode fibers.
 - b. Establishes a permanent fusion splice.
 - c. Waterproof.
 - d. Re-enterable, rearrangeable, and reusable.
 - e. Splice loss less than 0.10 dB.
 - f. Protected by a splice enclosure.
6. Requirement for outdoor fiber splice enclosures:
 - a. Seal.
 - b. Bond.
 - c. Anchor.
 - d. Protect fiber optic cable splices.
 - e. Stand-alone unit that does not require an outer enclosure.
 - f. Provide for a maximum of 6 cable entries in a butt-end configuration.
 - g. Used in aerial, underground, and direct buried applications.
7. Requirement for indoor fiber splice enclosures:
 - a. Anchor.
 - b. Protect fiber optic cable splices.
 - c. Stand-alone unit that does not require an outer enclosure.
 - d. Suitable for the minimum number of splices at that location plus additional capacity for reconfigurations.
8. Re-splice any splice that has a loss greater than 0.10 dB.
9. Leave a minimum of 20 feet of fiber optic cable at each end of splice.

- G. Terminations:
1. Terminate all fiber inside a patch panel.
 - a. Direct landing to a switch, router hub, or PLC will not be allowed.
 2. Terminate outdoor cables using a breakout kit that seals the cable and provides physical protection for the fiber strands.
 3. Terminate indoor cables using breakout kits with field installed terminators.
 4. Labeling:
 - a. Permanently label all cable terminations. Use labels produced by a wire printer using pressure sensitive polyester labels. Label patch panels as specified in the Identification for Electrical Systems section.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

- A. Factory test:
10. Before shipment and while on the shipping reel, test 100 percent of all fibers for attenuation:
 - a. Copies of the results shall be:
 - 1) Maintained on file.
 - 2) Attached to the cable reel in a waterproof pouch.
 - 3) Submitted before the delivery of the cable to the job site to Engineer for approval.
 11. Conduct the flex test in accordance with FOTP-104 test condition I and III with a maximum sheave diameter of 20 times the cable OD.
 12. Verify that the cable withstands 25 impact cycles with:
 - a. The average increase in attenuation for the fibers less than 0.20 dB at 1,550 nm.
 - b. No evidence of cracking or splitting.
 - c. Conduct the test in accordance with FOTP-25.
 13. Certify that the cable withstands a tensile load of 2,700 N (600 pounds):
 - a. Without exhibiting an average increase in attenuation of greater than 0.10 dB.
 - b. Test in accordance with FOTP-33 using a maximum mandrel and sheave diameter of 560 millimeters.
 - c. Apply the load for 1 hour in Test Condition II.
 14. Certify that the cable withstands a simulated lightning strike:
 - a. Peak value of the current pulse greater than 105kA.
 - b. Use a test current with a damped oscillatory maximum time-to-peak value of 15 μ s (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
 - c. The time to half-value of the waveform envelope 40 to 70 μ s.
 - d. Conduct the test in accordance with the FOTP-181.
 - e. In addition to the analysis criterion set forth in FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e., core tube) and strength members must be intact after removal of the cable specimens from the test box.

3.8 FIELD QUALITY CONTROL

- A. As specified in the Common Work Results for Electrical section.
- B. General:
1. All test results shall meet or exceed manufacturer specifications:

- a. Test each fiber of each cable for breaks, abnormalities, and overall attenuation characteristics.
 - b. Replace any fiber that does not meet or exceed manufacturer specifications.
2. Conduct post-installation tests of the fiber optic system in accordance with the Field Electrical Acceptance Tests section.
3. Pre-installation tests and post-installation tests to be witnessed and signed off by Engineer and Owner.
4. Perform OLTS test with equipment capable and calibrated to show anomalies of 0.1 dB as a minimum:
 - a. Test multimode fibers at 850 nm and 1,300 nm.
 - b. Test single mode fibers at 1,310 and 1,550 nm.
5. Perform OTDR tests on fiber cables less than 100 meters with the aid of a launch cable:
 - a. Adjust OTDR pulse width settings to a maximum setting of 1/1000th of the cable length or 10 nanoseconds.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING

- A. Clean all fiber optic connectors after termination and before testing. After cleaning, cover all un-terminated connectors with a protective boot.
- B. At the completion of construction, touch up the finish on all fiber patch panels and enclosures.

3.11 PROTECTION

- A. As specified in the Common Work Results for Electrical section.
- B. Protect the fiber system from physical damage and the encroachment of dust, before, during, and after installation.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Metallic conduits.
 - 2. Nonmetallic conduits.
 - 3. Conduit bodies.
 - 4. Conduit fittings and accessories.
 - 5. Conduit installation.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. American National Standards Institute (ANSI):
 - 1. C80.1 - Electrical Rigid Steel Conduit.
 - 2. C80.3 - Steel Electrical Metallic Tubing.
 - 3. C80.5 - Electrical Rigid Aluminum Conduit.
 - 4. C80.6 - Electrical Intermediate Metal Conduit.
- C. National Electrical Manufacturer's Association (NEMA):
 - 1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
 - 2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
 - 3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - 4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
 - 5. TC13 - Electrical Nonmetallic Tubing.
 - 6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- D. Underwriters Laboratories (UL):
 - 1. 1 - Standard for Flexible Metal Conduit.
 - 2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
 - 3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
 - 4. 360 - Standard for Liquidtight Flexible Steel Conduit.
 - 5. 651 - Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
 - 6. 651B - Standard for Continuous Length HDPE Conduit.
 - 7. 797 - Standard for Electrical Metallic Tubing - Steel.
 - 8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
 - 9. 1653 - Standard for Electrical Nonmetallic Tubing.
 - 10. 1660 - Standard for Liquidtight Flexible Nonmetallic Conduit.
 - 11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. Specific definitions and abbreviations:

1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
3. GRC: Galvanized rigid steel conduit.
4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
5. EMT: Electrical metallic tubing.
6. PVC: Polyvinyl chloride rigid nonmetallic conduit.
7. SLT: Sealtight-liquidtight flexible conduit.
8. EFLX: Explosion proof flexible conduit.
9. RAC: Rigid aluminum conduit.
10. NPT: National pipe thread.

1.4 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
 2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
- C. Certifications:
 1. Furnish PVC-coated conduit manufacturer's certification for each installer.
- D. Record Documents:
 1. Incorporate all changes in conduit routing on electrical plan drawings.
 2. Dimension underground and concealed conduits from building lines.
 3. Furnish hard copy drawings.

1.5 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.
- C. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.
- B. Do not expose non-metallic conduit to direct sunlight.
- C. Do not store conduit in direct contact with the ground.
- D. Do not store aluminum conduit in contact with concrete.

1.7 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.8 SEQUENCING

- A. Before installing any conduit or locating any device box:
 - 1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
 - 2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.9 SCHEDULING (NOT USED)

1.10 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.11 SYSTEM START-UP

- A. As specified in the Common Work Results for Electrical section.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Galvanized rigid steel conduit:
 - 1. One of the following or equal:
 - a. Western Tube and Conduit.
 - b. Allied Tube and Conduit.
 - c. Wheatland Tube Co.
- B. PVC-coated rigid steel conduit:
 - 1. One of the following or equal:
 - a. Robroy Ind.
 - b. Ocal, Inc.
 - c. Calbond.
 - d. Allied.
 - e. NEC, Inc. BlackGuard.
- C. Sealtight-liquidtight flexible conduit:
 - 1. One of the following or equal:
 - a. Southwire.
 - b. AFC Cable Systems.
 - c. Electri-Flex Co.
 - d. Anaconda.
- D. Explosion proof flexible conduit:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. Hubbell Killark.
- E. Conduit bodies:

1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z/Gedney.
 - d. Ocal, Inc.
 - e. Robroy Ind.
 - f. Calbond.
 - g. Carlon.

- F. Joint compound:
 1. The following or equal:
 - a. Thomas and Betts.

- G. Galvanized rigid steel conduit expansion fittings:
 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z/Gedney.

- H. PVC-coated rigid steel conduit expansion fittings:
 1. One of the following or equal:
 - a. Ocal, Inc.
 - b. Robroy Ind.
 - c. NEC, Inc. BlackGuard.

- I. Conduit sleeve:
 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z/Gedney.

- J. Conduit seals:
 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. O-Z/Gedney.

- K. Conduit hangers and supports:
 1. As specified in the Hangers and Supports section.

- L. Conduit through wall and floor seals:
 1. The following or equal:
 - a. O-Z/Gedney:
 - 1) Type "WSK."
 - 2) Type "CSM."

2.2 SYSTEM DESCRIPTION

- A. Provide conduits, conduit bodies, fittings, junction boxes, and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

2.3 EXISTING PRODUCTS (NOT USED)

2.4 MATERIALS (NOT USED)

2.5 MANUFACTURED UNITS (NOT USED)

2.6 EQUIPMENT (NOT USED)

2.7 COMPONENTS

A. GRC:

1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
 - a. Running conduit threads are not acceptable.
2. Hot-dip galvanized inside and out:
 - a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
 - b. Electro-galvanizing is not acceptable.
3. Manufactured in accordance with:
 - a. UL-6.
 - b. ANSI C80.1.

B. PCS:

1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for Type GRC.
2. Coated conduit NEMA Standard RN-1:
 - a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
3. Factory-bonded PVC jacket:
 - a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
 - b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
 - c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
 - d. The PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
 - 1) Confirm bond with certified test results.
4. A urethane coating shall be uniformly and consistently applied to the interior of all conduits and fittings:
 - a. Nominal thickness of 0.002 inch.
 - b. Conduits having areas with thin or no coating are not acceptable.
 - c. All threads shall be coated with urethane.
5. The PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
6. PCS conduit bodies and fittings:
 - a. Malleable iron.
 - b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
 - c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of ribs to protect the coating from tool damage during installation.
 - d. 0.002-inch interior urethane coating.
 - e. Utilize the PVC coating as an integral part of the gasket design.
 - f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.

- g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
 - 1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
 - 2) The sleeve shall provide a vapor- and moisture resistant seal at every connection.
- C. SLT:
 - 1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
 - a. General purpose:
 - 1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
 - b. Oil-resistant:
 - 1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
 - 2. Sunlight-resistant, weatherproof, and watertight.
 - 3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
 - 4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
 - 5. Overall PVC jacket.
 - 6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.
- D. EFLX:
 - 1. Suitable for the hazardous Class and Group where installed:
 - a. As specified in the Common Work Results for Electrical section.
 - 2. Metallic braid shall provide continuous electrical path.
 - 3. Stainless steel construction.
 - 4. Provide fittings and unions as required for the installation.
- E. PVC:
 - 1. Extruded from virgin PVC compound:
 - a. Schedule 40 unless otherwise specified.
 - b. Schedule 80 extra-heavy wall where specified.
 - 2. Rated for 90 degrees Celsius conductors or cable.
 - 3. Rated for use in direct sunlight.
- F. Conduit bodies:
 - 1. Material consistent with conduit type:
 - a. Malleable iron bodies and covers when used with Type GRC.
 - b. Cast aluminum bodies and covers when used with Type RAC.
 - c. PVC bodies and covers when used with Type PVC.
 - d. PVC-coated malleable iron bodies and covers when used with Type PCS.
 - 2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
 - a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
 - 3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.8 ACCESSORIES

- A. Connectors and fittings:
 - 1. Manufactured with compatible materials to the corresponding conduit.
- B. Insulated throat metallic bushings:

1. Construction:
 - a. Malleable iron or zinc-plated steel when used with steel conduit.
 - b. Aluminum when used with aluminum conduit.
 - c. Positive metallic conduit end stop.
 - d. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
 - e. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

- C. Insulated grounding bushings:
 1. Construction:
 - a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
 - b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
 - c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.

- D. Electrical unions (Erickson Couplings):
 1. Construction:
 - a. Malleable iron for use with steel conduit.
 - b. Aluminum for use with aluminum conduit.
 - c. Concrete tight, 3-piece construction.
 - d. Rated for Class I Division 1 Group D in hazardous areas.

- E. SLT fittings:
 1. Construction:
 - a. Malleable iron.
 - b. Furnished with locknut and sealing ring.
 - c. Liquidtight, raintight, oiltight.
 - d. Insulated throat.
 - e. Furnish as straight, 45-degree elbows, and 90-degree elbows.
 - f. Designed to prevent sleeving:
 - 1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
 - g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
 - h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
 2. Corrosion-resistant and outdoor SLT fittings:
 - a. Construction:
 - 1) PVC-coated liquidtight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
 - 2) Insulated throat and an integral sealing ring.

- F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
 1. Construction:
 - a. Insulated throat.
 - b. PVC-coated when used in corrosive areas.
 - c. Bonding locknut.
 - d. Recessed neoprene o-ring to ensure watertight and dusttight connector.
 - e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
 - f. 1-1/2-inch through 6-inch malleable iron zinc plated.
 - g. Aluminum with aluminum conduit.
 2. Usage:

- a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.
- G. Sealing fittings:
 - 1. Construction:
 - a. 40-percent wire fill capacity.
 - b. PVC-coated when used in corrosive areas.
 - c. Malleable ductile iron with steel conduit.
 - d. Aluminum with aluminum conduit.
 - e. Type EYDX where drains are required.
 - f. Type EYSX where drains are not required.
 - g. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; and Class II, Divisions 1 and 2, Groups E, F, and G.
 - 2. Sealing compound:
 - a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
 - b. Approved for the conditions and use.
 - 1) Not affected by surrounding atmosphere or liquids.
 - c. Melting point shall be 200 degrees Fahrenheit minimum.
- H. PVC fittings:
 - 1. Materials:
 - a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
 - b. All metal hardware shall be stainless steel.
- I. Through wall and floor seals:
 - 1. Materials:
 - a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish Aluminum.
 - b. Grommet: Neoprene.
 - c. Pressure rings: PVC-coated steel.
 - d. Disc material: PVC-coated steel.
- J. Expansion/deflection couplings:
 - 1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
 - 2. Shall allow movement of 3/4 inch from the normal in all directions.
 - 3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
 - 4. Constructed to maintain electrical continuity of the conduit system.
 - 5. Materials:
 - a. End couplings: Bronze or galvanized ductile iron.
 - b. Sleeve: Neoprene.
 - c. Bands: Stainless steel.
 - d. Bonding jumper: Tinned copper braid.
- K. Expansion couplings:
 - 1. Shall allow for expansion and contraction of conduit:
 - a. Permitting 8-inch movement, 4 inches in either direction.
 - 2. Constructed to maintain electrical continuity of the conduit system.
 - 3. Materials:
 - a. Head: Malleable or ductile iron.
 - b. Sleeve: Steel.
 - c. Insulating bushing: Phenolic.
 - d. Finish: Hot-dip galvanized.
 - e. Aluminum when used with Type RAC.

f. PVC-coated when used with Type PCS.

L. Conduit markers:

1. As specified in the Identification for Electrical Systems section.

2.9 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in the Common Work Results for Electrical section.

B. General:

1. Conduit routing:

a. The electrical drawings are diagrammatic in nature:

- 1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
- 2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
 - a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
 - b) Make changes in conduit routing due to the relocation of equipment.
- 3) The electrical drawings do not indicate all required junction boxes and pull boxes:
 - a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
 - (1) To meet cable manufacturer's pulling tension requirements.
 - (2) To limit total conduit bends between pull locations.
 - b) Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:

- 1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
- 2) Perform any changes resulting in additional conduits, or extra work from such deviations.
- 3) Incorporate any deviations on the Record Documents.

2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.

3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
 - a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
 - b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
 - c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
 - d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
 - a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
 - a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
 - b. Make changes in direction with long radius bends or with conduit bodies.
7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route all exposed conduits to preserve headroom, access space and work space, and to prevent tripping hazards and clearance problems:
 - a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
 - b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
9. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
11. Install conduits through wall and floor seals where indicated on the Drawings.
12. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
 - a. Remove and replace conduits through which mandrel will not pass.
13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
14. Install complete conduit systems before conductors are installed.
15. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
16. Underground conduits:
 - a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
 - 1) As specified in the Duct Banks section.
 - b. Make underground conduit size transitions at handholes and manholes.
 - c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.

- d. Seal around conduit penetrations of below grade walls with a mechanical seal.
- C. Lighting and receptacle conduits:
- 1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
 - 2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
 - 3. Minimum conduit size:
 - a. 3/4-inch for exposed conduits.
 - b. 1-inch for underground or in-slab conduits.
 - 4. Provide conduit materials for the installed location as specified in the Common Work Results for Electrical section.
- D. Hazardous areas:
- 1. As specified in the Common Work Results for Electrical section for hazardous areas and specific Class and Division.
 - 2. As specified in the Hazardous Classified Area Construction section for hazardous area conduit installation requirements.
- E. Conduit usage:
- 1. Exposed conduits:
 - a. Rigid conduit:
 - 1) Install the rigid conduit type for each location as specified in the Common Work Results for Electrical section.
 - 2) Minimum size: 3/4-inch.
 - b. Flexible conduit:
 - 1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
 - a) Use Type SLT with rigid metallic conduit.
 - b) Use Type EFLX in Class I Division 1 locations.
 - 2) Minimum size: 3/4-inch:
 - a) 1/2 when required for connection to instruments.
 - 3) Maximum length:
 - a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

- b) Removable instruments or hinged equipment:
 - (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete-encased and embedded conduits:
 - a. Straight runs and bends less than 45 degrees:
 - 1) Type PVC Schedule 40.
 - b. Bends with total deflection greater than 45 degrees;
 - 1) PCS,
 - c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
 - 1) PCS.
 - d. Minimum size:
 - 1) 2-inch in duct banks.
 - 2) 1-inch for in-slab conduits.
 - 3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.
 3. Direct-buried and sand-bedded duct bank conduits:
 - a. Type PCS.
 - b. Minimum size: 1-inch.
 4. Below-slab conduits:
 - a. Type PCS.
 - b. Minimum size: 1-inch.
 5. PVC-coated rigid metallic conduit:
 - a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
 6. GRC:
 - a. Conduit shall be cut square and reamed before threading.
- F. Conduit joints and bends:
1. General:
 - a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
 - b. Keep bends and offsets in conduit runs to an absolute minimum.
 - c. All bends shall be symmetrical.
 - d. The following conduit systems shall use large-radius sweep elbows:
 - 1) Underground conduits.
 - 2) Conduits containing fiber optic cables.
 - e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
 - f. Make field bends with a radius of not less than the requirements found in the NEC:
 - 1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
 - 2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
 - a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
 - b) For the serving utilities, make bends to meet their requirements.
 - g. Replace all deformed, flattened, or kinked conduit.
 2. Threaded conduit:
 - a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
 - b. Thoroughly ream conduit after threads have been cut to remove burrs.
 - c. Use bushings or conduit fittings at conduit terminations.

- d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar™," or CRC "Zinc It."
 - e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
 - 1) Apply to the male threads and tighten joints securely.
 - 2) Clean excess sealant from exposed threads after assembly.
 - f. Securely tighten all threaded connections.
 - g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.
3. PVC:
- a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
 - b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at all bends:
 - 1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.
- G. Conduit sealing and drainage:
- 1. Conduit drainage and sealing other than required for hazardous and classified areas:
 - a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
 - b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
 - c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
 - 1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
 - d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
 - e. Seal one end only of all underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
 - 2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of the conduit.
- H. Conduit supports:
- 1. General:
 - a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
 - 1) As specified in the Hangers and Supports section.
 - 2) Provide support materials consistent with the type of conduit being installed as specified in the Common Work Results for Electrical section.
 - b. Support conduit at the intervals required by the NEC.
 - c. Perforated strap and plumbers tape are not acceptable for conduit supports.
 - 2. Conduit on concrete or masonry:
 - a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
 - b. Use preset inserts in concrete when possible.
 - c. Use pipe spacers (clamp backs) in wet locations.
 - 3. Suspended conduit:
 - a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.

- b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.
 - 4. Supports at structural steel members:
 - a. Use beam clamps.
 - b. Drilling or welding may be used only as specified or with approval of the Engineer.
 - 5. PVC-coated rigid metal systems:
 - a. Provide right-angle beam clamps and "U" bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
 - b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.
 - I. Expansion or expansion/deflection fittings:
 - 1. General:
 - a. Align expansion coupling with the conduit run to prevent binding.
 - b. Follow manufacturer's instructions to set the piston opening.
 - c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
 - d. Furnish fittings of the same material as the conduit system.
 - 2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
 - a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
 - J. Empty conduits:
 - 1. Provide a polyethylene rope rated at 250 pounds tensile strength in each empty conduit more than 10 feet in length.
 - 2. Seal ends of all conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
 - a. Keep ends sealed until immediately before pulling conductors.
 - K. Miscellaneous:
 - 1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
 - 2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
 - a. Running threads and threadless couplings are not allowed.
 - 3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
- 3.4 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 RE-INSTALLATION (NOT USED)
- 3.7 COMMISSIONING (NOT USED)
- 3.8 FIELD QUALITY CONTROL
- A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 261330

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Electrical underground duct banks.
 - 2. Duct bank installation requirements.

1.02 REFERENCES

- A. As specified in the Common Work Results for Electrical section.

1.03 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.04 SYSTEM DESCRIPTION

- A. Provide trenching, forming, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.
- B. Provide concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals as specified in the Submittal Procedures section and the Common Work Results for Electrical section.
- B. Product data:
 - 1. PVC conduit spacers.
 - 2. Detectable underground marking tape.
 - 3. Pull line.
- C. Shop drawings:
 - 1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.
 - 2. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
 - a. Submit shop drawings detailing the new building footer crossing locations and plan drawings labeling all equipment to be installed on top of the new routing for approval by the project Structural Engineer.

1.06 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in the Common Work Results for Electrical section.

1.09 SEQUENCING

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Conduit spacers:

1. One of the following or equal:
 - a. Carlon Snap-Loc.
 - b. Cantex.
 - c. Osburn Associates, Inc.

B. Detectable underground marking tape:

1. One of the following or equal:
 - a. Blackburn Manufacturing Co.
 - b. Pro-Line Safety Products.
 - c. Panduit.

C. Pull line:

1. One of the following or equal:
 - a. Arnco.
 - b. Greenlee.
 - c. Osburn Associates, Inc.

D. Duct seal:

1. The following or equal:
 - a. OZ Gedney type DUX.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Provide conduit as specified in the Conduits section:

1. Use duct suitable for use with 194 degree Fahrenheit rated conductors.

2.04 MANUFACTURED UNITS

- A. Conduit spacers:
 - 1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
 - 2. Saddle type.
 - 3. Non-metallic, non-corrosive, non-conductive.
 - 4. Interlocking type:
 - a. Vertical interlocking.
 - b. Horizontal interlocking.
 - 5. Suitable for concrete encasement.
 - 6. Molded-in rebar holder.
 - 7. Accommodates 2-inch through 6-inch conduit sizes.
 - 8. Relieves the conduit from both horizontal and vertical stresses.
- B. Pull line:
 - 1. Minimum 1/4-inch wide, flat design.
 - 2. Polyester.
 - 3. Minimum pulling strength 1,200 pounds.
- C. Detectable marking tape:
 - 1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
 - 2. Aluminum core laminated between polyethylene film.
 - 3. 6-inch wide red tape imprinted with black lettering stating "CAUTION - BURIED ELECTRIC LINE BELOW" or equivalent.
- D. Duct seal:
 - 1. Non-hardening sealing compound.
 - 2. Flexible, can be applied by hand.
 - 3. UL Listed for use with installed conductors.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES

- A. Provide a red-oxide conduit encasement coloring agent.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Duct banks:
 - 1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
 - 2. Damage minimization:
 - a. Conduit should not be left exposed in an open trench longer than is necessary.
 - b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
 - 3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
 - 4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank.
 - 5. Install underground ducts to be self-draining:
 - a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
 - b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
 - c. Slope a minimum of 1/4 inch per 10 feet.
 - 6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
 - 7. Install pull line in spare conduits:
 - a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
 - b. Cap above ground spare conduit risers at each end with screw-on conduit caps.
- C. Trenching:
 - 1. Trench must be uniformly graded with the bottom, rock free and covered with select material.
 - 2. Whenever possible, use the walls of the trench as forms for concrete encasement:
 - a. Forms are required where the soil is not self-supporting.
 - 3. Avoid damaging existing ducts, conduits, cables, and other utilities.
- D. Duct spacing:
 - 1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings:
 - a. Separate medium voltage ducts a minimum of 7.5 inches on center.
 - 2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
 - a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
 - 1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
 - a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
 - 3. Spacers shall not be located at the center of a bend:
 - a. Locate spacer in the tangent, free of the coupling on fabricated bends.
 - b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

- E. Terminating:
 - 1. Use bell ends in duct at entrances into cable vaults.
 - 2. Make conduit entrances into cable vaults tangential to walls of cable vault.
 - 3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
 - 4. Install duct seal in all conduits including spare conduits, at entrance to manholes/handholes, and building/equipment stub-ups. Form by hand to conduit and around cables to develop moisture barrier.
 - 5. New manhole or handhole applications, provide a single opening or "window" per duct bank, sized to accommodate the duct bank envelope.
- F. Concrete:
 - 1. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
 - a. Tie wire shall not act as a substitute for spacers.
 - 2. Install minimum 3-inch cover around conduit and rebar.
 - 3. Consolidation of encasement concrete around duct banks shall be by hand puddling, with no mechanical vibration.
 - 4. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.
- G. Marking tape:
 - 1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING (NOT USED)

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 261340

BOXES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Device boxes.
 - 2. Raceway system boxes.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- C. ASTM International (ASTM):
 - 1. A47 - Standard Specification for Ferritic Malleable Iron Castings.
 - 2. D149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 - 3. D495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
 - 4. D570 - Standard Test Method for Water Absorption of Plastics.
 - 5. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
 - 6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - 7. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
- D. Joint Industry Conference (JIC).
- E. Underwriters Laboratories, Inc. (UL):
 - 1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. Specific definitions:
 - 1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
 - 2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.4 SYSTEM DESCRIPTION

- A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.
- B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Manufacturer.
 - 2. Materials.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - e. NEMA rating.
 - 4. Conduit entry locations.
 - 5. Catalog cut sheets.
 - 6. Installation instructions.
- C. Shop drawings:
 - 1. Include identification and sizes of pullboxes.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Regulatory requirements:
 - 1. Outlet boxes shall comply with all applicable standards of:
 - a. JIC.
 - b. NEC.
 - c. NEMA.
 - d. UL.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING

- A. As specified in the Common Work Results for Electrical.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. One of the following or equal:
1. Cast device boxes:
 - a. Appleton.
 - b. Crouse - Hinds.
 - c. OZ/Gedney.
 2. Stainless steel enclosures:
 - a. Hoffman.
 - b. Stahlin.
 - c. Rittal.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS

- A. Cast device boxes:
1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Tapered threaded hubs with integral bushing.
 2. Malleable iron boxes:
 - a. Conforming to ASTM A47 Grade 32510.
- B. Plastic coated cast device boxes:
1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
 - f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
 - g. With pressure sealing sleeve to protect the connection with conduit.

- C. Class I Division 1 areas:
 - 1. Provide boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
 - a. The approval ratings must be permanently marked on each item.
- D. Class I, Division 2 areas:
 - 1. For boxes not containing arcing parts:
 - a. As specified in the Common Work Results for Electrical section.
 - b. Pressed metal boxes are not allowed.
 - 2. For boxes containing arcing parts provide:
 - a. Boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
 - 1) The approval ratings must be permanently marked on each item.
 - 3. Cast iron Cast copper - free aluminum box and cover.
 - 4. Precision machined flame path between box and cover with neoprene o-ring.
 - 5. For applications requiring hinged cover, provide flexible hinge mounting either left or right side.
 - 6. External flange.
 - 7. Provisions for mounting pan.
 - 8. Ground lug.
 - 9. Stainless steel:
 - a. NEMA Type 4X:
 - 1) Boxes in locations subject to flooding or temporary submersion:
 - a) NEMA Type 6.
 - b. Fabricated from 14-gauge Type 316 stainless steel.
 - c. All seams continuously welded.
 - d. Door:
 - 1) Rolled lip around 3 sides.
 - 2) Attached to enclosure by means of a continuous stainless-steel hinge and pin.
 - e. Neoprene door gasket to provide a watertight seal:
 - 1) Attached with an adhesive.
 - 2) Retained by a retaining strip.
 - f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
 - 1) With a hasp and staple for padlocking.
 - g. Provide large enclosures with door and body stiffeners for extra rigidity.
 - h. No holes or knockouts.
 - i. Finish:
 - 1) Brushed.
 - j. Stainless steel external mounting brackets when surface mounted.

2.5 EQUIPMENT (NOT USED)

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES

- A. Fasteners:
 - 1. Electroplated or stainless steel in boxes with wiring devices.
 - 2. Screws, nuts, bolts, and other threaded fasteners:
 - a. Stainless steel.
- B. Provide breather and drain fittings where appropriate.
- C. Internal panels:

1. Provide internal panels where required for mounting of terminal strips or other equipment.
2. With plated steel shoulder studs.
3. Steel with white polyester powder finish.

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in the Common Work Results for Electrical section.

B. General:

1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in the Common Work Results for Electrical section.
2. Provide outlet box materials to match the conduit system:
 - a. GRC - Cast ferrous boxes.
 - b. PCS - PVC coated cast ferrous boxes.
 - c. PVC - PVC boxes.
3. Solid type gang boxes:
 - a. For more than 2 devices.
 - b. For barriered outlets.
4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
 - a. Use machined spacers to maintain air space; built-up washers are not acceptable.
 - b. Use stainless steel or nylon materials for spacers.
5. Use cast malleable iron boxes when box must support other devices.
6. Boxes serving luminaires or devices:
 - a. Use as pullboxes wherever possible.
7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
 - a. Furnish wireways for discrete and analog/DC wiring.
 - b. Separate analog wiring from 120 V discrete or power wiring.
9. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
10. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

- C. Outlet boxes:
 - 1. Locate outlet boxes as indicated on the Drawings:
 - a. Adjust locations so as not to conflict with structural requirements or other trades.
 - 2. Use deep threaded-hub malleable iron or aluminum boxes:
 - a. In hazardous areas.
 - b. Where exposed to the weather.
 - c. In unheated areas.
 - d. Where subject to mechanical damage:
 - 1) Defined as exposed boxes less than 10 feet above the floor.
 - e. To act as a pullbox for conductors in a conduit system.
 - f. Accommodate wiring devices.
 - 3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
 - 4. Outlet boxes may be used as junction boxes wherever possible.
- D. Pullboxes and junction boxes:
 - 1. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
 - 2. Install pullboxes such that access to them is not restricted.
- E. For boxes not indicated:
 - 1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in the Common Work Results for Electrical section.
 - 2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
 - a. One-piece, galvanized, pressed steel.
 - 3. Ceiling boxes for flush mounting in concrete:
 - a. Deep, galvanized, pressed steel.
 - 4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
 - a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
 - 5. Outlet, control station, and junction boxes for installation in corrosive locations:
 - a. Fiberglass reinforced polyester, stainless steel, or plastic coated steel to match the conduit system.
 - b. Furnished with mounting lugs.
- F. Hazardous locations:
 - 1. All metallic boxes, fittings, and joints shall utilize threaded connections to the conduit system.
 - 2. All threaded connections shall be wrench tightened so that at least 5 threads are fully engaged.
 - 3. Conduits entering and exiting metallic boxes in Class I Division 2 areas shall utilize approved grounding bushings to bond the conduits together.
 - 4. Provide the following types of conduit bodies and boxes:
 - a. Malleable iron bodies and boxes with GRC or IMC conduit systems.
 - b. PVC coated conduit bodies and boxes with PCS conduit systems.

- 3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 REINSTALLATION (NOT USED)
- 3.7 COMMISSIONING
 - A. As specified in the Commissioning section.
- 3.8 FIELD QUALITY CONTROL
 - A. As specified in the Common Work Results for Electrical section.
- 3.9 ADJUSTING (NOT USED)
- 3.10 CLEANING
 - A. As specified in the Common Work Results for Electrical section.
- 3.11 PROTECTION
 - A. As specified in the Common Work Results for Electrical section.
- 3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 261360

WIREWAY

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Wireway systems as indicated on the Drawings.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. ICS-6 - Industrial Control and Systems: Enclosures.
- C. Underwriter's Laboratories (UL):
 - 1. Article 870 - Wireways, Auxiliary Gutters, and Associated Fittings.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.4 SYSTEM DESCRIPTION

- A. System includes horizontal and/or vertical straight runs of wireway, fittings, covers, splices, barriers, and related accessory and supports:
 - 1. Connected to form a complete system.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Technical information:
 - a. Catalog cut sheets.
 - b. Wireway construction and materials.
 - c. Maximum loading and span.
 - d. NEMA enclosure type.
 - 2. Dimensions:
 - a. Width.
 - b. Depth.
 - 3. Weight of wireway sections and fittings.
 - 4. Complete bill of materials.
 - 5. Manufacturer's installation instructions.
- C. Shop drawings:
 - 1. Provide complete details and scaled drawings for the layout of the installed wireway system showing all components and proposed mounting details.
- D. Calculations:

1. Provide cross sectional area and fill calculations.
 - a. Cross sectional area and fill shall be in accordance with the NEC.
2. Provide structural calculations to ensure that the installed system meets all structural, seismic as specified in the Common Work Results for Electrical section, wind as specified in the Common Work Results for Electrical Requirements section at the Project Site with respect to support and mounting:
 - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Manufacturer qualifications:
 1. Member of NEMA for the manufacturer of wireway systems and fittings of types and capacities required.
- C. Wireway shall be UL listed and labeled.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING

- A. The Drawings indicate the general route of the wireway systems. Data presented on those drawings are as accurate as preliminary surveys and planning can determine until final equipment selection is made.
- B. Specifications and Drawings are for assistance and guidance, but exact routing, locations, distances, and levels will be governed by actual field conditions. Make field surveys as part of the work before ordering material.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

- A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Metallic wireway:
 - 1. One of the following or equal:
 - a. B-Line.
 - b. Hoffman.
 - c. Hammond.
 - d. Rittal Electromate.
- B. Non-metallic wireway:
 - 1. One of the following or equal:
 - a. Hoffman.
 - b. Carlon.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

- A. Provide wireways as indicated on the Drawings with respect to:
 - 1. Type (lay-in or feed-through or trough).
 - 2. Dimensions.
 - 3. NEMA enclosure rating.
 - 4. Wireway material.

2.6 COMPONENTS

- A. Fittings:
 - 1. Elbows, tees, and crossings:
 - a. Of the same materials and construction as the straight runs.
 - 2. Expansion fittings:
 - a. Provide flexible or sliding fittings.
- B. Covers:
 - 1. Hinged on one side.

2.7 ACCESSORIES

- A. Mounting hardware:
 - 1. As specified in the Common Work Results for Electrical section.

2.8 MIXES (NOT USED)

2.9 FABRICATIONS (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Manufactured in accordance with NEMA ICS-6.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify all dimensions and route before ordering wireway:
 - 1. Make all necessary field measurements.
 - 2. Coordinate with all subcontractors and suppliers to determine structural dimensions and equipment dimensions to avoid all potential conflicts with other systems.

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Install the wireway per the manufacturer's guidelines and submitted installation instructions to meet the seismic and wind requirements at the project site.
- C. General:
 - 1. Install in straight runs as much as possible, minimizing the number of turns.
 - 2. Expansion fittings:
 - a. Install as recommended by the manufacturer to accommodate thermal expansion.
 - b. Install where wireway crosses structural expansion joints.
 - 3. Fittings:
 - a. Not all fittings are indicated on the Drawings:
 - 1) Provide all fittings required to suit the installation.
 - 4. Wireway supports:
 - a. Support wireway in accordance with manufacturer's instructions and as required by the seismic conditions.
 - b. Support bracket spacing shall meet the requirements of the wireway manufacturer, and NEC.
 - c. Provide wireway supports with channels under the entire width of wireway.
 - d. Secure wireway to supports with manufacturer-approved fittings.
 - 5. Mounting:
 - a. Oriented to allow hinged doors to be opened minimum 90 degrees.
 - b. Oriented to allow safe access to doors for maintenance and future installations.
 - 6. Wiring installation:
 - a. In accordance the NEC.
 - b. Begin wiring installation only after the complete raceway system is installed.
 - c. Verify that all wireway surfaces and accessories are smooth, free from burrs or sharp edges.
 - d. Only install wiring that is UL listed for wireway use.
 - 7. Wall penetrations:
 - a. Terminate wireway on both sides of penetration, and penetrate wall via conduits:
 - 1) Seal all open spaces inside and around conduits where they penetrate building exterior walls or fire-rated walls.
 - 2) Fill spare conduits with sealing compound.
 - 3) Provide sealing material in accordance with all applicable codes and regulations.

3.4 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 PRE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. As specified in the Commissioning section.

3.8 FIELD QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

B. Inspect entire wireway system for the following:

1. Secure anchoring.
2. Proper supports.
3. Burrs or sharp edges.
4. Sufficient clearance from ducts and piping, especially hot pipes.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in the Common Work Results for Electrical section.

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 261400

WIRING DEVICES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Switches.
 - 2. Receptacles.
 - 3. Plates.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. Federal Specifications (FS):
 - 1. W-C 596 - Connector, Electrical, Power, General Specification for.
 - 2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
- C. National Electrical Manufacturers Association (NEMA):
 - 1. WD1 - General Color Requirements for Wiring Devices.
 - 2. ICS 5 - Industrial Control and Systems, Control Circuit and Pilot Devices.
 - 3. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
 - 4. WD6 - Wiring Devices Dimensional Specifications.
- D. Telecommunications Industry Association:
 - 1. T568A - Eight-position jack pin/pair assignment.
 - 2. T568B - Optional eight-position jack pin/pair assignment.
- E. Underwriters Laboratories, Inc. (UL):
 - 1. 20 - General Use Snap Switches.
 - 2. 498 - Standard for Attachment Plugs and Receptacles.
 - 3. 514D - Cover Plates for Flush-Mounted Wiring Devices.
 - 4. 943 - Ground-Fault Circuit-Interruptioners.
 - 5. 1472 - Solid State Dimming Controls.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. Specific definitions:
 - 1. GFCI: Ground fault circuit interrupter.

1.4 SYSTEM DESCRIPTION

- A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Catalog cut sheets.
- C. Shop drawings:
 - 1. Engraving schedule:
 - a. Furnish complete engraving schedule for engraved nameplates.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Wiring devices shall be UL listed and labeled.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

- A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Switches:
 - 1. One of the following or equal:
 - a. Hubbell.
 - b. Leviton.
 - c. Cooper Wiring Devices.
 - 2. Switches for hazardous areas:
 - a. One of the following or equal:
 - 1) Appleton.
 - 2) Crouse-Hinds.

- B. Receptacles:
 - 1. General purpose receptacles:
 - a. One of the following or equal:
 - 1) Hubbell.
 - 2) Leviton.
 - 3) Cooper Wiring Devices.
 - 2. Receptacles for hazardous areas:
 - a. One of the following or equal:
 - 1) Crouse-Hinds.
 - 2) Appleton.

- C. Plates:
 - 1. General location:
 - a. One of the following or equal:
 - 1) Legrand.
 - 2) Cooper Wiring Devices.
 - 2. Wet or corrosive areas:
 - a. One of the following or equal:
 - 1) Hubbell.
 - 2) Cooper Wiring Devices.
 - 3) Thomas and Betts.
 - 4) Pass and Seymour.
 - 3. In-use covers:
 - a. One of the following or equal:
 - 1) TayMac.
 - 2) Cooper Wiring Devices.
 - 3) Pass and Seymour.
 - 4) Thomas and Betts.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS

- A. Switches:
 - 1. General:
 - a. 120-277 VAC.
 - b. 20 ampere.
 - c. Listed in accordance with UL 20.
 - d. Designed and constructed in accordance with FS W-S-896/2.
 - e. Back and side wired unless otherwise indicated.
 - f. Integral grounding terminal.
 - g. Totally enclosed:
 - 1) Color-coded body with color corresponding to ampere rating.
 - h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
 - i. Color:
 - 1) Ivory in finished areas.
 - 2) Brown in all other areas.
 - 2. General purpose switches:
 - a. Toggle type.
 - 3. Switches for office areas:
 - a. Rocker type.
 - b. Rectangular.
 - 4. Switches for use with photocell:

- a. Maintained contact.
 - b. 2 circuit.
 - c. 3 position:
 - 1) Center off.
 - 5. Switches for hazardous areas:
 - a. Suitable for use in Class I Division 1 and Class I Division 2 locations.
 - b. Factory sealed.
 - c. Through-feed or dead-end as required.
- B. Receptacles:
- 1. General purpose receptacles:
 - a. Single or duplex as indicated on the Drawings.
 - b. 125 VAC.
 - c. 20 ampere or as indicated on the Drawings.
 - d. NEMA Type 5-20R configuration for 20 ampere receptacles.
 - e. Other NEMA configurations as indicated on the Drawings.
 - f. Listed in accordance with UL 498.
 - g. Designed and constructed in accordance with FS W-C-596.
 - h. Back and side wired.
 - i. 1-piece, rivet-less mounting strap.
 - j. Color:
 - 1) Ivory in finished areas.
 - 2) Brown in all other areas.
 - 3) Orange when powered by a UPS.
 - 2. Ground fault interrupter receptacles (GFCI):
 - a. 125 VAC.
 - b. 20 ampere.
 - c. Trip level 4-6 milliamperes.
 - d. Individual and feed through protection.
 - e. UL 943 and UL 498 listed.
 - f. NEMA Type 5-20R configuration.
 - g. For damp or wet locations:
 - 1) Weather resistant, in accordance with UL 498.
 - 3. Receptacles for hazardous areas:
 - a. 125 VAC.
 - b. 20 ampere.
 - c. Factory sealed.
 - d. Single receptacle.
 - e. 2-wire, 3-pole.
 - f. Grounded through extra pole and shell.
 - g. Dead-front construction.
 - h. Interlocked to prevent plug from being withdrawn until circuit has been broken.
- C. Plates:
- 1. General location:
 - a. Type 302 or 304 stainless steel.
 - b. Brushed satin finish.
 - c. Minimum thickness: 0.032 inches.
 - d. Rectangular or square shape.
 - e. Engraving:
 - 1) Engrave each switch plate with the following:
 - a) Area served.
 - b) Panelboard and Circuit.
 - 2) Engrave each receptacle plate with the following:
 - a) Panelboard and Circuit.
 - 3) Treat engraving to improve visibility.

- 4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
 - f. Coordinate the number of gangs, number, and type of openings with the specific location.
- 2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
 - a. General:
 - 1) UL listed for wet locations.
 - 2) Gasketed.
 - 3) Die cast metal:
 - a) Match material to box material.
 - b. Switches:
 - 1) Lever operated:
 - a) Provide toggle switch.
 - c. Receptacles:
 - 1) Weather proof in-use cover:
 - a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
 - b) Gasketed.
 - c) Lockable.
 - d) UL listed and in accordance with NEC.
- 3. Corrosive areas:
 - a. Neoprene.
 - b. Gasketed.
 - c. Weatherproof.

2.5 EQUIPMENT (NOT USED)

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES (NOT USED)

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in the Common Work Results for Electrical section.

B. Mounting heights:

- 1. Process and production areas:
 - a. Switches and receptacles 48 inches from finished floor to top of plate.
- 2. Offices and finished areas:
 - a. Switches: 48 inches from finished floor to top of plate.

- b. Receptacles: 18 inches from finished floor to center of plate.
 - C. Receptacles:
 - 1. Provide GFCI receptacles as indicated on the Drawings.
 - a. Provide weather resistant GFCI receptacles in all wet or damp areas.
 - 1) As specified in the Common Work Results for Electrical section.
 - 2. Mount non-weatherproof receptacles vertically:
 - a. Ground slot down.
 - 3. Mount weatherproof receptacles horizontally:
 - a. Neutral slot up.
 - 4. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.
 - D. Ensure all plates make a firm seal with wall for recessed mounted devices:
 - 1. Outside edges of plates parallel with building lines.
- 3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 REINSTALLATION (NOT USED)
- 3.7 COMMISSIONING
- A. As specified in the Commissioning section.
- 3.8 FIELD QUALITY CONTROL
- A. As specified in the Common Work Results for Electrical section.
- 3.9 ADJUSTING (NOT USED)
- 3.10 CLEANING (NOT USED)
- 3.11 PROTECTION
- A. As specified in the Common Work Results for Electrical section.
- 3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 261500

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Wire connecting devices.
 - 2. Terminations.
 - 3. Splices.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. ASTM International (ASTM):
 - 1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- C. CSA International (CSA):
 - 1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.4 SYSTEM DESCRIPTION

- A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Installation instructions.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. All materials shall be UL listed.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

A. Control connections:

1. Use insulated ring type wire terminators for connections to all screw terminals:
 - a. With chamfered/funneled terminal barrel entry.
 - b. Deep internal serrations.
 - c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
 - d. Electroplated-tin copper conductor.
 - e. Manufacturers: The following or equal:
 - 1) Thomas and Betts, Stakon.
2. For process equipment connections work from manufacturer's drawings.

B. Joints, splices, taps, and connections:

1. 600-volt conductors:
 - a. Use solderless connectors.
 - b. Use only plated copper alloy connectors or lugs:
 - 1) Aluminum connectors or lugs are not acceptable for copper conductors.
 - c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.

- d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
 - 1) Manufacturers: The following or equal:
 - a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
 - e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
 - 1) Manufacturers: One of the following or equal:
 - a) Burndy.
 - b) Thomas and Betts.
 - f. Heat shrink tubing:
 - 1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
 - 2) Minimum shrink ratio: 4 to 1.
 - 3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
 - 4) Internally applied adhesive sealant.
 - 5) Cross-linked polyolefin:
 - a) Manufacturers: One of the following or equal:
 - (1) 3M, ITCSN.
 - (2) Thomas & Betts, Shrink-Kon.
 - 2. Instrumentation class cable splices:
 - a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
 - b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
 - c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
 - d. Two-part mold body with tongue and groove seams and built in spacer webbing.
 - e. Manufacturers: The following or equal:
 - 1) 3M, Scotchcast 72-N.
- C. Insulating tape:
- 1. General purpose insulating tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
 - c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
 - d. Flame retardant, hot- and cold- weather resistant, UV resistant.
 - e. For use as a primary insulation for wire cable splices up to 600 VAC.
 - f. Meeting and complying with:
 - 1) ASTM D3005 Type I.
 - 2) UL 510.
 - 3) CSA C22.2.
 - g. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number Super 33+.
 - 2. General-purpose color-coding tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application on PVC and polyethylene jacketed cables.
 - c. For use indoors and outdoors in weather protected enclosures.
 - d. Available with the following colors:
 - 1) Red.
 - 2) Yellow.
 - 3) Blue.
 - 4) Brown.
 - 5) Gray.
 - 6) White.
 - 7) Green.

- 8) Orange.
- 9) Violet.
- e. For use as phase identification, marking, insulating, and harnessing.
- f. Meeting and complying with:
 - 1) UL 510.
 - 2) CSA C22.2.
- g. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number 35.

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES (NOT USED)

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in the Common Work Results for Electrical section.

B. Load connections:

- 1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.

C. Zero to 600-volt systems:

- 1. Make all connections with the proper tool and die as specified by the device manufacturer.
- 2. Use only tooling and dies manufactured by the device manufacturer.
- 3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
- 4. Number all power and control wires before termination.

D. Motor connections (600 volts and below):

- 1. Terminate all leads and wires with compression type ring lugs.
- 2. Terminations on all motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
- 3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
 - a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
 - b. Shrink cap with low heat as recommended by manufacturer.
- 4. Wire markers shall be readable after boot installation.

- 5. Manufacturers: The following or equal:
 - a. Raychem, MCK.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. As specified in the Commissioning section.

3.8 FIELD QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 262100

UTILITY COORDINATION

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Coordination with the utility companies to provide service.
 - 2. Contractor's responsibilities for connecting to utilities and providing utility service to the facilities.
 - 3. Descriptions of utility services required.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.4 SYSTEM DESCRIPTION

- A. Electrical service:
 - 1. Provide all Work and materials and bear all costs for providing temporary construction power and the permanent electrical service, including but not limited to:
 - a. All Work and materials not provided by the electric utility.
 - b. All permits and fees required by the electric utility.
 - 2. Provide electrical ducts, raceways, conductors and connections indicated on the Drawings, and all other Work and materials required for a complete electrical service, including but not limited to the following:
 - a. Electrical service conduits and conductors from the point of electric utility connection to the service entrance equipment.
 - b. Metering conduits from the instrument transformers to the meter.
- B. Telephone service:
 - 1. Provide all Work and materials and bear all costs for the telephone service during construction:
 - a. All permits and fees required by the telephone utility.
 - 2. Provide the telephone entrance conduit(s) from the terminal pole/pedestal to the telephone board, and all other Work and materials required for a complete telephone service.
- C. General:
 - 1. Coordinate and obtain inspections and final installation approval from the serving utilities and other authorities having jurisdiction.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Certification:

1. Submit certification that the intended installation has been coordinated with the utility companies.
2. Include a narrative description of the utility's requirements and points of connection, names, and telephone numbers for contacts at the utilities.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Materials and equipment used in performance of Electrical Work shall be listed or labeled by UL, or other equivalent recognized independent testing laboratory, for the class of service intended.

1.7 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING

- A. General:
 1. Before start of Site Work, make arrangements for temporary telephone and electrical service as required.
- B. Electrical systems:
 1. Before bidding, the electrical contractor shall contact the utilities to determine the Work and materials that will be required from the Contractor, and all fees and permits that will be required, so that all utility systems furnished by the Contractor will be included in the bid.
 2. Coordinate Work with Engineer to minimize downtime of existing operating equipment and electrical distribution systems and to preclude unsafe operation:
 - a. Notify Owner 10 days before power interruptions.
 - b. Coordinate downtime with Owner and local electric utility.
 3. Before commencing Work, coordinate electric service entrance requirements with local electric utility to ensure that the installation will be complete as specified in these Contract Documents:
 - a. Ensure power transformer size, electrical characteristics, and location are consistent with the design and service voltage provided by the electric utility coordinated with other trades.
 - b. Arrange for utility revenue meter.
 - c. Coordinate installation of metering CTs and PTs furnished by the electric utility.
 - d. Pay any charges required by the electric utility for connection and turn-on.
- C. Telephone systems:
 1. Before commencing Work, coordinate complete telephone service:
 - a. Verify compliance with telephone utility requirements.
 - b. Verify exact location of each service point and type of service.
 - c. Pay any charges required by the telephone utility for connection and turn-on.
 2. Coordinate complete telephone line connections at locations indicated on the Drawings with the local telephone utility.

- D. Before commencing Site Work, coordinate underground conduit installations with other Work to eliminate conflicts and avoid interferences with other underground systems.

1.11 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

- A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS (NOT USED)

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS

- A. Furnish materials in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

- A. Furnish equipment in accordance with the applicable requirements of the utilities and as specified in these Specifications.

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES (NOT USED)

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. As specified in the Common Work Results for Electrical section.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. As specified in the Commissioning section.

3.8 FIELD QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in the Common Work Results for Electrical section.

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 262650

REDUCED HARMONIC VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Reduced harmonic 18 pulse or active front end, variable frequency drives (VFD), 60 to 500 horsepower for control of standard NEMA Design B squirrel cage induction motors.
 - 2. **NOTE: VFD's SHALL BE SIZED AND RATED TO DELIVER APPROVED MOTOR NAMEPLATE FLA AT 50 DEGREES C. WHERE 40 DEGREE C EQUIPMENT IS PROPOSED, VFD SHALL BE SIZED AT A MINIMUM OF 125% OF MOTOR NAMEPLATE FLA AND ASSOCIATED FEEDER SIZES SHALL BE INCREASE TO MATCH AT NO CHANGE IN CONTRACT PRICE.**

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. National Electrical Manufacturers Association (NEMA).
- C. Underwriters' Laboratories (UL):
 - 1. 50 – Standards for Enclosures for Electrical Equipment.
 - 2. 508A – Standard for Safety for Industrial Control Panels.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. Specific Definitions
 - 1. VFD: Variable Frequency Drive.
 - 2. AFE: Active Front End.
 - 3. IGBT: Insulated Gate Bipolar Transistor.

1.4 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Each VFD system shall consist of all components required to meet the performance, protection, safety, testing and certification criteria of this Section.
 - 2. The VFD system:
 - a. Is a fully integrated package.
 - b. Includes all material necessary to interconnect VFD system elements, even if shipped separately.
 - 3. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer.
 - 4. Each VFD shall be completely factory pre-wired, assembled and then tested as a complete package by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
 - 5. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics:

- a. The VFD manufacturer shall furnish equipment necessary to mitigate potential damage to motor insulation.
- b. Coordinate bearing protection methods with the supplier of the driven equipment.
- c. Motors as specified in the Low Voltage Motors section up to 500 Horsepower.

B. Performance:

- 1. Operating envelope:
 - a. Speed and torque requirements:
 - 1) Provide a variable torque or constant torque VFD as required by the driven load.
 - 2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 110 percent (25 to 66 hertz) speed range.
 - b. Current requirements:
 - 1) Provide 100 percent of rated output current on a continuous basis.
 - 2) Variable torque VFD :
 - a) Minimum 110 percent current overload for 1 minute.
 - 3) Constant torque VFD :
 - a) Minimum 150 percent current overload for 1 minute.
- 2. Harmonics:
 - a. The VFD shall meet the following distortion limits at 2 percent line voltage unbalance measured at the input terminals of the VFD:
 - 1) Voltage harmonics: The maximum allowable total harmonic distortion, THD, for each VFD shall not exceed 5 percent.
 - 2) Current harmonics: The maximum allowable total harmonic current distortion limit, TDD, for each VFD shall not exceed 5 percent as measured at the input terminals of the VFD system.
- 3. Efficiency:
 - a. VFD system minimum efficiency shall be 93 percent at rated kilowatt output of the VFD. VFD system efficiency shall be calculated as follows:

$$\text{Efficiency (\%)} = \frac{\text{Power (Load)}}{\text{Power (Supply)}} \times 100$$
- b. Power:
 - 1) Load power is the total 3-phase power measured at the output terminals of the drive system, including the output filter.
 - 2) Supply power is the total power measured at the input terminals of the VFD including phase shifting transformer or active front end components and auxiliary equipment (e.g., controls, fans) for complete system operation.
- 4. Total power factor:
 - a. Minimum of 0.96 lagging across the entire speed range.
 - b. Under no operating conditions shall the VFD have a leading power factor.
- 5. Frequency accuracy:
 - a. Minimum of within 0.01 percent.
- 6. Speed regulation:
 - a. Minimum of within 0.5 percent across the entire speed range.
- 7. Capable of working with all available power sources (utility and on-site generation) and with all new and existing VFDs.

1.5 SUBMITTALS

A. Furnish submittals as specified in the Common Work Results for Electrical section:

- 1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.

- B. Product data:
1. Manufacturer of the VFD.
 2. Manufacturer of all components of the VFD.
 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 4. Weight.
 5. Nameplate schedule.
 6. Bill of material.
 7. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Input current.
 - d. Output current.
 - e. Interrupting rating.
 - f. Momentary current rating.
 8. Catalog cut sheets for major components.
 9. Surge protection data.
 10. Design data:
 - a. Efficiency and power factor values.
 - b. Certification that the drive is sized for the full nameplate motor horsepower and current (at rated RPM) of the driven load at the installed altitude.
 - c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
 - d. Certification that all electronic circuits and printed circuit boards are conformably coated.
 - e. Certification that the VFD will operate with all power sources (including alternate utilities and on-site generation when applicable).
 11. List of recommended spare parts.
 12. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in the Common Work Results for Electrical section:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
1. Complete plan and elevation drawings showing:
 - a. All dimensions.
 - b. Panel, sub-panel, and component layout indexed to the bill of material.
 - c. Conduit connections.
 - d. Required clearance around equipment.
 2. Block diagram showing the basic control and protection systems identifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.
 3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
 - a. Wiring diagrams shall include terminal number and wire numbers.
 4. Complete 1-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
 - a. Device electrical ratings shall be clearly indicated on the Drawings.
- D. Certifications:

1. Certification letter from the VFD manufacturer stating that the VFD(s) are capable of operating with all new and existing sources (utility sources and on-site generation).
 2. Certification letter from the VFD manufacturer stating that the VFD(s) are capable of operating with all new and existing VFDs on site.
- E. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in the Common Work Results for Electrical section.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- F. Test forms and reports:
1. Submit complete factory acceptance test procedures and all forms used during the test.
 - a. For VFD units less than 250 horsepower, provide certified test results for the actual VFD being furnished or prototype units. For VFD units 250 horsepower and larger, provide certified test results for the actual VFD being furnished.
 - b. Provide the following certified test reports:
 - 1) Efficiency at rated power output and output frequency of 60 hertz.
 - 2) Power factor at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent speed.
 - 3) Harmonics at the input terminals of the VFD at 100 percent speed and 100 percent load.
 - a) Voltage distortion: Measure individual harmonics up to and including the 50th harmonic and total harmonic distortion.
 - b) Current distortion: Measure individual harmonics up to and including the 50th harmonic and total demand distortion.
 - c. Submit complete field acceptance test procedures and all forms used during the test:
 - 1) Certification that the actual measured harmonic distortion for both voltage and current is within the specification limits at the installed site.
 - 2) Certification that the actual measured peak voltage at the motor terminations is less than 90 percent of the motor insulation dielectric withstand level.
- G. Record documents:
1. Certified record documents of all equipment with information listed above.
- H. Manufacturer's field reports:
1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer's requirements.
 2. Report listing the setting of all VFD adjustable parameters and their values after start-up.
 3. Certification letter from the VFD manufacturer stating that the VFD(s) are programmed to avoid system resonances when connected to high impedances sources like standby generator.

- I. Operation and maintenance manuals:
 - 1. Spare parts list with supplier names and part numbers.
 - 2. Start-up and commissioning instructions and data.
 - 3. Complete bill of material indexed to the drawings, identifying the catalog or part numbers, manufacturer, and quantities of components of the VFD system.
 - 4. Operating manuals:
 - a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
 - 5. Operating instructions:
 - a. The written descriptions shall detail the operational functions of all controls on the front panel including keypad functions and parameters.
 - 6. Maintenance manual:
 - a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
 - b. Manuals shall include but are not limited to the following:
 - 1) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
 - 2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.
 - 3) All schematic wiring and external diagrams:
 - a) Furnish drawings in a fully legible reduced 11-inch by 17-inch format.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Qualifications:
 - 1. Any third party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
 - 2. VFDs shall be UL 508C listed and labeled.
 - 3. VFD systems (packaged VFD panels) shall be UL 508A listed and labeled.
 - 4. VFDs shall be manufactured by the VFD manufacturer at its own facility, which shall have a quality assurance program that is certified in accordance with ISO 9001.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.
- B. Ship VFDs to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on site off-loading equipment:
 - 1. VFDs shall be delivered to the site pre-assembled and wired.
 - 2. Ship each VFD with 2 tamperproof accelerometers that record the maximum shock and vibration experienced by the VFD during shipping and handling.
- C. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING

- A. Conduct factory acceptance test and submit certified test results for Engineer's review.

- B. Ship equipment to Project Site after successful completion of factory acceptance test.
 - C. Assemble equipment in the field.
 - D. Conduct field acceptance tests including harmonic testing and submit results for Engineer's review.
 - 1. All utility power sources and on-site generation shall be installed and operable for field test.
 - E. Submit manufacturer's certification that equipment has been properly installed and is fully functional for Engineer's review.
 - F. Conduct Owner's training sessions.
 - G. Commissioning and process start-up as specified in the Commissioning section.
- 1.10 SCHEDULING
- A. As specified in the Common Work Results for Electrical section.
- 1.11 WARRANTY
- A. As specified in the Common Work Results for Electrical section.
- 1.12 SYSTEM START-UP
- A. As specified in the Common Work Results for Electrical section.
 - B. The VFD manufacturer shall be responsible for start-up of the VFDs in the presence of the equipment suppliers, Contractor, Engineer, and Owner.
- 1.13 OWNERS INSTRUCTIONS (NOT USED)
- 1.14 MAINTENANCE
- A. As specified in the Common Work Results for Electrical section.
 - B. Maintenance service: Manufacturer shall describe the field service system available to support the proposed VFD system. As a minimum describe:
 - 1. Type of technical support available (e.g., system engineering and technician).
 - 2. Location of field service personnel.
 - 3. Field service daily rates in dollars per hour and dollars per day.
 - 4. Guaranteed response times to service requests.
 - C. Spare parts:
 - 1. The following spare parts shall be furnished:
 - a. Any special dedicated tools for emergency service and troubleshooting.
 - b. All hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. One of the following or equal:
 - 1. Eaton.
 - 2. Allen-Bradley.
 - 3. Schneider-Electric.
 - 4. ABB.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

- A. General:
 - 1. Sinusoidal pulse width modulated, (PWM), voltage source type drive shall consist of the following:
 - a. Rectifier section.
 - b. Direct current link with capacitors.
 - c. Insulated gate bipolar transistor (IGBT), inverter section.
 - d. Microprocessor based controls.
 - e. Output filter.
 - 2. Rectifier section:
 - a. Provide VFDs with either an 18-pulse rectifier section or an active front end:
 - b. 18-pulse rectifier:
 - 1) Integral phase shifting auto-transformer:
 - a) Converts 3-phase utility power to 3 sets of 3 power circuits with each set phase shifted and powering its own 3-phase bridge rectifier.
 - 2) Minimum 18-pulse diode rectifier section consisting of 3 three-phase bridge rectifiers.
 - a) Specifically designed as a system to share currents between the bridges to within 1 percent.
 - c. Active front end rectifier:
 - 1) IGBT based converter module.
 - a) Six IGBTs minimum.
 - 2) Inductor/capacitor/inductor, LCL, harmonic filter.
 - a) Low pass filter.
 - b) The filter shall be disconnected from the line when the VFD is off.
- B. Ratings:
 - 1. Voltage:
 - a. Input voltage: 480 Volts plus or minus 10 percent, 3-phase, 3-wire, 60 hertz.
 - b. Solidly grounded.
 - 2. Short-circuit rating:
 - a. 65 kA RMS symmetrical.
- C. Operational features:
 - 1. Protective features:
 - a. Annunciated at the keypad and available via network connection.
 - b. Include the following protective features:
 - 1) Motor overload protection.

- 2) Instantaneous overcurrent.
 - 3) Instantaneous overvoltage.
 - 4) Undervoltage.
 - 5) Power unit overtemperature.
 - 6) Phase loss.
 - 7) VFD output short circuit.
 - 8) VFD output ground fault.
 - 9) Blown fuse with blown fuse indication.
 - 10) IGBT protection.
 - 11) Cooling fan failure.
 - 12) Component failure.
2. Control mode:
 - a. The VFD shall operate in either a constant volts/hertz or sensorless vector mode. Selectable using the programming keypad.
 3. Frequency control:
 - a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
 - b. Programmable minimum frequency.
 - c. Programmable maximum frequency.
 4. Acceleration/Deceleration:
 - a. Separately adjustable acceleration and deceleration rates.
 - b. Each rate shall be adjustable from 0.01 to 1,800 seconds.
 5. Spinning load:
 - a. Capable of determining the speed and direction of a spinning load, "catch" the load and accelerate or decelerate it without damage to the load.
 6. Programmable loss of signal:
 - a. Upon loss of reference speed signal the VFD shall be programmable to either stop, maintain current speed, or default to preselected speed.
 7. Power interrupt ride through:
 - a. Capable of continuous operation in the event of a power loss of 5 cycles or less.
 8. Hardwired inputs and outputs:
 - a. Manufacturer's standard number the following:
 - 1) Analog inputs:
 - a) Configurable as either 0 to 10 volts or 4 to 20 milliamperes.
 - 2) Analog outputs:
 - a) Programmable 4 to 20 milliamperes isolated.
 - 3) Discrete inputs:
 - a) Programmable.
 - 4) Discrete outputs:
 - a) Programmable.
 - b) Form C relay contacts.
 - 5) Potentiometer 3-wire input.
 - b. Provide additional inputs and outputs as required to meet the control functions indicated on the Drawings.
 9. Communications:
 - a. Provide each VFD with an EtherNet i/P communications interface module.
 - b. The use of gateways is not acceptable.
 - c. Control and monitoring of the bypass starter shall be available over the communications network.
 - d. All protocols shall be certified by the governing authority.
 10. Real-time clock:
 - a. Capable of providing time-stamped events.
 - b. Set locally or via a remote controller.
 - c. Programable for day, month, year, local time zones in hours, minutes and seconds.
 11. Diagnostics:
 - a. Minimum of 4 fault conditions in memory on a first in - first out basis.

- b. Time stamped.
- c. Operating frequency, drive status and power mode shall also be stored at the time of the fault.
- d. Fault memory shall be maintained in the event of a power outage.
- e. The fault memory shall be accessible via RS-232, RS-422 or RS-485.
- 12. Automatic restart:
 - a. User selectable, automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
 - 1) Programmable for up to 9 automatic restart attempts with an adjustable time delay between restart attempts.

2.6 COMPONENTS

- A. Enclosure:
 - 1. NEMA Type 12.
 - 2. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions:
 - a. Provide cooling device alarm.
- B. Power disconnect:
 - 1. Flange mounted thermal magnetic circuit breaker:
 - a. Lockable in the OFF position.
- C. Phase shifting transformer:
 - 1. Auto-transformer.
 - 2. Integral part of the VFD assembly and factory mounted and wired within the VFD enclosure.
 - 3. Embedded thermal protection.
 - 4. Rated for rectifier duty.
 - 5. Copper or aluminum windings with 180-degree Celsius insulation.
- D. Keypad:
 - 1. Furnished with a keypad for programming and control.
 - 2. Password security to protect drive parameters.
 - 3. Mounted on the door of the VFD.
 - 4. Back-lit LCD with a minimum of 2 lines of a minimum of 16 characters each.
 - 5. Programming and display features language: English.
 - 6. Capable of displaying the following parameters:
 - a. Speed (percent).
 - b. Input current (amperes).
 - c. Output current (amperes).
 - d. Output frequency (hertz).
 - e. Input voltage.
 - f. Output voltage.
 - g. Total 3-phase kilowatt.
 - h. Kilowatt hour meter.
 - i. Elapsed run time meter.
 - j. Revolutions per minute.
 - k. Direct current bus voltage.
 - 7. In addition to all keys required for programming, the keypad shall have the following:
 - a. Automatic/Manual selector.
 - b. Start pushbutton.
 - c. Stop pushbutton.
 - d. Jog pushbutton.
 - e. Speed increment.
 - f. Speed decrement.

- g. Forward/Reverse selector.
 - h. RUN indicator.
 - i. PROGRAM indicator.
 - j. FAULT indicator.
 - k. DRIVE READY indicator.
 - l. Diagnostics.
 - 8. Provide the VFD with the hardwired controls indicated on the Drawings.
- E. Control power transformer:
- 1. Furnish a control power transformer mounted and wired inside the drive enclosure:
 - a. Primary and secondary fusing.
 - 2. Size the transformer to supply power to all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.
- 2.7 ACCESSORIES
- A. Surge protection:
- 1. Metal oxide varistors:
 - a. Provide protection for the VFD against:
 - 1) Line transients: 5,000 volt peak minimum.
 - 2) Line to ground transients: 7,000 peak minimum.
- B. Conformal coating:
- 1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H₂S and chlorine.
- C. Air filters:
- 1. Mounted on the outside of the VFD enclosure:
 - a. Replaceable without requiring that the VFD be turned off or the door opened.
 - 2. Located on the front or top of the VFD enclosure.
 - a. Side or rear mounted air filters are not acceptable.
- 2.8 MIXES (NOT USED)
- 2.9 FABRICATION (NOT USED)
- 2.10 FINISHES
- A. Enclosure finish shall be manufacturer's standard gray.
- 2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

- 3.1 EXAMINATION (NOT USED)
- 3.2 PREPARATION (NOT USED)
- 3.3 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

C. General:

1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete installation of the VFD (free-standing or within motor control center).
2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
3. Perform Work in accordance with the manufacturer's instructions and shop drawings.
4. Furnish components, and equipment as required to complete the installation.
5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
6. Install free-standing enclosures on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt the VFD frame to the leveling channels.
7. Provide openings in top or bottom of the VFD (free-standing or within motor control center) enclosure for conduit only, no additional openings will be allowed:
 - a. Improperly cut holes will require that the entire panel be replaced:
 - 1) No hole closers or patches will be allowed.
8. Bundle circuits together and terminate in each unit:
 - a. Tie with nylon wire ties. As specified in the 600-Volt or Less Wires and Cables section.
 - b. Label all wires at each end with wire numbers shown on the approved Control Drawings.
 - c. All connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. Factory testing:

1. Owner and Engineer will witness the factory acceptance test as specified in the Common Work Results for Electrical section.
2. General:
 - a. All VFDs furnished under this Section shall be tested and inspected as specified below.
 - b. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
3. Failure of any component during testing requires replacement of the faulted component and a complete retest.
4. Testing sequence:
 - a. Submit a detailed test procedure for the VFD factory test:
 - 1) A minimum of 8 weeks in advance of the proposed testing date.
 - 2) No tests shall be performed until the test procedure is reviewed and accepted by the Engineer.
5. Component tests:
 - a. Preliminary inspection:
 - 1) Verify that all components are correct.
 - 2) Verify that all connections are properly torqued.
 - b. Printed circuit boards:
 - 1) Test each printed circuit board per the manufacturer's standard testing procedure.

- c. Wiring:
 - 1) Control and power wiring continuity verified point-to-point.
 - 2) Hi-pot power and control wiring at manufacturer's recommended levels.
 - 3) Verify ground bond resistance.
 - d. Load testing:
 - 1) No load testing in accordance with the manufacturer's standard factory test procedure.
 - 2) Full load testing:
 - a) Test each VFD and all control logic with a representative motor or dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.
 - b) Tests shall be conducted in a manner in which the inverter (IGBT) section supplies all the output power (kw) of the VFD system. Control strategies using a contactor or other means of bypassing the VFD when operating at the line frequency shall not be permitted.
 - c) Tests shall be conducted using a minimum output frequency of 60 hertz, and a minimum switching frequency of 2.5 kHz.
- B. Owner training:
- 1. As specified in the Commissioning section and the Common Work Results for Electrical section.

3.8 FIELD QUALITY CONTROL

- A. As specified in the Common Work Results for Electrical section.
- B. Provide the services of a VFD manufacturer representative for start-up assistance and training:
- 1. Inspection and field adjustment:
 - a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
 - 2. Start-up field testing:
 - a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
 - b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.
 - c. Compliance with the following specified parameters shall be verified by the VFD manufacturer:
 - 1) Motor terminal voltage:
 - a) Make field measurements at the motor connection box.
 - b) Make measurements of the full speed range of the VFD.
 - c) Make measurements with a recording type oscilloscope.
 - 2) Harmonics:
 - a) Make field measurements at the input terminals of the VFD with and without the VFD in operation.
 - b) Make measurements with a recording type harmonic analyzer displaying individual and total harmonic currents and voltages:
 - (1) Record currents and voltages for a minimum of 10 minutes.
 - (2) Analyzers using snapshots are not acceptable.
 - d. All utility sources and on-site generation shall be operational for start-up field testing.

3.9 ADJUSTING

- A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.
- B. Provide the services of a VFD manufacturer factory technician to make all drive parameter and protective device settings:
 - 1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
 - 2. Provide documentation of VFD settings included but not limited to:
 - a. Minimum speed.
 - b. Maximum speed.
 - c. Skip speeds.
 - d. Current limit.
 - e. Acceleration time.
 - f. Deceleration time.
 - g. Carrier frequency.

3.10 CLEANING

- A. As specified in the Common Work Results for Electrical section.

3.11 PROTECTION

- A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 262720

DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Enclosed dry-type transformers:
 - a. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
 - b. Primary voltage 600 volts and below.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.
 - 2. C57.12.01 - IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.
 - 3. C57.96 - IEEE Guide for Loading Dry-Type Distribution and Power Transformers.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. Underwriters Laboratory (UL):
 - 1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.
- E. U.S. Department of Energy (DOE):
 - 1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. NEMA:
 - 1. Type 2 enclosure in accordance with NEMA 250.
 - 2. Type 3R enclosure in accordance with NEMA 250.

1.4 SYSTEM DESCRIPTIONS

- A. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
 - 1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in the Common Work Results for Electrical section after all derating factors have been applied.
 - 2. Suitable for continuous operation at full rating with normal life expectancy in accordance with IEEE C57.96.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Nameplate data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - 4. Inrush current.
 - 5. Insulation system and temperature constraints.
 - 6. Number and rating of taps.
 - 7. Sound levels.
 - 8. Connection diagrams:
 - a. Primary.
 - b. Secondary.
 - 9. BIL rating.
 - 10. Required clearances.
 - 11. Percent impedance.
 - 12. Efficiency.
 - 13. Certification of full capacity capability at the Project elevation and ambient conditions.
 - 14. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in the Common Work Results for Electrical section:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Installation instructions:
 - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 - 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in the Common Work Results for Electrical section.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. One of the following or equal:

1. General Electric.
2. Jefferson.
3. Schneider Electric.
4. Eaton.
5. ABB.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS

A. Cores:

1. Non-aging, grain-oriented silicon steel.
2. Magnetic flux densities below the saturation point.

B. Windings:

1. High-grade magnet wire.
2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
 - a. Cured to reduce hot-spots and seal out moisture.
3. Material electrical grade:
 - a. Copper.

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

A. General:

1. 10 kilovolts BIL for 600-volt class windings.
2. Sound levels, in accordance with IEEE 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (db)
1-9	40
10-50	45

Kilovolt-Amperes Range	Audible Sound Level (db)
51-150	50
151-300	55
301-500	60
501-700	62
701-1000	64

3. Taps:
 - a. 15 kilovolt-amperes and less:
 - 1) Two 5 percent full capacity primary taps below rated voltage.
 - b. 25 kilovolt-amperes and larger:
 - 1) Four 2.5 percent full capacity primary taps below rated voltage.
 - 2) Two 2.5 percent full capacity primary taps above rated voltage.
 - c. Operated by a tap changer handle or tap jumpers accessible through a panel.
 4. Terminals:
 - a. UL listed for either copper or aluminum conductors.
 - b. Rated for 75 degrees Celsius.
 5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with IEEE C57.96.
- B. Transformers less than 15 kilovolt-amperes:
1. Insulation class: 185 degrees Celsius.
 2. Temperature rise: 115 degrees Celsius.
- C. Energy efficient transformers 15 kilovolt-amperes and larger:
1. Insulation class: 220 degrees Celsius.
 2. Temperature rise: 80/115/150 degrees Celsius, except as noted below:
 - a. 150-degree Celsius rise for dry-type transformers located in motor control centers.
 3. Efficiency:
 - a. In accordance with DOE 10 CFR Part 431.
- D. Enclosures:
1. Heavy gauge steel:
 - a. Outdoor: Moisture and water resistant with rodent screens over all openings and in a weather-protected enclosure, NEMA Type 3R.
 - b. Indoor: NEMA Type 2.
 2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
 3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
 - a. Neoprene vibration pads and sleeves.

2.6 COMPONENTS (NOT USED)

2.7 ACCESSORIES

- A. Nameplates:
1. Non-corrosive metal or UL listed non-metallic:
 - a. Stamped, engraved or printed with the following information:
 - 1) Phases.
 - 2) Frequency.
 - 3) Kilovolt-ampere rating.
 - 4) Voltage ratings.
 - 5) Temperature rise.

- 6) Impedance.
- 7) Insulation class.
- 8) BIL rating.
- 9) Connection diagram.
- 10) Weight.
- 11) Manufacturer.
- 12) The identification "transformer".
- 13) Classes of cooling.
- 14) Tap voltage(s).
- 15) Vector diagram.

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited manufacturer's standard gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 - 1. Floor, wall, platform, motor control center, packaged power supply, or roof mounted, as indicated on the Drawings.
 - 2. Install where not in direct contact with building structure.
 - 3. Install on single layer vibration pad under the entire mounting surface.
 - a. Manufacturers: The following or equal:
 - 1) Korfund.
 - 4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
 - 5. Ground the enclosure:
 - a. To an equipment ground conductor in the conduit.
 - b. To the facility grounding electrode system.
 - 6. Floor mounted transformers:
 - a. Install transformers on a housekeeping pads.
 - b. Install transformers with adequate space from walls or other enclosures for proper ventilation in accordance with the manufacturer's recommendations.

3.4 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. As specified in the Commissioning section.

B. Factory tests:

1. Applied voltage test to each winding and from each winding to the core:
 - a. 600-volt class winding 4.5 kilovolt.
2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
3. Voltage ratio and polarity.
4. Sound level, performed in a test room with ambient sound level not exceeding 24 db.
5. Perform all tests in accordance with UL 1561.

3.8 FIELD QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING

A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

3.10 CLEANING

A. As specified in the Common Work Results for Electrical section.

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 262850

SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. High-energy surge protective devices.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
 - 2. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
 - 3. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
 - 4. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 V and less) AC Power Circuits.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. Underwriters Laboratory:
 - 1. 1449, 4th Edition, Standard for Surge Protective Devices.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. NEMA:
 - 1. Type 1 enclosure in accordance with NEMA 250.
 - 2. Type 4 enclosure in accordance with NEMA 250.
 - 3. Type 4X enclosure in accordance with NEMA 250.
 - 4. Type 12 enclosure in accordance with NEMA 250.
- C. Specific definitions:
 - 1. SPD: Surge protective device.
 - 2. SAD: Silicon avalanche diode.
 - 3. MOV: Metal oxide varistor.
 - 4. MCOV: Maximum continuous operating voltage.
 - 5. I_n : Nominal discharge current.
 - 6. VPR: Voltage protection rating.
 - 7. SCCR: Short circuit current rating.

1.4 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.

- B. Product data:
 - 1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
 - 2. Manufacturer's catalog cut sheets indicating:
 - a. Manufacturer and model numbers.
 - b. Ratings of each SPD including but not limited to:
 - 1) Short circuit current rating.
 - 2) Nominal discharge current.
 - 3) Maximum continuous operating voltage.
 - 4) Voltage protection rating.
 - 5) System voltage.
 - 6) System frequency.
 - 7) Surge current capacity.
 - 3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
 - a. Overcurrent protection.
 - b. UL 1449.
- C. Shop drawings:
 - 1. Provide electrical and mechanical drawings by the manufacturer that detail:
 - a. Unit dimensions.
 - b. Weights.
 - c. Components.
 - d. Field connection locations.
 - e. Mounting provisions.
 - f. Connection details.
 - g. Wiring diagram.
- D. Operation and maintenance manuals:
 - 1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.5 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE C62.41.1, C62.41.2, C62.45, C62.62).
 - 2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
 - 3. National Electrical Manufacturer Association.
 - 4. National Fire Protection Association (NFPA 20, 75 and 780).
 - 5. National Electric Code (NFPA 70).
 - 6. Underwriters Laboratories (UL 1449 4th Edition and UL 1283).
 - 7. International Electrotechnical Commission (IEC 801).

1.6 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.7 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.8 SEQUENCING

- A. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.9 SCHEDULING (NOT USED)

1.10 WARRANTY

- A. As specified in the Common Work Results for Electrical section.
- B. Extended warranty:
 - 1. Furnish a manufacturer's full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
 - 2. Warranty shall include:
 - a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
 - b. A 24-hour toll-free 800-number for warranty support.

1.11 SYSTEM START-UP

- A. As specified in the Common Work Results for Electrical section.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. One of the following or equal:
 - 1. Liebert.
 - 2. Eaton.
 - 3. Schneider Electric.
 - 4. General Electric.

2.2 SYSTEM DESCRIPTION

- A. Surge protective devices as an integral component of the electrical equipment or externally mounted as indicated on the Drawings.

2.3 EXISTING PRODUCTS (NOT USED)

2.4 MATERIALS (NOT USED)

2.5 MANUFACTURED UNITS

- A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.
- B. Electrical requirements:
 - 1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
 - 2. MCOV:

- a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
- 3. Operating frequency:
 - a. 47 to 63 hertz.
- 4. SCCR:
 - a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
 - b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
- 5. Nominal discharge current I_n :
 - a. 20 kA.
- 6. Maximum VPR:

Modes	<u>240/120</u>	<u>208Y/120</u>	480Y/277	480V
L-N, L-G, N-G	900	900	1,500	1,500
L-L	1,200	1,200	2000	2,000

- 7. Peak surge current:
 - a. Service entrance locations:
 - 1) 240 kA per phase minimum.
 - 2) 120 kA per mode minimum.
 - b. Branch locations:
 - 1) 120 kA per phase, minimum.
 - 2) 60 kA per mode minimum.
- C. Protection modes:
 - 1. Provide SPD protection modes as follows:
 - a. Line to Neutral (L-N) where applicable.
 - b. Line to Ground (L-G).
 - c. Neutral to Ground (N-G), where applicable.
- D. Environmental requirements:
 - 1. Storage temperature:
 - a. -40 degrees to 122 degrees Fahrenheit.
 - 2. Operating temperature:
 - a. 32 degrees to 140 Fahrenheit.
 - 3. Relative humidity:
 - a. 5 percent to 95 percent.
 - 4. Audible noise:
 - a. Less than 45 dBa at 5 feet (1.5 m).
 - 5. Operating altitude:
 - a. Zero to 12,000 feet above sea level.
- E. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B and C3 environments, as tested to IEEE C62.45.

2.6 EQUIPMENT (NOT USED)

2.7 COMPONENTS

- A. Enclosure:
 - 1. Located in electrical equipment as indicated on the Drawings.
 - 2. External mounting:
 - a. NEMA Type 4X enclosure:
 - 1) No ventilation openings.

- b. Hinged cover requiring a tool for internal access.
 - c. Internal drawing pocket.
 - d. All monitoring indications must be visible without opening the door.
- B. Internal connections:
 - 1. Provide low impedance copper plates for intra-unit connections:
 - a. Attach surge modules using bolted connections to the plates for low impedance connections.
 - 2. Size all connections, conductors, and terminals for the specified surge current capacity.
- C. Surge diversion modules:
 - 1. MOV:
 - a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.
- D. Overcurrent protection:
 - 1. Individually fuse all components, including suppression, filtering, and monitoring components:
 - a. Rated to allow maximum specified nominal discharge current capacity.
 - b. Overcurrent protection that limits specified surge currents is not acceptable.
- E. Connections:
 - 1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.8 ACCESSORIES

- A. Unit status indicators:
 - 1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
 - a. The absence of the green light and the presence of the red light indicate that surge protection is reduced, and service is needed to restore full operation.
 - b. Indicates the status of protection on each mode or phase.
- B. Dry contacts for remote monitoring:
 - 1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.
- C. Provide an audible alarm which activates under any fault condition.
 - 1. Provide an alarm On/Off switch to silence the alarm.
 - 2. A visible LED will confirm whether alarm is On or Disabled.
 - 3. Locate both switches and the audible alarm on the unit's front cover.
- D. Provide an integral disconnect switch located in-line with the SPD enclosure:
 - 1. External manual operator.
 - 2. The switch shall disconnect all ungrounded circuit conductors from the SPD.
 - 3. The integral disconnect switch shall be capable of withstanding, without failure, the maximum published surge current magnitude and short circuit current without failure or damage to the switch.
- E. Interconnection cable:
 - 1. Interconnect the SPD to the power system using a manufacturer furnished assembly of low impedance coaxial cables installed in flexible conduit.
 - 2. Cable designed to transmit transients with minimal voltage drop.
 - 3. UL listed.

2.9 MIXES (NOT USED)

- 2.10 FABRICATION (NOT USED)
- 2.11 FINISHES (NOT USED)
- 2.12 SOURCE QUALITY CONTROL
 - A. Permanently affix surge rating to the SPD.
 - B. Perform manufacturer's standard factory test:
 - 1. Perform testing in accordance with UL 1449.

PART 3 EXECUTION

- 3.1 EXAMINATION (NOT USED)
- 3.2 PREPARATION (NOT USED)
- 3.3 INSTALLATION
 - A. As specified in the Common Work Results for Electrical section.
 - B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.
 - C. Special techniques:
 - 1. Install the SPD with as short and straight conductors including ground conductor as practically possible:
 - a. Twist the input conductors together to reduce input conductor inductance.
 - 2. Interconnect the SPD to the power system using a manufacturer supplied interconnection cable consisting of low impedance coaxial cables installed in a flexible conduit.
 - 3. Do not subject SPD to insulation resistance testing.
- 3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 RE-INSTALLATION (NOT USED)
- 3.7 COMMISSIONING
 - A. As specified in the Commissioning section.
- 3.8 FIELD QUALITY CONTROL
 - A. As specified in the Field Electrical Acceptance Tests section.
- 3.9 ADJUSTING (NOT USED)
- 3.10 CLEANING (NOT USED)
- 3.11 PROTECTION
 - A. As specified in the Common Work Results for Electrical section.
- 3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 262900

ELECTRICAL POWER MONITORING

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Power meters.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. American National Standard Institute (ANSI):
 - 1. C12.20 - Electricity Meters - 0.2 and 0.5 Accuracy Classes.
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C57.13.6 - Standard for High Accuracy Instrument Transformers.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. Specific definitions:
 - 1. FS - Full Scale.
 - 2. RDG - Of Reading.
 - 3. SSM - Solid State Multifunction Power Meter.
 - 4. THD - Total Harmonic Distortion.

1.4 SYSTEM DESCRIPTION (NOT USED)

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Power meter data including but not limited to:
 - a. Power requirements.
 - b. Communications protocols.
 - c. Input/outputs.
 - d. Dimensions.
 - e. Measurement functions.
 - f. Front panel controls.
 - g. Display characteristics.
- C. Operation and maintenance manuals:
 - 1. Descriptive and technical bulletins and sales aids edited to reflect only the equipment to be provided and covering each of the components in the system.
 - 2. A maintenance section including all instruction leaflets and technical data necessary to setup, change setup and maintain the power meters.
 - 3. Original licensed copies of all software and software manuals.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- 1.7 DELIVERY, STORAGE, AND HANDLING
 - A. As specified in the Common Work Results for Electrical section.
- 1.8 PROJECT OR SITE CONDITIONS
 - A. As specified in the Common Work Results for Electrical section.
- 1.9 SEQUENCING (NOT USED)
- 1.10 SCHEDULING (NOT USED)
- 1.11 WARRANTY
 - A. As specified in the Common Work Results for Electrical.
- 1.12 SYSTEM START-UP
 - A. As specified in the Common Work Results for Electrical section.
- 1.13 OWNER'S INSTRUCTIONS (NOT USED)
- 1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

- 2.1 MANUFACTURERS
 - A. One of the following or equal:
 - 1. Allen-Bradley.
 - 2. Eaton.
 - 3. General Electric.
 - 4. Schneider Electric.
- 2.2 EXISTING PRODUCTS (NOT USED)
- 2.3 MATERIALS (NOT USED)
- 2.4 MANUFACTURED UNITS (NOT USED)
- 2.5 EQUIPMENT (NOT USED)
- 2.6 COMPONENTS
 - A. Power meters:
 - 1. Power meter type 1 (SSM1) device which shall include at a minimum:
 - a. Individual phase currents, plus or minus 0.5 percent FS.
 - b. Phase-to-phase and phase-to-neutral voltages, plus or minus 0.5 percent FS.
 - c. Watts, VARs, VA, plus or minus 1 percent FS.
 - d. Watt-hours, VAR-hours, VA-hours, plus or minus 1 percent FS.
 - e. PF (apparent and displacement), plus or minus 2 percent FS.
 - f. Frequency, plus or minus 1 percent hertz.

- g. Demand:
 - 1) Ampere, plus or minus 0.5 percent full scale.
 - 2) Watt, VAR, VA, plus or minus 1 percent full scale.
- h. Minimum and maximum values:
 - 1) Volts (L-L), volts (L-N), current, watts, VARS, VA.
 - 2) Power factor:
 - a) Apparent.
 - b) Displacement.
 - c) Frequency.
- i. Synch-input kilowatts utility.
- j. LCD with LED backlight.

2.7 ACCESSORIES

A. Current transformers:

- 1. Ring type current transformers:
 - a. Suitable for service within low or medium voltage equipment as indicated on the Drawings.
 - b. Designed to have a mechanical and thermal rating to withstand short-circuit current, stresses, and heating effects equal to the rating of the equipment of the application.
- 2. Current ratio: As indicated on the Drawings, for use as a guideline:
- 3. Rated in accordance with IEEE C57.13.6 with accuracy of the current transformers suitable for relay accuracy class and rated for 200 percent burden for the required connected devices.
- 4. Identify polarity with standard marking or symbols.
- 5. Capable of carrying rated primary current continuously without damage.
- 6. Install secondary wiring from current transformers in a suitable wiring trough, or conduit to proper short-circuiting type terminal blocks for connection to relays, instruments, and other devices.

B. Potential transformers:

- 1. Indoor dry type, single-phase, 60 hertz, with a minimum thermal capacity of not less than 400 volt-amperes at 55 Celsius rise above 40 Celsius ambient.
- 2. Accuracy classification determined in accordance with IEEE C57.13.6, suitable for relay accuracy class, and 200 percent burden, for the required connected devices, with the secondary voltage 120 volts.
- 3. Insulation levels as required for the equipment system voltage but not less than:
 - a. 600 VAC, 10 kV BIL for 480 VAC systems.
 - b. 5.6 KV, 60 kV BIL for 2300 and 4160 VAC systems.
 - c. 15.5 KV, 110 kV BIL for 12.47 kV and 13.2 kV systems.
- 4. Identify polarity with standard markings or symbols.
- 5. Connect transformer secondary to potential buses as required.
- 6. Protect medium voltage potential transformers on the primary side with medium voltage current-limiting fuses.
- 7. Protect low voltage potential transformers on the primary side and secondary side with current-limiting fuses.
- 8. Mount medium voltage potential transformers in a separate compartment on a drawout device which, when in the FULLY WITHDRAWN position, disconnects both primary and secondary terminals of the transformer and grounds the primary potential fuses.

- 2.8 MIXES (NOT USED)
- 2.9 FABRICATION (NOT USED)
- 2.10 FINISHES (NOT USED)
- 2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

- 3.1 EXAMINATION (NOT USED)
- 3.2 PREPARATION (NOT USED)
- 3.3 INSTALLATION
 - A. As specified in the Common Work Results for Electrical section.
 - B. Install power meters in the electrical equipment as indicated on the Drawings.
- 3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 RE-INSTALLATION (NOT USED)
- 3.7 COMMISSIONING
 - A. As specified in the Commissioning section.
- 3.8 FIELD QUALITY CONTROL
 - A. As specified in the Common Work Results for Electrical section.
- 3.9 ADJUSTING (NOT USED)
- 3.10 CLEANING
 - A. As specified in the Common Work Results for Electrical section.
- 3.11 PROTECTION
 - A. As specified in the Common Work Results for Electrical section.
- 3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 264110
DISCONNECT SWITCHES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Fusible and non-fusible disconnect switches.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. National Electric Manufacturer's Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment.
 - 2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- C. Underwriters Laboratories Inc. (UL):
 - 1. 20 - General-Use Snap Switches.
 - 2. 98 - Enclosed and Dead-Front Switches.
 - 3. 508 - Standard for Industrial Control Equipment.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. Specific definitions:
 - 1. Safety switches and disconnect switches are to be considered synonymous.

1.4 SYSTEM DESCRIPTION

- A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.
- B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Manufacturer.
 - 2. Manufacturer's specifications and description.
 - 3. Ratings:
 - a. Voltage.
 - b. Current.
 - c. Horsepower.
 - d. Short circuit rating.
 - 4. Fused or non-fused.
 - 5. NEMA enclosure type.
 - 6. Dimensions:

- a. Height.
 - b. Width.
 - c. Depth.
 - 7. Weight.
 - 8. Cross-referenced to the disconnect schedule indicated on the Drawings.
- C. Shop drawings:
 - 1. Manufacturer's installation instructions:
 - a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
 - b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
 - 2. Identify motor or equipment served by each switch; indicate nameplate inscription.
- D. Installation instructions:
 - 1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in the Common Work Results for Electrical section and calculations:
 - a. Stamped by a professional engineer registered in the state where the Project is being constructed.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Regulatory requirements:
 - 1. NEMA KS1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
 - 2. UL 98 - Enclosed and Dead-Front Switches.
- C. Disconnect switches shall be UL listed and labeled.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING

- A. After successful review of the initial fault current study, submit complete equipment submittal.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

- A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. One of the following or equal:
1. Schneider Electric.
 2. Eaton.
 3. General Electric.
 4. Siemens.
 5. Appleton.
 6. Crouse-Hinds.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

- A. Switch mechanism:
1. Quick-make, quick-break heavy-duty operating mechanisms:
 - a. Provisions for padlocking the switch in the Off position.
 - b. A minimum of 90-degree handle travel position between Off and On positions:
 - 1) Provide handle position indicators to identify the handle position.
 - c. Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
 - 1) With an externally operated override.
- B. Switch interior:
1. Switch blades visible when the switch is Off and the cover is open.
 2. Lugs:
 - a. Front accessible.
 - b. Removable.
 - c. UL listed for 60/75-degree Celsius copper conductors.
 3. Current carrying parts completely plated to resist corrosion.
 4. Removable arc suppressors to facilitate easy access to line side lugs.
 5. Furnish equipment ground kits for every switch.
- C. Fused switches:
1. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
 - a. Ratings 100 amperes through 600 amperes at 240 volts.
 - b. Ratings 30 amperes through 600 amperes at 600 volts.
 - c. Provide spring reinforced and plated fuse clips.
- D. Ratings:
1. UL horsepower rated for AC or DC with the rating not less than the load served.
 2. Current:
 - a. 30 to 1,200 amperes.
 3. Voltage:
 - a. 250 volts AC, DC.
 - b. 600 volts (30 A to 200 A, 600 volts DC).

- 4. Poles:
 - a. 2, 3, 4, and 6 poles.
 - 5. UL listed short circuit ratings:
 - a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
 - b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).
 - c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1,200 amperes).
 - 6. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050 - Common Work Results for Electrical for the installed location.
- E. Size, fusing and number poles as indicated on the Drawings or as required:
- 1. Provide solid neutral where indicated on the Drawings.
- 2.6 COMPONENTS (NOT USED)
- 2.7 ACCESSORIES
- A. Disconnect switches to have provisions for a field installable "B" type electrical interlock for position indication as indicated on the Drawings.
 - B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.
 - C. NEMA Type 7 and 9 enclosures furnished with drain and breather kit when used in outdoor applications.
- 2.8 MIXES (NOT USED)
- 2.9 FABRICATION (NOT USED)
- 2.10 FINISHES (NOT USED)
- 2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

- 3.1 EXAMINATION (NOT USED)
- 3.2 PREPARATION (NOT USED)
- 3.3 INSTALLATION
- A. As specified in the Common Work Results for Electrical section.
 - B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
 - C. General:
 - 1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
 - 2. Provide all mounting brackets, stands, supports and hardware as required:

- a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
 - b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
- 3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
 - a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
 - b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
- 4. Provide a nameplate for each disconnect switch:
 - a. Provide per requirements specified in the Identification for Electrical Systems section.
 - b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. As specified in the Commissioning section.

3.8 FIELD QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in the Common Work Results for Electrical section.

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Low voltage molded case circuit breakers.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. AB 3. - Molded Case Circuit Breakers and Their Application.
- C. Underwriter's Laboratories (UL):
 - 1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 - 2. 943 - Ground Fault Circuit Interrupters.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. In accordance with UL 489.

1.4 SYSTEM DESCRIPTION

- A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.7 DELIVERY, STORAGE AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. One of the following or equal:

1. Eaton.
2. General Electric Co.
3. Schneider Electric.
4. ABB.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS

A. General:

1. Conforming to UL 489.
2. Operating mechanism:
 - a. Quick-make, quick-break, non-welding silver alloy contacts.
 - b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
 - c. Mechanically trip free from the handle.
 - d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
 - e. Lockable in the "OFF" position.
3. Arc extinction:
 - a. In arc chutes.
4. Voltage and current ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Minimum frame size 100A.
5. Interrupting ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

- B. Motor circuit protectors:
 - 1. Instantaneous only circuit breaker as part of a listed combination motor controller.
 - 2. Each pole continuously adjustable in a linear scale with 'LO' and 'HI' settings factory calibrated.

2.5 EQUIPMENT (NOT USED)

2.6 COMPONENTS

- A. Terminals:
 - 1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.
- B. Case:
 - 1. Molded polyester glass reinforced.
 - 2. Ratings clearly marked.
- C. Trip units:
 - 1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
 - 2. Thermal magnetic:
 - a. Instantaneous short circuit protection.
 - b. Inverse time delay overload.
 - c. Ambient or enclosure compensated by means of a bimetallic element.
 - 3. Solid state:
 - a. With the following settings as indicated on the Drawings.
 - 1) Adjustable long time current setting.
 - 2) Adjustable long time delay.
 - 3) Adjustable short time pickup.
 - 4) Adjustable short time delay.
 - 5) Adjustable instantaneous pickup.
 - 6) Adjustable ground fault pickup as indicated on the Drawings.
 - 7) Adjustable ground fault delay as indicated on the Drawings.
- D. Molded case circuit breakers for use in panelboards:
 - 1. Bolt-on type:
 - a. Plug-in type breakers are not acceptable.
 - 2. Ground fault trip devices as indicated on the Drawings.

2.7 ACCESSORIES (NOT USED)

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Test breakers in accordance with:
 - 1. UL 489.
 - 2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING (NOT USED)

3.8 FIELD QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 264130

LOW VOLTAGE INSULATED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Low voltage insulated case circuit breakers.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. American National Standards Institute (ANSI):
 - 1. C37.13 - Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures.
 - 2. C37.16 - Low Voltage Power Circuit Breakers and AC Power Circuit Breakers - Preferred Ratings, Related Requirements, and Application Recommendations.
 - 3. C37.17 - Standard for Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers.
 - 4. C37.50 - Low Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. Standard No. AB 1. - Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures. (Adopted as UL 489).
- D. Underwriter's Laboratories (UL):
 - 1. UL 1066 - Standard for Safety for Low Voltage AC and DC Power Circuit Breakers Used in Enclosures.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.4 SYSTEM DESCRIPTION

- A. Insulated case circuit breakers as indicated on the Drawings and connect to form a completed system:
 - 1. Used to open and close a circuit, and to open a circuit automatically on a predetermined overload or overcurrent, without damage to itself when properly applied within its ratings.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Manufacturer's time-current curves for all trip devices furnished.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.

- B. Insulated case circuit breakers shall be UL listed and labeled.
- 1.7 DELIVERY, STORAGE AND HANDLING
 - A. As specified in the Common Work Results for Electrical section.
- 1.8 PROJECT OR SITE CONDITIONS
 - A. As specified in the Common Work Results for Electrical section.
- 1.9 SEQUENCING (NOT USED)
- 1.10 SCHEDULING (NOT USED)
- 1.11 WARRANTY
 - A. As specified in the Common Work Results for Electrical section.
- 1.12 SYSTEM START-UP
 - A. As specified in the Common Work Results for Electrical section.
- 1.13 OWNER'S INSTRUCTIONS (NOT USED)
- 1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

- 2.1 MANUFACTURERS
 - A. One of the following or equal:
 - 1. Eaton.
 - 2. General Electric Co.
 - 3. Schneider Electric.
 - 4. ABB.
- 2.2 EXISTING PRODUCTS (NOT USED)
- 2.3 MATERIALS (NOT USED)
- 2.4 MANUFACTURED UNITS
 - A. Operating mechanism:
 - 1. Manual or electric as indicated on the Drawings:
 - a. Manual operation:
 - 1) The circuit breaker closing spring is energized by no more than 6 operations of the constant-force charging handle.
 - 2) Pushing the "CLOSE (ON)" button will close the breaker's contacts and pushing the "OPEN (OFF)" button will open the breaker's contacts.
 - 3) The opening springs are automatically charged when the breaker is closed.
 - b. Quick-make, quick-break, non-welding silver alloy contacts.
 - c. Common trip, open and close for multi-pole breakers such that all poles open and close simultaneously.
 - d. Mechanically trip free from the handle.

- e. Trip indicating handles - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
 - f. Lockable in the "OFF" position.
- B. Arc extinction:
 - 1. In arc chutes.
- C. Voltage and current ratings:
 - 1. Minimum ratings as indicated on the Drawings.
- D. Interrupting ratings:
 - 1. Minimum ratings as indicated on the Drawings.
 - a. Modify as required to meet requirements of Contractor's Short Circuit Fault Analysis as specified in the Electrical System Studies section.
 - 2. Matching the rating of the assembly.
- E. Circuit breaker mounting shall be as indicated on the Drawings and consist of one of the following configurations:
 - 1. Draw out type capable of being racked to the disconnect position with the door closed:
 - a. Interlocks shall be provided to prevent connecting or disconnecting the circuit breaker unless the breaker is in the open position.
 - b. The breaker shall be prevented from being closed during any racking operation.
 - c. A test position shall be provided to permit operating the breaker while it is disconnected from the power circuit.
 - d. Equipped with interlocks to discharge stored energy spring before the circuit breaker is withdrawn from the cell.
 - 2. Plug-in (stationary) type capable of being removed with the main bus power off.
 - 3. Individually mounted in a separate enclosure.

2.5 EQUIPMENT (NOT USED)

2.6 COMPONENTS

- A. Terminals:
 - 1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.
- B. Case:
 - 1. Molded polyester glass reinforced.
 - 2. Double level of insulation between primary current-carrying parts and operating personnel.
 - 3. Ratings clearly marked.
 - 4. Open contact indication.
 - 5. Closed contact indication.
 - 6. Charging spring charged indication.
 - 7. Charging spring discharged indication.
 - 8. Open pushbutton.
 - 9. Close pushbutton.
 - 10. Retractable charging handle.
- C. Trip units:
 - 1. Microprocessor based with positive action flux-shifting trip device and a solid-state type with the following functions:
 - a. Adjustable ampere setting:
 - 1) To determine the value of current that the breaker will carry indefinitely.

- b. Adjustable long time delay:
 - 1) Varies the time it will take the breakers to trip under sustained overload.
 - c. Adjustable short time pickup:
 - 1) Controls the level of high current the breaker will carry for short periods.
 - d. Adjustable short time delay:
 - 1) Controls the length of time the breaker will carry a high current without tripping.
 - e. Adjustable instantaneous pickup:
 - 1) Controls level at which immediate tripping of breaker occurs.
 - f. Adjustable ground fault pickup:
 - 1) Controls the level at which the breaker will trip under a ground fault condition.
 - g. Adjustable ground fault delay:
 - 1) Controls the time that a ground fault can exist without tripping the breaker.
 - h. Long time pickup indicator:
 - 1) Provides a visual indication that the breaker is experiencing an overload condition.
- D. Fault indicators:
- 1. Powered from a lithium battery.
 - 2. LED indicators for:
 - a. Short circuit fault trip on the instantaneous feature.
 - b. Ground fault trip.

2.7 ACCESSORIES

- A. Provide circuit breakers with the following accessories as indicated on the Drawings and required for proper operation of the control system:
- 1. Electrical operator (field convertible by adding a plug-in motor operator):
 - a. The circuit breaker closing spring is energized by an electric motor-driven charging mechanism.
 - 2. Neutral current sensor for use when the ground-fault option is selected on 3-phase, 4-wire 480Y/277 VAC power systems.
 - 3. Anti-pump provision to prevent closing or reclosing operations when used with a normally closed contact in the 'close' circuit.
 - 4. Auxiliary switch to signal the breaker's opened or closed status.
 - 5. Terminal blocks.
 - 6. Operations counter.

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Test breakers in accordance with:
- 1. UL 489.
 - 2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

A. Install breakers to correspond to the accepted shop drawings.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. As specified in the Commissioning section.

3.8 FIELD QUALITY CONTROL

A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with the manufacturer's recommendations.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 264410

GROUP-MOUNTED CIRCUIT BREAKER SWITCHBOARDS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Free standing, dead-front type metal-enclosed distribution, low voltage switchboards, utilizing group mounted circuit protective devices.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. National Electrical Manufacturers' Association (NEMA):
 - 1. PB-2 - Dead-front Distribution Switchboards.
- C. Underwriters' Laboratories, Inc. (UL):
 - 1. 50 - Standard for Enclosures for Electrical Equipment.
 - 2. 891 - Switchboards.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.4 SYSTEM DESCRIPTION

- A. Factory assembled, wired, and tested switchboards, with major components being products of a single manufacturer, including but not limited to, circuit breakers, bus and enclosure with accessories and features specified in this Section and indicated on the Drawings.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Manufacturer of switchboard.
 - 2. Manufacturer of all component parts of switchboard.
 - 3. Weight of switchboard.
 - 4. Dimensions:
 - a. Height.
 - b. Length.
 - c. Width.
 - 5. Nameplate schedule.
 - 6. Bill of material.
 - 7. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Current.
 - d. Interrupting rating (circuit breakers and fuses).
 - e. Momentary current rating.

8. List of recommended spare parts.
 9. Name and telephone number of manufacturer's authorized parts and repair provider.
 10. Furnish circuit breaker submittals as specified in:
 - a. Low Voltage Molded Case Circuit Breakers section.
 - b. Low Voltage Insulated Case Circuit Breakers section.
 11. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in the Common Work Results for Electrical section:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
1. Layout drawings:
 - a. Complete, detailed, and scaled switchboard layout:
 - 1) Front panel.
 - 2) Sub-panels.
 - 3) Interior panels.
 - 4) Top and bottom conduit windows.
- D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in the Common Work Results for Electrical section.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operating and maintenance manuals:
1. Submit operating instructions and a maintenance manual for the switchboard(s) furnished and/or installed under this Contract.
 2. Maintenance manual:
 - a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as data identifying all parts.
 - b. Manuals to include but are not limited to the following:
 - 1) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
- F. Test forms and reports:
1. Submit complete factory acceptance test procedures and all forms used during the test.
 2. Manufacturer to furnish a certified report after the shop tests.
 3. Manufacturer to furnish a certified report after the start-up:
 - a. Report must state that the installation is complete and satisfactory, or list items requiring additional work and a proposal for the corrective actions.

- G. Certification letters:
 - 1. Provide a letter from the switchboard manufacturer that lists every paragraph, subparagraph etc. of this Section and states compliance or non-compliance with said paragraph. If non-compliance is indicated, provide an explanation for the deviation and alternative method to address the non-compliance.
- H. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the switchboard to prove the switchboard is suitable for the seismic requirements at the Project Site.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Where indicated on the Drawings as service entrance equipment, the switchboard shall be UL labeled and listed "Suitable for Service Entrance."
- C. Sections and devices shall be UL listed and labeled.
- D. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of 5 years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.7 DELIVERY STORAGE AND HANDLING

- A. As specified in the Common Work Results for Electrical section.
- B. Ship the switchboard to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize onsite off-loading equipment:
 - 1. Energize space heaters in NEMA 3R switchboards.
- C. Furnish temporary equipment heaters within the switchboard to prevent condensation from forming.

1.8 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING

- A. Conduct the initial fault current study as specified in the Electrical System Studies section and submit results for Engineer's review.
- B. After successful review of the initial fault current study, submit complete equipment submittal.
- C. Conduct factory acceptance test and submit certified test results for Engineer's review.
- D. Ship equipment to Project Site after successful completion of factory acceptance test.
- E. Assemble equipment in the field.

- F. Conduct field acceptance test and submit results for Engineer's review.
- G. Submit manufacturer's certification that equipment has been properly installed and is fully functional for Engineer's review.
- H. Conduct Owner's training sessions.
- I. Commissioning as specified in the Commissioning section.

1.10 SCHEDULING

- A. As specified in the Common Work Results for Electrical section.

1.11 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

- A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. One of the following or equal:
 - 1. Eaton, "Pow-R-Line C."
 - 2. General Electric Co., "Spectra Series."
 - 3. Schneider Electric, "Power-Style QED."
- B. Circuit breakers: Same manufacturer as the switchboard.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

- A. Switchboard:
 - 1. Furnish low voltage switchboards as specified and indicated on the Drawings.
 - 2. Provide complete and functional switchboards with required controls.
 - 3. Furnish and install devices or accessories not described in this Section but necessary for the proper installation and operation of the equipment.

- B. Voltage ratings:
 - 1. Voltage level and configuration: As indicated on the Drawings.
 - 2. Frequency: 60 hertz.
- C. Bus:
 - 1. General:
 - a. Tin-plated copper.
 - b. Bus cross-section in accordance with UL heat rise requirements.
 - c. Current density of 1,000 amperes per square inch.
 - d. Mounted on supports of high-impact, non-tracking insulators.
 - e. Phase A-B-C bus arrangement:
 - 1) Top-to-bottom, left-to-right, front-to-back throughout the switchboard.
 - f. Symmetrical short circuit current bracing of as indicated on the Drawings.
 - g. Continuous current rating as indicated on the Drawings.
 - 2. Horizontal bus:
 - a. Provisions for future connections to additional switchboard sections.
 - 3. Ground bus:
 - a. Sized per UL 891.
 - 4. Neutral bus:
 - a. Sized for 100 percent.
- D. Enclosure:
 - 1. General:
 - a. Self-supporting structures bolted together to form the required line-up.
 - b. All sections rear aligned.
 - c. Dead-front.
 - d. Conduit entry:
 - 1) Open-bottom.
 - 2) Removable top cover.
 - 2. Frame:
 - a. Die-formed 12 gauge steel.
 - 3. Covers:
 - a. Bolt-on.
 - b. Code gauge steel.
 - c. Removable front covers.
 - 1) Held in place by captive screws.
 - 4. Rating:
 - a. NEMA Type 1.

2.6 COMPONENTS

- A. Circuit breakers:
 - 1. General:
 - a. Molded case circuit breakers as specified in the Low Voltage Molded Case Circuit Breakers section.
 - b. Insulated case circuit breakers as specified in the Low Voltage Insulated Case Circuit Breakers section.
 - 2. Main circuit breaker:
 - a. Frame, trip and short circuit ratings as indicated on the Drawings.
 - b. 100 percent rated.
 - c. Fixed mounted insulated case.
 - 3. Feeder breakers:
 - a. Frame, trip and short circuit ratings as indicated on the Drawings.

- B. Wiring:
 - 1. Provide all necessary internal wiring, fuse blocks, and terminal blocks as required.
 - 2. Number all wires at each end and indicate wire numbers on shop drawings.
 - 3. Type SIS switchboard wire with at least 26 strands.
 - 4. Minimum wire size:
 - a. No. 14 for control circuits.
 - b. No. 12 for potential and current transformer circuits.
 - 5. Numbered and labeled in accordance with the Identification for Electrical Systems section.

2.7 ACCESSORIES

- A. Metering system:
 - 1. Include metering as indicated on the Drawings.
 - 2. Provide microprocessor based power meters as specified in the Electrical Power Monitoring section.
- B. Surge protective devices:
 - 1. Provide surge protective devices as indicated on the Drawings and as specified in the Surge Protective Devices section.
- C. Nameplates:
 - 1. Provide engraved plastic nameplates to identify:
 - a. Switchboard units.
 - b. Door mounted components.
 - c. Interior mounted devices.
 - 2. As specified in the Identification for Electrical Systems section.
 - 3. Engraved with the circuit number and circuit name as indicated on the Drawings.
 - 4. Manufacturers labels:
 - a. Each vertical section shall have a label identifying:
 - 1) Serial number.
 - 2) Shop order number.
 - 3) Bus rating.
 - 4) Vertical section reference number.
 - 5) Date of manufacture.
- D. Warning signs:
 - 1. Voltage:
 - a. Provide a minimum of 2 warning signs on the front of the switchboard lineup and 2 on the back.
 - b. Red laminated plastic engraved with white letters approximately 1/2 inch high.
 - c. Signs shall read:
 - 1) "WARNING-HIGH VOLTAGE-KEEP OUT".
 - 2. Arc flash:
 - a. Provide one warning sign for each switchboard compartment.
 - b. Signs shall have read a minimum of:
 - 1) "DANGER ELECTRIC ARC FLASH HAZARD."
 - 2) Signs shall meet the requirements of NFPA 70E and NEC Article 110.16.
- E. Lugs:
 - 1. For all external connections of No. 6 AWG or larger.
 - 2. UL listed for copper or aluminum conductors.

3. Rated for 75-degree Celsius conductors.
4. Lugs shall be of the compression type in design requiring a hydraulic press and die for installation.

2.8 MIXES (NOT USED)

2.9 FABRICATION (NOT USED)

2.10 FINISHES

- A. Chemically clean all steel surfaces before painting.
- B. Exterior color manufacturer's standard gray over phosphate-type rust inhibitor.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete the installation of the switchboard.
 2. Assemble and install the switchboard in the location and layout indicated on the Drawings.
 3. Perform work in accordance with manufacturer's instructions and shop drawings.
 4. Furnish components and equipment as required to complete the installation.
 5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
 6. Install the switchboard on a raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt the switchboard frame to be to the leveling channels.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 REINSTALLATION (NOT USED)

3.7 COMMISSIONING

- A. Factory tests:

1. Completely assemble, wire and test the switchboard:
 - a. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.

3.8 FIELD QUALITY CONTROL

- A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING

- A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

3.10 CLEANING

- A. As specified in the Common Work Results for Electrical section.

3.11 PROTECTION

- A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 264450

PANELBOARDS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Panelboards serving feeder circuits and branch circuits.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. Underwriter's Laboratories, Inc. (UL):
 - 1. 67 - Standard for Panelboards.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.

1.4 SYSTEM DESCRIPTION

- A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
 - 1. Service voltage and configuration as indicated on the panel schedules.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Manufacturer of panelboard.
 - 2. Bill of material.
 - 3. Assembly ratings including:
 - a. Voltage.
 - b. Phase.
 - c. Continuous current.
 - d. Short circuit interrupting rating.
 - 4. NEMA enclosure type.
 - 5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
 - 6. Furnish circuit breaker submittals as specified in the Low Voltage Molded Case Circuit Breakers section.
 - 7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in the Common Work Results for Electrical section:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
 - 1. Drawings to contain:

- a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
 - 1) Height.
 - 2) Length.
 - 3) Width.
 - b. Weight.
 - c. Anchoring locations.
 - d. Breaker layout drawing with dimensions:
 - 1) Location of the main, branches, solid neutral, and ground.
 - e. Conduit entry/exit locations:
 - 1) Identify all conduit entry/exit locations and restrictions.
 - f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.
- D. Installation instructions:
 - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 - 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in the Common Work Results for Electrical section.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operations and maintenance manual:
 - 1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
 - a. Including but not limited to:
 - 1) Instruction narratives and bulletins.
 - 2) Renewal parts lists.
 - 3) Time-current curves for all devices.
- F. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Panelboards shall be UL listed and labeled.
 - 1. Where indicated as service entrance equipment, panelboards shall be UL labeled and listed "Suitable for Service Entrance."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.8 PROJECT OR SITE CONDITIONS

A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP

A. As specified in the Common Work Results for Electrical section.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. One of the following or equal:

1. Eaton.
2. General Electric Co.
3. Schneider Electric.

B. Circuit breakers:

1. Same manufacturer as the panelboard.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS (NOT USED)

2.4 MANUFACTURED UNITS (NOT USED)

2.5 EQUIPMENT

A. Provide panelboards with:

1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.

B. Short circuit rating:

1. Provide panelboards with short-circuit ratings as indicated on the Drawings:
2. Testing method in accordance with UL 67.
3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
4. Panelboards shall be fully rated.

2.6 COMPONENTS

A. Enclosure:

1. NEMA enclosure type as indicated on the Drawings.
 - a. Where not indicated on the Drawings, as specified in the Common Work Results for Electrical section for the installed location.
2. Minimum width: 20 inches.
3. Gutter space in accordance with the NEC:
 - a. Minimum of 4 inches of gutter space.
4. Dead-front, no live parts when the panelboard is in service.
5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
6. 4-piece front to provide ease of wiring access.
7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
 - a. Minimum 2 keys per panelboard.
 - b. Key all panelboard locks alike.
8. Circuit directory frame and card on the inside of the door.
9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
10. Outdoor locations: Provide NEMA Type 3R enclosures with a NEMA Type 3R outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard, unless otherwise indicated.

B. Bus:

1. General:
 - a. Tin-plated copper.
2. Phase bus:
 - a. Full size and height without reduction.
 - b. Dimensions and temperature rise in accordance with UL 67:
 - 1) Limit current density to less than 1,000 amps per square inch.
 - c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
3. Ground bus:
 - a. Copper, solidly bonded.
4. Neutral bus:
 - a. Provide where indicated on the Drawings.
 - b. 100 percent rated.
 - c. Provide lugs for each outgoing feeder requiring a neutral connection.
5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.

C. Lugs:

1. UL listed for copper and aluminum wire:
 - a. Provide lugs rated for 75-degree Celsius terminations.
 - b. Provide bolted or compression main lug terminations as required for the incoming cable size.

D. Circuit breakers: As specified in the Low Voltage Molded Case Circuit Breakers section and as indicated on the Drawings:

1. Provide all circuit breakers with bolt-on connections:
 - a. Plug-in circuit breakers are not allowed.

2.7 ACCESSORIES

A. Surge protective devices:

1. Furnish panelboards with surge protective devices as indicated on the Drawings.
 2. As specified in the Surge Protective Devices section.
- B. Nameplates:
1. As specified in the Identification for Electrical Systems section.
 2. Install on outside of door.
 3. Indicating:
 - a. Panel designation.
 - b. Voltage.
 - c. Number of phases and configuration.
- C. Circuit identification labels:
1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
 2. Type all information on the cards using designations in the panel schedules.
 3. Laminated on both sides.
- D. Pad locking mechanism:
1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
 2. At a minimum, provide 1 mechanism per panelboard:
 - a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.
- 2.8 MIXES (NOT USED)
- 2.9 FABRICATION (NOT USED)
- 2.10 FINISHES
- A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer's standard gray.
- B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.
- 2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

- 3.1 EXAMINATION (NOT USED)
- 3.2 PREPARATION (NOT USED)
- 3.3 INSTALLATION
- A. As specified in the Common Work Results for Electrical section.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
1. Surface, flush or MCC mounted as indicated on the Drawings.

2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
3. Perform work in accordance with the manufacturer's instructions and shop drawings.
4. Provide all brackets, hangers, supports, and hardware for mounting as required.
5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless-steel preformed channel, with channel running vertically from top to bottom of panelboard:
 - a. Use only stainless-steel mounting hardware.
6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

- A. Factory testing:
 1. Perform standard factory tests on the panelboards:
 2. Test in accordance with the latest version of NEMA and UL standards.

3.8 FIELD QUALITY CONTROL

- A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in the Common Work Results for Electrical section.

3.11 PROTECTION

- A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES

- A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.
- B. Provide typewritten schedule in each panelboard.

END OF SECTION

**SECTION 264810
ENGINE GENERATOR**

PART 1 GENERAL

1.1 SUMMARY

- A This section includes **OWNER FURNISHED CONTRACTOR INSTALLED EQUIPMENT**
1. The Owner will prepurchase the generator.
 2. The Contractor shall be responsible for coordinating shipping schedule between the Owner and the generator manufacturer.
 3. The contractor shall be responsible for offloading the generator upon delivery.
 4. The Contractor shall be responsible for all other aspects of this specification other than generator purchase.
- B This section includes the following items from a single supplier:
1. Engine Generator Set
 2. Enclosure
 3. Fuel Tank
 4. Related Accessories as specified
- C Related Requirements
1. It is the intent of this specification to secure an engine-driven generator set that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.
 2. Any exceptions to the published specifications shall be subject to the approval of the engineer and submitted minimum 10 days prior to the closing of the bid with a line-by-line summary description of all the items of compliance, any items that have been omitted or have been taken exception to, and a complete description of all deviations.
 3. It is the intent of this specification to secure a generator set system that has been tested during design verification, in production, and at the final job site. The generator set will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.
 4. All equipment shall be new and of current production by an international power system manufacturer of generators, transfer switches, and paralleling switchgear. The manufacturer shall be a supplier of a complete and coordinated system. There will be single-source responsibility for warranty, parts, and service through a factory-authorized representative with factory-trained technicians.

1.2 SUBMITTALS

- A Action Submittals
1. Product Data
 - a The submittal shall include prototype test certification and specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal

number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.

B Informational Submittal

1. Certificates

- a The generator set shall be listed to UL 2200 or submitted to an independent third-party certification process to verify compliance as installed.

C Closeout Submittal

- 1. Maintenance Contracts
- 2. Operation And Maintenance Data
- 3. Warranty Documentation
- 4. Record Documentation

1.3 Quality Assurance

A Regulatory Agency

- 1. The generator set shall conform to the requirements of the following codes and standards:
 - a CSA C22.2, No. 14-M91 Industrial Control Equipment.
 - b EN50082-2, Electromagnetic Compatibility-Generic Immunity Requirements, Part 2: Industrial.
 - c EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
 - d IEC8528 part 4, Control Systems for Generator Sets.
 - e IEC Std 61000-2 and 61000-3 for susceptibility, 61000-6 radiated and conducted electromagnetic emissions.
 - f IEEE446 Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
 - g NFPA 70, National Electrical Code, Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
 - h NFPA 99, Essential Electrical Systems for Health Care Facilities.
 - i NFPA 110, Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit. Component level type tests will not substitute for this requirement.
- 2. Qualifications
 - a The equipment shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production, and service of its complete product line.
 - b The power system shall be produced by a manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year.
- 3. Manufacturers
 - a The power system shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.
 - b The basis of design is a Kohler model KD1250-A. If the supplier wishes to propose equivalent equipment as manufactured by Caterpillar, all additional costs associated with re-engineering and mechanical & electrical modifications to the installation will be at the contractor's expense. The contractor must also supply the details below with his proposal:
 - A line-by-line clarification of the specification marked with "D" for deviation; "E" for exception, and "C" for comply.
 - The weight & outline dimensions of the proposed equipment

Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications shall be allowed or included in the certification.

1.4 Warranty

A Manufacturer's Warranty

1. The generator set shall include a standard warranty covering three (3) years or 1000 hours standby (United States-only) or two (2) years or 8700 hours prime, whichever occurs first (hours or years), to warrant against defective material and workmanship in accordance with the manufacturer's published warranty from the date of initial startup.
2. The generator set manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and functional tests performed on all systems.

PART 2 PRODUCTS

2.1 Equipment

A Equipment

1. The generator set shall be a Kohler model KD1250-A with a KH04590TO4D alternator. It shall provide 1,562 kVA and 1,250kW when operating at 277/480 volts, 60 Hz, 0.80 power factor. The generator set shall be capable of a 130°C Standby @40C rating while operating in an ambient condition of less than or equal to 104 °F and a maximum elevation of 1000 ft above sea level. The standby rating shall be available for the duration of the outage.

B Engine

1. The minimum 36.0 liter displacement engine shall deliver a minimum of 1865 HP at a governed engine speed of 1800 rpm, and shall be equipped with the following:
 - a. Electronic isochronous governor capable of 0.25% steady-state frequency regulation
 - b. 24-volt positive-engagement solenoid shift-starting motors
 - c. 140-ampere automatic battery charging alternator with a solid-state voltage regulation
 - d. Positive displacement, full-pressure lubrication oil pump, cartridge oil filters, dipstick, and oil drain
 - e. Dry-type replaceable air cleaner elements for normal applications
 - f. Engine-driven or electric fuel-transfer pump including fuel filter and electric solenoid fuel shutoff valve capable of lifting fuel
 - g. Common rail fuel injection system
 - h. Variable flow rate fuel pump which helps adjust for the required flowrate and results in a very minimal return fuel rate
 - i. The turbocharged engine shall be fueled by diesel
 - j. The engine shall have a minimum of 16 cylinders and be liquid-cooled
2. The engine shall be EPA Tier II certified from the factory.
3. The generator must accept rated load in one-step.

- C Cooling System
 - 1. The engine shall be liquid-cooled by a closed loop, unit mounted radiator rated to operate the generator set at full load at an ambient temperature of 50 degrees C (122 degrees F). The radiator fan and other rotating engine parts shall be guarded against accidental contact. The radiator core will be modular in design, enabling a damaged section to be replaced individually instead of the entire core.
- D Standard Air Cleaner
 - 1. The air cleaner shall provide engine air filtration which meets the engine manufacturer's specifications under typical operating conditions.
- E Battery
 - 1. Each generator set is provided a quantity of four AGM batteries that meets the engine manufactures' specifications for the ambient conditions specified in Part 1 Project Conditions and shall comply with the NFPA requirements for engine cranking cycles. Each battery shall be rated according to SAE Standards J-537 with a minimum cold cranking amp of 1110 amps and a minimum reserve capacity of 380 minutes at 80°F. The battery will contain two handles to aid in lifting and the case must be constructed of polypropylene to resist breakage and extend service life. AGM battery technology utilize an Absorbed Glass Mat and protects the battery's internal components by acting like a shock absorber and blocking vibration and other possible damaging movement.
 - 2. Battery rack and battery cables capable of holding the manufacturer's recommended batteries shall be supplied.
 - 3. Redundant battery requirements double the standard configuration.
- F Housing
 - 1. Level 2 Sound Attenuated Enclosure
 - a. The generator set shall be supplied with a Level 2 Sound Attenuated Enclosure that is UL2200 listed, providing a sound reduction of 75.5 dB(A) while the generator is operating at 100% load at 7 meters (23 feet) using acoustic insulation and acoustic-lined inlet hoods, and using acoustic insulation and acoustic-lined inlet hoods, constructed from a minimum of 0.125 inch thick formed heavy duty aluminum panels. The acoustic insulation used shall meet UL 94 HF1 flammability classification. The enclosure shall be manufactured from bolted panels to facilitate service, future modifications, or field replacement. The enclosure shall use a vertically louvered air inlet and outlet hood with 90-degree angle to discharge air up and reduce noise. The enclosure shall have an integral rodent guard and skid end caps. The enclosure shall be certified to 186 mph (299 kph) wind load rating. The snow load rating shall be 70 lbs./ sq. ft. or greater.
 - b. The enclosure components and skid shall be cleaned with a two-stage alkaline cleaning process to remove grease, grit, and grime from parts. Components shall then be subjected to a Zirconium-based conversion coating process to prepare the metal for electrocoat (e-coat) adhesion. All enclosure parts shall receive a 100% epoxy primer electrocoat (e-coat) with high-edge protection. Following the e-coat process, the parts shall be finish coated with powder baked paint for superior finish, durability, and appearance with a Power Armor™ industrial finish that provides heavy duty durability in harsh conditions, and is fade-, scratch- and corrosion-resistant.
 - c. The enclosure must surpass a 3,000 hour salt spray corrosion test per ASTM B-1117.
 - d. Enclosures will be finished in the manufacturer's standard color.
 - e. The enclosures shall allow the generator set to operate at full load based on the cooling capability of the genset. The enclosure will

account for no more than a 5°C derating of the ambient cooling capability of the generator.

- f. Enclosures shall be equipped with sufficient side and end doors to allow access for operation, inspection, and service of the unit and all options. Minimum requirements are two doors per side. When the generator set controller faces the rear of the generator set, an additional rear facing door is required. Access to the controller and main line circuit breaker shall meet the requirements of the National Electric Code.
- g. The enclosure shall be furnished with stainless steel latches, hinges, and hardware on the external panels of the enclosure. Access doors shall be rubber sealed to prevent water intrusion and to minimize noise.
- h. Doors shall be equipped with lockable latches. Locks shall be keyed alike. Door locks shall be recessed to minimize potential of damage to door/enclosure.
- i. A duct between the radiator and air outlet shall be provided to prevent re-circulation of hot air.
- j. The complete exhaust system shall be internal to the enclosure.
- k. The critical silencer shall be fitted with a tailpipe and rain cap.
- l. The enclosures shall feature a sloped roof to prevent pooling and increase longevity.
- m. The generator set enclosure shall be furnished with the battery charger wired into the load center.
- n. The generator set enclosure shall be furnished with the block heater wired into the load center.
- o. The generator set enclosure shall be furnished with a load center 120/208/240VAC three phase, 100 a max w/main and 12 branch circuits, (2) 3-way switches, (2) LED lights, and (2) duplex GFI receptacles.

G Fuel oil storage

- 1. Double Wall Secondary Containment Sub-base Fuel Tank
 - a. The generator set shall be supplied with a sub-base fuel tank of sufficient capacity to hold a minimum of 24 hours at 100% load of diesel fuel.
 - b. The sub-base fuel system shall be listed under UL 142, subsection entitled Special Purpose Tanks EFVT category, and will bear their mark of UL Approval according to their particular classification.
 - c. The above ground steel secondary containment rectangular tank for use as a sub base for diesel generators is manufactured and intended to be installed in accordance with the Flammable and Combustible Liquids Code—NFPA 30, the Standard for Installation and Use of Stationary Combustible Engine and Gas Turbines—NFPA 37, and Emergency and Standby Power Systems—NFPA 110.
 - d. The primary tank shall be rectangular in shape and constructed in clam shell fashion to ensure maximum structural integrity and allow the use of a full throat fillet weld.
 - e. Steel Channel Support System. Reinforced steel box channel for generator support, with a load rating of 5,000 lbs. per generator mounting hole location. Full height gussets at either end of channel and at generator mounting holes shall be utilized.
 - f. Exterior Finish. The sub-base tank exterior finish shall be Power Armor Plus™, a polyurea-textured rubberized coating.
 - g. Normal venting shall be sized in accordance with the American Petroleum Institute Standard No 2000, Venting Atmospheric and Low-Pressure Storage Tanks not less than 1-1/4" (3 cm.) nominal inside diameter.
 - h. The emergency vent opening shall be sized to accommodate the total capacity of both normal and emergency venting and shall be not less than that derived from NFPA 30, table 2-8, and based on the wetted surface area of the tank. The

wetted area of the tank shall be calculated on the basis of 100 percent of the primary tank. The vent is to be spring-pressure operated: opening pressure is 0.5/psig and full opening pressure is 2.5 psig. The emergency relief vent is to be sized to accommodate the total venting capacity of both normal and emergency vents.

- i There shall be a 2" NPT opening within the primary tank and lockable manual fill cap.
- j A direct reading, UL listed, magnetic fuel level gauge with a hermetically sealed, vacuum tested dial, to eliminate fogging, shall be provided.
- k A float switch for remote or local annunciation of a (50% standard) low fuel level condition shall be supplied.
- l 5 Gallon Fill/Spill Containment- Aboveground fill/spill container, contains fuel overfill spills that may occur during fill-up.

H Controller

1. Advanced Power Management (APM603) Generator Set Controller
 - a. The generator set controller shall be a microprocessor-based control system that will provide automatic starting, system monitoring, and protection.
 - b. The controller shall be mounted on the generator set and shall have integral vibration isolation. The controller shall be prototype and reliability tested to ensure operation in the conditions encountered.
2. Codes and Standards
 - a. The generator set controller shall meet NFPA 110 Level 1 requirements and shall include an integral alarm horn as required by NFPA.
 - b. The controller shall meet NFPA 99 and NEC requirements.
 - c. The controller shall be UL 6200 recognized.
 - d. The controller shall meet ASTM B117 (salt spray test).
3. Applicability
 - a. The controller shall be a standard offering in the manufacturer's controller product line.
 - b. The controller's environmental specification shall be: -40°C to 70°C operating temperature range and 5-95% humidity, non-condensing.
 - c. The controller front face shall meet an environmental rating of IP65 when mounted properly on the generator.
4. Controller Buttons, Display, and Components
 - a. The generator set controller shall include the following features and functions:
 - i. Master Control Push Buttons – the buttons shall be tactile-feel membrane with an indicator light to initiate the following functions:
 1. Run Mode – when in Run mode the generator set shall start.
 2. Off/Reset Mode – when in Off/Reset mode, the generator set shall not accept any remote start commands and shall be capable of resetting all faults, allowing for the restarting of the generator set after a shutdown.
 3. Auto Mode – when in Auto mode, the generator set shall be ready to accept a signal from a remote device.
 - ii. Control Panel shall include:
 1. Emergency Stop Switch – the latch type stop switch shall be red in color with a “mushroom” type head. Depressing the stop button will immediately stop the generator set and lockout the generator set for any automatic remote starting.
 2. Alarm Horn – the horn sounds when any faults or warnings are present. The horn shall also sound when the controller is not in the Auto mode.
 - iii. Display – the display shall be a 7” TFT color touchscreen.
 - iv. Fault Light – the controller shall have an annunciator fault light that glows red for faults and yellow for warnings. The warning light will also illuminate when not in Auto.

- v. Alarm Silence/Lamp Test Button – when this button is held, it shall test all controller lamps. This button will also silence the alarm horn when the unit is not Auto or has a fault.
 - vi. USB Connection – the controller shall have a USB connection port for a storage device that is accessible on the front of the control panel without having to open any electrical enclosure panels on the generator. This connection shall allow for updating of all software and firmware. This connection shall allow for downloading of controller parameter settings and the event log. This connection shall allow for data logging storage. This connection shall allow the ability to capture screenshots.
 - vii. Mini-USB Connection – the controller shall have a mini-USB connection port for a PC connection that is accessible on the front of the control panel without having to open any electrical enclosure panels on the generator. This connection shall allow a certified technician to service the generator controller using a dedicated PC program. The program shall allow for servicing of generator set parameters, faults diagnostics and viewing of controller information. The program shall allow for uploading of software and firmware as well as downloading of parameter settings and the event log.
- 5. The controller shall have three user level access
 - a. User Level – no password required, and user can view all metered values and settings
 - b. Operator Level – password required to adjust settings that do not impact the generator
 - c. Technician Level – password required to adjust all settings
- 6. Overview and Favorites
 - a. Overview – User shall be able to customize up to 16 gauges for a personalized Home screen that will allow for immediate access to site specific critical data.
 - b. Favorites – User shall be able to create their own menu set up with parameters for easy viewing.
- 7. Load Management
 - a. Programmable outputs included to command the connect and disconnect of loads based on generator or paralleling system state:
 - i. Loads connected based on available capacity
 - ii. Loads disconnected at system startup
 - iii. Loads disconnected based on a maximum kW setting or under frequency setting
 - b. Supports up to 16 prioritize load steps per system
 - i. Can be used on a single generator system
 - ii. Can be combined in a paralleling system for a total system load control capability
 - c. Simplified load management system view from any generator controller in the system
- 8. Controller Engine Control Features and Functions
 - a. User-programmable time delay for engine start.
 - b. User-programmable time delay engine cool down.
 - c. Capability to start and run at user-adjustable idle speed during warm-up for a selectable time-period until engine reaches preprogrammed temperature.
 - d. The idle function including engine cooldown at idle speed.
 - e. Real-time clock and calendar for time stamping of events.
 - f. Output with adjustable timer for an ether injection starting system.
 - g. Programmable cyclic cranking that can adjust on time, off time, and number of cycles.
- 9. Controller Alternator Control Features and Functions

- a. Patented High-speed RMS Digital Voltage Regulation – the system shall have integral microprocessor-based voltage regulator system that provides + 0.25% voltage regulation no-load to full load with three phase sensing. A separate voltage regulator is not acceptable. The digital voltage regulator shall be applicable to single- or three-phase systems. The system shall be prototype tested and control variation of voltage to frequency. The voltage regulator shall be adjustable at the controller with maximum + 10% adjustable of nominal voltage.
 - b. Alternator Thermal Overload Protection – the system shall have integral alternator overload and short circuit protection matched to each alternator for the particular voltage and phase configuration.
 - c. Overcurrent Protective Device– the system shall have a thermal trip, instantaneous trip and maintenance mode per NEC240.87.
10. Other Control Features and Functions
- a. Event Logging – the controller keeps a record of up to 10,000 events with date and time locally for warning and shutdown faults. This event log can be downloaded onto a USB storage device or onto a PC through the service program.
 - i. Event Snapshot – the control system shall capture 15 seconds of critical data around the time a fault or warning. This data shall be viewable on the controller and downloadable.
 - b. Data Logging – the controller shall allow customized parameters to be logged based on a start trigger from the controller interface.
 - i. The parameters are selectable from all monitored parameters.
 - ii. The sample period shall be configurable from 1 second to 1 day.
 - iii. The collected data shall be stored on a USB storage device plugged into the control panel.
11. Control Monitoring Requirements
- a. The generator set shall have alarms and status indication lamps that show non-automatic status, warning, and shutdown conditions. The controller shall indicate with a warning lamp and or alarm and on the digital display screen any shutdown, warning, or engine fault condition that exists in the generator set system. The following alarms and shutdowns shall exist as a minimum:
 - i. All monitored functions must be viewable on the control panel display
 - ii. The following generator set functions shall be monitored:
 - 1. All output voltages - single phase, three phase, line to line, and line to neutral, 0.25% accuracy
 - 2. All single phase and three phase currents, 0.25% accuracy
 - 3. Output frequency, 0.25% accuracy
 - 4. Power factor by phase with leading/lagging indication
 - 5. Total instantaneous kilowatt loading and kilowatts per phase, 0.5% accuracy
 - 6. kVARS total and per phase, 0.5% accuracy
 - 7. kVA total and per phase, 0.5% accuracy
 - 8. kW hours
 - 9. A display of percent generator set duty level (actual kW loading divided by the kW rating)
 - iii. Engine parameters listed below shall be monitored:
 - 1. Ambient Temperature
 - 2. Charge Air Pressure
 - 3. Charge Air Temperature
 - 4. Common Rail Fuel Pressure
 - 5. Coolant Level
 - 6. Coolant Temperature
 - 7. Crankcase Pressure
 - 8. Engine Speed

9. Fuel Consumption Rate
10. Fuel Pressure
11. Fuel Temperature
12. Intercooler Temperature (K175 engines only)
13. Oil Temperature
14. Oil Pressure
15. Runtime Hours
16. Full description of active ECM DTC
- iv. Operational records shall be stored in the control beginning at system startup
 1. Total Run Time Hours
 2. Total Loaded Hours
 3. Total Unloaded Hours
 4. Total kW Hours
 5. Controller Hours
 6. Controller Run Time Hours
 7. ECM Run Time Hours
 8. Number of Starts
 9. Number of Crank Attempts
 10. Last Crank Duration
 11. Last Start Runtime Duration
 12. Last Start Time of Day
 13. Last Start Date (Day)
 14. Last Start Date (Month)
 15. Last Start Date (Year)
 16. Last Stop Time of Day
 17. Last Stop Date (Day)
 18. Last Stop Date (Month)
 19. Last Stop Date (Year)
- v. The following operational records shall be resettable for maintenance purposes:
 1. Total Run Time Since Maintenance
 2. Loaded Hours Since Maintenance
 3. Unloaded Hours Since Maintenance
 4. kW Hours Since Maintenance
 5. Reset Maintenance Records
- vi. For maintenance and service purposes, the controller shall store and display on demand the information:
 1. Generator Model
 2. Generator Serial Number
 3. ECM Serial Number
 4. Alternator Part Number
 5. Engine Model Number
 6. Engine Serial Number
 7. Controller Serial Number
 8. Firmware Version
- vii. The controller shall support a variety of maintenance parameters including:
 1. Last Start Time of Day
 2. ECM Runtime Hours
 3. Controller Runtime Hours
 4. Last Stop Date (Month)
 5. Last Start Time of Day
 6. Last Stop Date (Day)
 7. Last Start Date (Day)
 8. Number of Starts

9. Last Stop Time of Day
 10. Last Stop Time of Day
 11. Controller Hours
 12. Number of Crank Attempts
 13. Last Crank Duration
 14. Last Start Runtime Duration
 15. Last Start Time of Day
 16. Last Start Time of Day
 17. Last Start Date (Month)
 18. Last Start Date (Year)
 19. Last Stop Time of Day
 20. Last Stop Time of Day
 21. Last Stop Date (Year)
12. Generator Set Warning, Shutdown Alarm and Status
- a. The generator set shall have alarms and status indication lamps that show Non-Automatic Status, Warning, and Shutdown conditions. The controller shall indicate with a warning lamp and/or alarm, and on the digital display screen any shutdown, warning, or engine fault condition that exists in the generator set system. The following alarms and shutdowns shall exist as a minimum:
 - i. OverCrank Shutdown
 - ii. UnderFrequency Shutdown
 - iii. OverFrequency Shutdown
 - iv. OverPower Shutdown
 - v. Low Oil Pressure Shutdown
 - vi. High Coolant Temperature Shutdown
 - vii. Local Emergency Stop Shutdown
 - viii. Remote Emergency Stop Shutdown
 - ix. OverSpeed Shutdown
 - x. ECM DTCs
 - xi. Loss ECM Comms Shutdown
 - xii. ECM Mismatch Shutdown
 - xiii. High Oil Temperature Shutdown
 - xiv. Alternator Protection Shutdown
 - xv. Protective Relay Shutdown OverPower
 - xvi. Protective Relay Shutdown OverCurrent
 - xvii. Protective Relay Shutdown Reverse VAR
 - xviii. Protective Relay Shutdown ReversePower
 - xix. UnderVoltage Shutdown (L-L, L-N, each phase)
 - xx. OverVoltage Shutdown (L-L, L-N, each phase)
 - xxi. OverCurrent Shutdown
 - xxii. Excitation Overvoltage Shutdown
 - xxiii. Low Fuel Level Shutdown
 - xxiv. Low Coolant Level Shutdown
 - xxv. Generator Over Power Shutdown
 - b. Conditions resulting in generator warning (generator will continue to operate):
 - i. UnderFrequency Warning
 - ii. OverFrequency Warning
 - iii. OverPower Warning
 - iv. Low Oil Pressure Warning
 - v. Low Coolant Temperature Warning
 - vi. High Coolant Temperature Warning
 - vii. Low Battery Voltage Warning
 - viii. High Battery Voltage Warning
 - ix. Battery Charger Fault Warning
 - x. High Oil Temperature Warning

- xi. GFCI Warning
 - xii. UnderVoltage Warning (L-L, L-N, each phase)
 - xiii. OverVoltage Warning (L-L, L-N, each phase)
 - xiv. OverCurrent Warning
 - xv. High Fuel Level Warning
 - xvi. Low Fuel Level Warning
 - xvii. Critically Low Fuel Level Warning
 - xviii. Generator Over Power Warning
 - xix. ECM DTC's
13. Inputs and Outputs
- a. Standard Dedicated User Inputs – the controller shall have dedicated inputs for:
 - i. Two-Wire Input
 - 1. Remote Engine Start
 - ii. Digital Input
 - 1. Auxiliary Fault (Shutdown)
 - 2. Auxiliary Warning
 - 3. Battery Charger Fault
 - 4. Breaker Closed
 - 5. Breaker Open
 - 6. Fuel Leak Alarm
 - 7. High Fuel Level
 - 8. Idle Mode Start
 - 9. Low Fuel Level Switch
 - 10. Low Oil Level
 - 11. Remote Emergency Stop
 - 12. Remote Reset
 - iii. Analog Voltage Input – Scalable Up To ± 10 VDC
 - 1. Speed Bias
 - 2. Voltage Bias
 - b. Standard Dedicated User Outputs – the controller shall have dedicated outputs for: (* Factory-set outputs provided on the optional DIOM)
 - i. Relay Driver Output
 - 1. Close Breaker
 - 2. Common Failure
 - 3. Common Warning
 - 4. EPS Supplying Load*
 - 5. Generator Running
 - 6. High Coolant Temperature
 - 7. Horn
 - 8. Low Coolant Temperature*
 - 9. Not in Auto*
 - 10. System Ready*
 - 11. Trip Breaker
 - c. Optional Configurable User Inputs and Outputs
 - i. User Configurable Inputs
 - 1. 16 Dry Contact Digital
 - ii. User Configurable Relay Outputs
 - 1. 8 NO/NC Relays
 - d. PLC-like capability for applying logic to customize generator system behavior.
14. Communications
- a. CAN
 - i. If the generator set engine is equipped with an ECM, the controller shall communicate with the ECM for control, monitoring, diagnosis, and meet SAE J1939 standards.
 - b. Modbus®

- i. Non-isolated for RSA III
 - ii. Isolated for Modbus devices
 - iii. Isolated for paralleling communication
 - iv. RJ45 for Modbus TCP, SNMP, and BACnet
 - c. Simple Network Management Protocol (SNMP)
 - i. Industry standard SNMP communication shall be available.
 - ii. The controller shall support SNMP communication via an RJ-45 Ethernet connection.
 - d. BACnet®
 - i. Industry standard BACnet® communication shall be available.
 - ii. The controller shall support BACnet® communication via an RJ-45 Ethernet connection.
 - e. Communication Connections
 - i. All communication connections shall be accessible in a dedicated customer connection area that is separated from factory wiring into the controller to prevent field connections from interfering with factory wiring.
 - ii. The controller shall not require any additional hardware to support Modbus®, SNMP or BACnet® communication.
15. Paralleling
- a. The controller shall be capable of paralleling with other generators with the same controller through a dedicated communication network between the controllers and onboard paralleling capabilities.
 - b. The controller shall support paralleling up to eight generators on a common bus.
 - c. The controller shall support paralleling a single generator with utility using kW, kVAR, and Power Factor settings.
 - d. Synchronization
 - i. The controller shall support onboard synchronization to allow matching of voltage, frequency and phase before closing a circuit breaker or contactor to connect the generator to the bus.
 - ii. The controller shall use first-on logic to determine which generator will close to the dead bus first.
 - iii. The controller shall support 3 common forms of synchronizing, Automatic (synch and close breaker), Sync-check (synch-no closure) and Permissive (no active synch, allow manual close if in synch).
 - iv. The controller shall announce a fail to synch fault when synchronization is not achieved within the programmed time delay.
 - v. The controller shall actively maintain synchronizing efforts to achieve synchronization even after the time delay has expired.
 - vi. The controller shall be capable of actively displaying the synchronizing parameter values for both the generator and the bus when synchronizing; voltage, frequency and phase.
 - vii. The controller shall be capable of displaying the phase rotation (ABC or CBA) for both the generator and the bus and prevent closure to the bus when phase rotation does not match the generator.
 - e. Load Sharing
 - i. The controller shall actively share real and reactive power amongst all generators on the common bus, on a per-unit or percentage basis.
 - ii. The controller shall support soft load and unload of the generator.
 - iii. The controller shall be capable of operating with droop control.
 - f. Circuit Breaker/Contactor Control
 - i. The controller shall be capable of operating a circuit breaker or contactor to apply electricity to the parallel electrical bus.

- ii. The controller system shall have a normally closed contact (fail safe) that will keep the breaker tripped until such conditions are met to allow closure.
 - iii. The controller system shall have a normally open contact to provide an energizing signal to close the circuit breaker.
 - iv. The controller system shall have normally open contact for control of a contactor.
 - v. The controller will announce a Fail to Close warning when closure is not detected after 1 closure attempt.
 - vi. The controller will announce a Fail to Close shutdown when the number of attempts exceeds the setting (max attempts).
 - vii. The controller will monitor current to detect a failure to open the generator circuit breaker.
 - viii. The controller will keep the generator running until the generator circuit breaker is seen open in order to keep the bus live to prevent other devices from closing to this bus without synchronizing.
16. Generator Management
- a. Allows the start and stop of generators based on load demand or state of other generators including:
 - i. Start Power
 - ii. Stop Power
 - iii. Start Accumulator
 - iv. Stop Accumulator
 - v. Total Online Capacity
 - vi. Total Available Capacity
 - vii. Total Bus Power
 - viii. Total Bus Capacity
 - ix. Negotiated Order
 - x. Stopped by Gen Management
 - xi. Start Command
 - b. The generator management can be configured to operate based on:
 - i. Engine Run Time
 - ii. Fuel Level
 - iii. Manual Order
 - c. The controller shall have a programmable disconnect point (kW) below which point the controller shall automatically trip the generator circuit breaker.
17. Protective Relays
- a. The controller shall provide a standard set of protective relay functions with programmable limits and time delays
 - i. Over Voltage (59)
 - 1. User adjustable range – 100% to 130%
 - 2. User adjustable range time delay – 0 to 120 seconds
 - ii. Under Voltage (27)
 - 1. User adjustable range – 70% to 100%
 - 2. User adjustable time delay – 0 to 120 seconds
 - iii. Over Frequency (81O)
 - 1. User adjustable range – 100% to 140%
 - 2. User adjustable time delay – 0 to 120 seconds
 - iv. Reverse Power (32R)
 - 1. User adjustable range – 0% to 50%
 - 2. User adjustable time delay – 0 to 120 seconds
 - v. Over Power (32O)
 - 1. User adjustable range – 90% to 150%
 - 2. User adjustable time delay – 0 to 120 seconds
 - vi. Loss of Field (40 Reverse VARS)
 - 1. User adjustable range – 10% to 100%

2. User adjustable time delays – 0 to 120 seconds
- vii. Over Current with Voltage Range
 1. User adjustable range – 100% to 200%
 2. User adjustable time delay – 0 to 120 seconds

I Generator Overcurrent and Fault Protection

1. Transfer Switch Breaker - The generator shall be provided with a factory installed, 100% rated LSI line circuit breaker rated at 2,500 amperes that is UL489 listed. Line circuit breakers shall be sized for the rated ampacity of the loads served by the breaker per the NEC.
2. The circuit breaker(s) shall incorporate an electronic trip device with the following characteristics:
 - a. Adjustable long time delay
 - b. Adjustable short time delay
 - c. Instantaneous
 - d. Zone Selective Interlocking**
3. Load side lugs shall be provided from the factory. The line circuit breaker shall include auxiliary contacts, shunt trip, undervoltage trip, alarm switch, and overcurrent switch functionality. Load side breaker connections made at the factory shall be separated from field connections.
4. The shunt trip device shall be connected to trip the generator breaker when the generator-set is shut down by other protective devices.
5. When GFI is required per the NEC, additional neutrals shall be factory installed, and the alarm indication shall be integrated with the generator-set alarms.
6. Barriers to provide segregation of wiring from an emergency source to emergency loads from all other wiring and equipment, if required by the NEC, shall be provided.

J Alternator

1. The alternator shall be salient-pole, brushless, 2/3-pitch, with 4 bus bar provision for external connections, self-ventilated, with drip-proof construction and amortisseur rotor windings, and skewed for smooth voltage waveform. The ratings shall meet the NEMA standard (MG1-32.40) temperature rise limits. The insulation shall be class H per UL1446 and the varnish shall be a vacuum pressure impregnated, fungus resistant epoxy. Temperature rise of the rotor and stator shall be limited to 130°C Standby @40C. The PMG based excitation system shall be of brushless construction controlled by a digital, three phase sensing, solid- state, voltage regulator. The AVR shall be capable of proper operation under severe nonlinear loads and provide individual adjustments for voltage range, stability, and volts-per-hertz operations. The AVR shall be protected from the environment by conformal coating. The waveform harmonic distortion shall not exceed 5% total RMS measured line-to-line at full rated load. The TIF factor shall not exceed 50.
2. The alternator shall have a maintenance-free bearing, designed for 40000 hour B10 life. The alternator shall be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.
3. The generator shall be inherently capable of sustaining at least 300% of rated current for at least 10 seconds under a 3-phase symmetrical short circuit without the addition of separate current-support devices.
4. Motor starting performance and voltage dip determinations shall be based on the complete generator set. The generator set shall be capable of supplying 5,351 LKVA for starting motor loads with a maximum instantaneous voltage dip of 35%, as measured by a digital RMS transient recorder in accordance with IEEE Standard 115. Motor starting performance and voltage dip determination that does not account for all components affecting total voltage dip, i.e., engine, alternator, voltage

regulator, and governor will not be acceptable. As such, the generator set shall be prototype tested to optimize and determine performance as a generator set system.

K Vibration Isolation

1. Vibration isolators shall be provided between the engine alternator and heavy-duty steel base.

2.2 Accessories

- A. Enclosure shall have an external emergency stop button that is recessed in the enclosure panel for protection.
- B. Battery rack and battery cables capable of holding the manufacturer's recommended batteries shall be supplied.
- C. The air cleaner restriction indicator shall indicate the need for maintenance of the air cleaners.
- D. The generator set shall be supplied with two 20-ampere automatic float/equalize battery charger capable of charging lead-acid, nickel-cadmium, and VRLA (gel-cell and AGM) type batteries, with the following features:
 1. Automatic 3-stage charge cycle for up to three independent batteries simultaneously per charger
 2. Load regulation of less than +/- 0.5%
 3. LCD Digital Display: AC Input Voltmeter, DC Output Voltmeter and Ammeter (1%)
 4. LED lamp indicator for: Current Limit, AC ON, and Charger Fail
 5. Filtered output for gel-cell and AGM batteries.
 6. Temperature compensation with ambient operating conditions of -40°C to 50°C and derated up to 70°C
 7. LED alarm indicator for charger failure with form "C" dry type relay contacts
 8. Redundant chargers will double the standard configuration
 9. UL 1236 Listed
 10. Meets ANSI C62.41
 11. CE Certified
- E. The generator shall be supplied with a thermostatically controlled heater to prevent the accumulation of moisture and dampness and to maintain the stator windings above the dew point. The heater shall be wired to be "on" at all times that the generator set is not operating.
- F. The engine exhaust silencer shall be temperature and rust resistant and rated for critical applications. The silencer will reduce total engine exhaust noise by 32-42 db(A).
- G. Supply flexible fuel lines to provide a flexible connection between the engine fuel fittings and the fuel supply tank piping and for the fuel return lines from the injector pump per engine manufacturer's recommendations. Flex line shall have a protective steel wire braid to protect the hose from abrasion.
- H. The exhaust piping shall be gas proof, seamless, stainless steel, flexible exhaust bellows and includes the flex exhaust tube and the mounting hardware.
- I. Remote annunciator panel – The remote annunciator shall meet NFPA 110, Level 1 requirements and enable remote viewing of the generator status. The panel shall be connected to the generator controller via either network communication wires or via hard wired connections. Options shall be available to provide ATS source availability, contactor position, and loaded or unloaded test for up to four transfer switches. The panel shall have the capability to be either flush- mounted or surface-mounted. The annunciator shall meet UL508 requirements.
- J. Block Heater - The block heater shall be thermostatically controlled, 9,000 watt, with isolating valves, and to maintain manufacturers recommended engine coolant temperature to meet the start-up requirements of NFPA 99 and NFPA 110, Level 1. A quantity of one block heater per generator set shall be supplied.

2.3 Source Quality Control

- A. Non-Conforming Work

1. To ensure that the equipment has been designed and built to the highest reliability and quality standards, the manufacturer and/or local representative shall be responsible for three separate tests: design prototype tests, final production tests, and site tests.
 - a. **Design Prototype Tests.** Components of the emergency system, such as the engine/generator set, transfer switch, and accessories, shall not be subjected to prototype tests because the tests are potentially damaging. Rather, similar design prototypes and preproduction models shall be subject to the following tests:
 - i. Maximum power (kW)
 - ii. Maximum motor starting (kVA) at 35% instantaneous voltage dip.
 - iii. Alternator temperature rise by embedded thermocouple and/or by resistance method per NEMA MG1-32.6.
 - iv. Governor speed regulation under steady-state and transient conditions.
 - v. Voltage regulation and generator transient response.
 - vi. Harmonic analysis, voltage waveform deviation, and telephone influence factor.
 - vii. Three-phase short circuit tests.
 - viii. Alternator cooling air flow.
 - ix. Torsional analysis to verify that the generator set is free of harmful torsional stresses.
 - x. Endurance testing.
 - b. **Final Production Tests.** Each generator set shall be tested under varying loads with guards and exhaust system in place. Tests shall include:
 - i. Single-step load pickup
 - ii. Safety shutdown device testing
 - iii. Rated Power @ 0.8 PF
 - iv. Maximum power
 - v. Upon request, a witness test, or a certified test record sent prior to shipment.
 - c. **Site Tests.** The manufacturer's distribution representative shall perform an installation check, startup, and building load test. The engineer, regular operators, and the maintenance staff shall be notified of the time and date of the site test. The tests shall include:
 - i. Fuel, lubricating oil, and antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.
 - ii. Accessories that normally function while the set is standing by shall be checked prior to cranking the engine. These shall include: block heaters, battery chargers, alternator strip heaters, remote annunciators, etc.
 - iii. Generator set startup under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during operation, normal and emergency line-to-line voltage and frequency, and phase rotation.
 - iv. Automatic start by means of a simulated power outage to test remote-automatic starting, transfer of the load, and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator set voltage, amperes, and frequency shall be monitored throughout the test.
 - i. Load bank testing. The test shall consist of four hours of

continuous operation using a portable resistive load bank.
Adjust the load bank load to provide one half hour each at zero load, 25 percent, 50 percent, and 75 percent of full load.
Followed by two hours of operation at rated standby load.
Furnish the portable load bank, all connecting cables, metering equipment, and other equipment or devices required to perform the on-site testing. During the test, readings shall be taken every 15 minutes showing % load, voltage, amps, oil pressure, water temperature, and battery charge.

- ii. Provide adequate fuel for testing and top off tank after testing.

END OF SECTION

**SECTION 16482
AUTOMATIC TRANSFER SWITCH**

PART 1 GENERAL

1.1 Summary

- A This section includes **OWNER FURNISHED CONTRACTOR INSTALLED EQUIPMENT**
1. The Owner will prepurchase the Automatic Transfer Switch.
 2. The Contractor shall be responsible for coordinating shipping schedule between the Owner and the ATS manufacturer.
 3. The contractor shall be responsible for offloading the ATS upon delivery.
 4. The Contractor shall be responsible for all other aspects of this specification other than ATS purchase.
- B This section includes the following items from a single supplier:
1. Automatic transfer switch
- C Related Requirements
1. It is the intent of this specification to secure an automatic transfer switch that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.
 2. Any exceptions to the published specifications shall be subject to the approval of the engineer and submitted minimum 10 days prior to the closing of the bid with a line by line summary description of all the items of compliance, any items that have been are omitted or have been taken exception to, and a complete description of all deviations.
 3. It is the intent of this specification to secure an automatic transfer switch that has been tested during design verification, in production, and at the final job site. The automatic transfer switch will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.
 4. All equipment shall be new and of current production by an international power system manufacturer of generators, transfer switches, and paralleling switchgear. The manufacturer shall be a supplier of a complete and coordinated system. There will be single-source responsibility for warranty, parts, and service through a factory-authorized representative with factory-trained technicians.

1.2 Submittals

- A Action Submittals
1. Product Data
 - a The submittal shall include specification sheets showing all standard and optional accessories to be supplied; schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications.
 2. Shop Drawings
- B Closeout Submittals
1. Operation And Maintenance Data

2. Warranty Documentation

1.3 Quality Assurance

A Regulatory Agency

1. The automatic transfer switch shall conform to the requirements of the following codes and standards:
 - a UL 1008 - Standard for Transfer Switch Equipment
 - b IEC 947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching EquipmentEN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
 - c NFPA 70 - National Electrical Code
 - d NFPA 99 - Essential Electrical Systems for Health Care Facilities
 - e NFPA 110 - Emergency and Standby Power Systems
 - f IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
 - g NEMA Standard ICS 10-2005, Electromechanical AC Transfer Switch Equipment.
 - h EN61000-4-4 Fast Transient Immunity Severity Level 4
 - i EN61000-4-5 Surge Immunity Class 4 (voltage sensing and programmable inputs only)
 - j IEEE 472 (ANSI C37.90A) Ring Wave Test
 - k IEC Specifications for EMI/EMC Immunity (CISPR 11, IEC 1000-4-2, IEC 1000-4-3, IEC 1000-4-4, IEC 1000-4-5, IEC 1000-4-6, IEC 1000-4-8, IEC 1000-4-11)
 - l CSA C22.2 No. 178 certification
2. Qualifications
 - a The automatic transfer switch shall be produced by a manufacturer who is ISO 9001 certified for the design, development, production and service of its complete product line.
 - b A manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year shall produce the automatic transfer switch.
3. Manufacturers
 - a The automatic transfer switch shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be installed as shown on the plans, drawings, and specifications herein.
 - b The manufacturer shall maintain a national service organization of employing personnel located throughout the contiguous United States. The Service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.
 - c The basis of design is a Kohler model KEP-DMTC-4000S-TQ. If the supplier wishes to propose equivalent equipment as manufactured by Russelectric, all additional costs associated with re-engineering and mechanical & electrical modifications to the installation will be at the contractor's expense. The contractor must also supply the details below with his proposal:
 - A line-by-line clarification of the specification marked with "D" for deviation; "E" for exception, and "C" for comply.
 - The weight & outline dimensions of the proposed equipment.

Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification. No exceptions to the specifications shall be allowed or included in the certification.

- d The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

1.4 Field or Site Conditions

A Ambient Conditions

- 1. Automatic transfer switch shall operate in the following conditions without any damage to the unit or its loads.
 - a Ambient Temperature: -4 to 158 Degrees F
 - b Relative Humidity: 5% to 95% noncondensing

1.5 Warranty or Bond

A Manufacturer's Warranty

- 1. The ATS shall include a standard warranty covering one (1) year to guarantee against defective material and workmanship in accordance with the manufacturer's published warranty from the date of initial startup.
- 2. The ATS manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions; adjustment to the generator set, transfer switch, and switchgear controls as required, and certification in the owner's maintenance log of repairs made and functional tests performed on all systems.

PART 2 PRODUCTS

2.1 Equipment

A Equipment

- 1. Furnish and install an automatic transfer switches system(s) with 3-Pole / 4-Wire, Solid Neutral, 4000 Amps, 480V/60Hz. Each automatic transfer shall consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. All transfer switches and controllers shall be the products of the same manufacturer.

B Manufacturer

- 1. Automatic transfer switches shall be Kohler Service Entrance Rated - Programmed Transition KEP-DMTC-4000S-TQ. Any alternate shall be submitted for approval to the consulting engineer at least 10 days prior to bid date. Alternate bids shall include a line-by-line clarification of the specification marked with "D" for deviation; "E" for exception, and "C" for comply.

C Construction

- 1. The transfer switch shall be electrically operated and mechanically held with double throw construction and operated by a momentarily energized solenoid-driven mechanism.

2. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.
3. The 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.
4. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.
5. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 800 amperes and higher shall have front removable and replaceable contacts. All stationery and moveable contacts shall be replaceable without removing power conductors and/or bus bars.
6. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching, or transfer between two active power sources, are not acceptable.
7. For two and three pole switches, where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.
8. For four pole switches with a switching neutral, where neutral conductors must be switched as shown on the plans, the contactor shall be provided with fully rated switched neutral transfer contacts. Overlapping neutral contacts may be used as an alternative.

D Enclosure

1. The ATS shall be furnished in a NEMA 3R enclosure.
2. All standard door mounted switches and indicating LEDs shall be integrated into a flush-mounted, interface membrane or equivalent in the enclosure door for easy viewing & replacement. The panel shall be capable of having a manual locking feature to allow the user to lockout all membrane mounted control switches to prevent unauthorized tampering. This cover shall be mounted with hinges and have a latch that may be padlocked. The membrane panel shall be suitable for mounting by others when furnished on open type units.

2.2 Operation

A Controls

1. A four line, 20 character LCD display and dynamic 4 button keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and control through the communications interface port or USB. The following parameters shall only be adjustable via a password protected programming on the controller:
 - a Nominal line voltage and frequency
 - b Single or three phase sensing
 - c Operating parameter protection
 - d Transfer operating mode configuration (Standard transition, Programmed transition, or Closed transition)

B Voltage and Frequency

1. Voltage (all phases) 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 % of nominal unless otherwise specified):

a	Parameter	Dropout/Trip	Pickup/Reset
b	Under voltage	75 to 98%	85 to 100%

- | | | | |
|---|-------------------|-------------|--------------------|
| c | Over voltage | 106 to 135% | 95 to 100% of trip |
| d | Under frequency | 95 to 99% | 80 to 95% |
| e | Over frequency | 01 to 115% | 105 to 120% |
| f | Voltage unbalance | 5 to 20% | 3 to 18% |
2. Repetitive accuracy of all settings shall be within $\pm 0.5\%$ over an operating temperature range of -20°C to 70°C .
 3. An adjustable dropout time for transient voltage and frequency excursions shall be provided. The time delays shall be 0.1 to 9.9 seconds for voltage and .1 to 15 seconds for frequency.
 4. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad, remotely via the communications interface port or USB.
 5. The controller shall be capable of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or BAC). Unacceptable phase rotation shall be indicated on the LCD; the service required LED and the annunciation through the communication protocol and dry contacts. In addition, the phase rotation sensing shall be capable of being disabled, if required.
 6. The controller shall be capable of detecting a single phasing condition of a source, even though a voltage may be regenerated by the load. This condition is a loss of phase and shall be considered a failed source.
 7. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases (phase to phase and phase to neutral), frequency, and phase rotation.

C Time Delays

1. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 12 or 24 VDC power supply.
2. A time delay shall be provided on transfer to the emergency source, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.
3. A time delay shall be provided on re-transfer to normal. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.
4. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.
5. A time delay activated output signal shall also be provided to drive external relay(s) for selective load disconnect and reconnect control. The controller shall be capable of controlling a maximum of 9 individual output time delays to step loads on after a transfer occurs. Each output may be individually programmed for their own time delay of up to 60 minutes. Each sequence shall be independently programmed for transferring from normal to emergency and transferring from emergency to normal.
6. All time delays shall be adjustable in 1 second increments.
7. All time delays shall be adjustable by using the display and keypad, with a remote device connected to the communications interface port or USB.
8. Each time delay shall be identified, and a dynamic countdown shall be shown on the display. Active time delays can be viewed with a remote device connected to the communications interface port or USB.

D Additional Features

1. The controller shall have 3 levels of security. Level 1 shall allow monitoring of settings and parameters only. The Level 1 shall be capable of restricted with the use of a lockable cover. Level 2 shall allow test functions to be performed and Level 3 shall allow setting of all parameters.

2. The display shall provide for the test functions, allowed through password security. The test function shall be load, no load or auto test. The auto test function shall request an elapsed time for test. At the completion of this time delay the test shall be automatically ended and a retransfer sequence shall commence. All loaded tests shall be immediately ended and retransfer shall occur if the emergency source fails and the normal source is acceptable.
3. A contact closure shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.
4. Auxiliary contacts shall be provided consisting of a minimum of two contacts, closed when the ATS is connected to the normal source and two contacts closed, when the ATS is connected to the emergency source.
5. LED indicating lights shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).
6. LED indicating lights shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal (green) and emergency sources (red), as determined by the voltage, frequency and phase rotation sensing trip and reset settings for each source.
7. A membrane switch shall be provided on the membrane panel to test all indicating lights and display when pressed.
8. Provide the ability to select "commit/no commit to transfer" to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.
9. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which closes to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad, communications interface port or USB. A "not-in-auto" LED shall indicate anytime the controller is inhibiting transfer from occurring.
10. The programmed transition feature shall control the transfer so that mechanism is placed in a load disconnect position for an adjustable period of time, giving motor and transformer loads and opportunity to decay to acceptable levels. The programmed transition feature shall be specifically designed for and be the product of the ATS manufacturer. The programmed transition setting shall be capable of being enabled or disabled from the user interface, communications interface port or USB. The controller shall include a built-in time delay for programmed transition operation. This time shall be adjustable from the user interface. The default value shall be 1 second and shall be adjustable from 0 to 60 minutes.
11. A time based load control feature shall be available to allow the prioritized addition and removal of loads based during transfer. This feature may be enabled for either or both sources. The user shall be able to control up to nine loads with independent timing sequences for pre and post transfer delays in either direction of transfer.
12. The controller shall provide 2 inputs for external controls that can be programmed from the following values:
 - a Common fault, Remote test, Inhibit transfer, Low battery voltage, Peak shave, Time delay bypass, Load shed forced to OFF position (Programmed transition only)
13. The controller shall provide two form "C" contact outputs rated for up to 12A @ 240VAC or 2A @ 480VAC that can be programmed from the following values:
 - a Aux switch open, Transfer switch aux contact fault, Alarm silenced, Alarm active, I/O communication loss, Contactor position, Exercise active, Test mode active, Fail to transfer, Fail to acquire standby source, Source available, Phase rotation error, Not in automatic mode, Common alarm, In phase monitor sync, Load bank control active, Load control active, Maintenance mode active, Non-emergency transfer, Fail to open/close, Loss of phase, Over/under voltage, Over/under

- frequency, Voltage unbalance, Start signal, Peak shave active, Preferred source supplying load, Standby source supplying load
14. The controller shall be capable of expanding the number of inputs and outputs with additional modules.
 15. Optional input/output modules shall be furnished which mount on the inside of the enclosure to facilitate ease of connections.
 16. Engine Exerciser - The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to 21 different exercise routines based on a calendar mode. For each routine, the user shall be able to:
 - a Enable or disable the routine
 - b Enable or disable transfer of the load during routine.
 - c Set the start time, time of day, day of week, week of month (1st, 2nd, 3rd, 4th, alternate or every)
 - d Set the duration of the run.
 - e At the end of the specified loaded exercise duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. All loaded exercises shall be immediately ended and retransfer shall occur if the standby source fails. The next exercise period shall be displayed on the main screen with the type of exercise, time, and date. The type of exercise and the time remaining shall be display when the exercise is active. It shall be possible of ending the exercise event with a single button push.
 17. Date and time - The date shall automatically adjust for leap year and the time shall have the capability of automatically adjusting for daylight saving and standard times.
 18. System Status - The controller shall have a default display the following on:
 - a System status
 - b Date, time, and type of the next exercise event
 - c Average voltage of the preferred and standby sources
 - d Scrolling through the displays shall indicate the following:
 - 1) Line to line and line to neutral voltages for both sources
 - 2) Frequency of each source
 - 3) Load current for each phase
 - 4) Single or three phase operation
 - 5) Type of transition
 - 6) Preferred source
 - 7) Commit or no commit modes of operation
 - 8) Source/source mode
 - 9) In phase monitor enable/disable
 - 10) Phase rotation
 - 11) Date and time
 19. Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in the operator's manual, are not permissible.
 20. Self-Diagnostics - The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.
 21. Communications Interface - The controller shall be capable of interfacing, through a standard communication with a network of transfer switches and generators. It shall be able to be connected via an RS-485 serial communication (up to 4000 ft. direct connect or multi-drop configuration). This module shall allow for seamless integration of existing or new communication transfer devices and generators.
 22. The transfer switch shall also be able to interface to 3rd party applications using Modbus RTU open standard protocols utilizing Modbus register maps. Proprietary protocols shall not be acceptable.
 23. The controller shall contain a USB port for use with a software diagnostic application available to factory authorized personnel for downloading the controller's parameters

and settings; exercise event schedules; maintenance records and event history. The application can also adjust parameters on the controller.

24. Data Logging - The controller shall have the ability to log data and to maintain the last 2000 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory. The controller shall be able to display up to the last 99 events. The remaining events shall be accessible via the communications interface port or USB.
 - a Event Logging
 - 1) Data, date, and time indication of any event
 - b Statistical Data
 - 1) Total number of transfers*
 - 2) Total number of fail to transfers*
 - 3) Total number of transfers due to preferred source failure*
 - 4) Total number of minutes of operation*
 - 5) Total number of minutes in the standby source*
 - 6) Total number of minutes not in the preferred source*
 - 7) Normal to emergency transfer time
 - 8) Emergency to normal transfer time
 - 9) System start date
 - 10) Last maintenance date
 - 11) * The statistical data shall be held in two registers. One register shall contain data since start up and the second register shall contain data from the last maintenance reset.
25. External DC Power Supply - An optional provision shall be available to connect up to two external 12/24 VDC power supply to allow the LCD and the door mounted control indicators to remain functional when both power sources are dead for extended periods of time. This module shall contain reverse battery connection indication and circuit protection.

2.3 Service Entrance Switch

- A. A two position disconnect switch shall be provided to disconnect the normal source and inhibit during maintenance or emergency.
 - i. The controller shall display SERVICE DISCONNECT
 - ii. Further transfer is inhibited after transfer to Emergency
- B. Molded case circuit breakers (MCCB) shall be 80% rated. Molded case switches (MCSW) shall be 100% rated. Insulated case circuit breakers and insulated case switches shall be 100% rated.
- C. The transfer switch mechanism shall provide a simple means of manual operation using only components, which are permanently affixed, in the operating position.
- D. The unit shall permit manual operation of the transfer switch while the system is energized and carrying rated load. Transfer switches, which require all sources of power to be de-energized prior to manual load transferring, shall not be acceptable.
- E. A control circuit isolation plug shall be provided to isolate all control circuitry inside the transfer switch to facilitate maintenance procedures. When isolated, there shall be no voltage present on the control circuitry.
- F. Cable Connections: Provision shall be made to terminate all incoming and outgoing power cables and grounding conductors. Connections shall be via screw type cable lugs.
- G. The Power Switching units shall be fix-mounted, utilize fully enclosed contacts and their withstand/closing rating shall be equal to or exceed the required withstand rating of the complete mechanism.
- H. The service entrance rated automatic transfer switch shall automatically transfer the load to the generator supply in the event of a utility supply failure and return the load to the utility supply upon restoration. The transfer switch shall incorporate an isolating mechanism and over current protection on the utility supply to allow operation as the main

services disconnect in accordance with NEC requirements. The transfer switch power switching devices shall be mechanically and electrically interlocked to prevent the utility and generator supplies from being interconnected.

- I. Insulated Case Circuit Breaker Service Entrance Rated Transfer Switches
 - i. The normal connection shall be provided with an electronic trip, 100% rated insulated case breaker with a 4000 amp current rating.
 - ii. **The normal connection shall include Zone Selective Interlock.**

2.4 Accessories

- A. Padlockable User Interface Cover. The user interface cover shall protect the controller user interface from the environment.
- B. Controller Disconnect Switch. A Logic disconnect switch shall be mounted inside the enclosure and shall disconnect power to controller without disconnecting the load. The logic disconnect switch shall disconnect utility power to the controller during maintenance and service without disconnecting power to the load. The switch has two positions, auto and disconnect. The disconnect position shall disconnect the voltage sensing leads for the utility source (A, B, C, N). It is assumed that the user shall disable the generator by placing the controller in the OFF position.

2.5 Source Quality Control

- A Test and Inspection
 - 1. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.
 - 2. The ATS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation, and servicing in accordance with ISO 9001.

END OF SECTION

SECTION 265100

LIGHTING: LED LUMINAIRES

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes: LED luminaires, drivers, poles, and accessories.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. Illuminating Engineering Society of North America (IESNA):
1. LM-79 - IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
 2. LM-80 - IES Approved Method: Measuring Lumen Maintenance of LED Light Sources.
 3. TM-21 - Projecting Long Term Lumen Maintenance of LED Light Sources.
- C. Institute of Electrical and Electronics Engineers (IEEE):
1. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
- D. National Electrical Manufacturers Association (NEMA):
1. 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
- E. Underwriters Laboratories (UL):
1. 1598 - Luminaires.
 2. 8750 - Light Emitting Diode (LED) Equipment For Use In Lighting Products.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. Specific definitions and abbreviations:
1. CCT: Correlated color temperature - Scientific scale to describe how “warm” or how “cool” the light source is, measured in Kelvin. The lower the Kelvin temperature, the warmer the light feels, or appears.
 2. CRI: Color Rendering Index - A quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.
 3. Driver - Device that manages power and controls the current flow from AC to DC for an LED lighting product.
 4. Efficacy - Lumen output of a light source per unit of power supplied to that source (lumens per watt).
 5. EMI: Electromagnetic Interference - Electrical interference (noise) generated by electrical and electronic devices.
 6. FC: Foot Candles - Measure of light level on a surface being illuminated.
 7. L70 - The extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
 8. LED: Light emitting diode - A solid-state semiconductor device that produces light when electrical current flows through it.

9. LED light source - See LED luminaire.
10. LED luminaire - A complete lighting unit consisting of LED-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light emitting elements, and to connect the unit to a branch circuit.
11. Lumen - The international (SI) unit of luminous flux or quantity of light. The amount of light that is spread over a square foot of surface by one candle power when all parts of the surface are exactly one foot from the light source.
12. Lumen ambient temperature multiplier - LED light source relative lumen output when compared to a standard ambient temperature.
13. Lumen maintenance factor - How well an LED light source is able to retain its intensity when compared to new.
14. Luminaire - Lighting unit.
15. THD: Total harmonic distortion - The combined effect of harmonic Distortion on the AC waveform produced by a driver or other device.

1.4 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 1. LED Luminaires:
 - a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule in the Drawings.
 - b. Provide for each luminaire type:
 - 1) Materials.
 - 2) Type of diffuser.
 - 3) Hardware.
 - 4) Gasketing.
 - 5) Reflector.
 - 6) Chassis.
 - 7) Finish and color.
 - 8) Driver type and protection.
 - 9) LED luminaire:
 - a) Initial lumen output at 40 degrees Celsius ambient.
 - b) Correlated color temperature.
 - c) Lumen maintenance factors.
 - d) Lumen ambient temperature multipliers.
 - e) Drive current.
 - f) Efficacy.
 - 10) Picture of luminaire.
 - 11) IES optical distributions.
 - 12) Dimensioned drawings:
 - a) Effective projected area rating for pole mounted luminaires.
 - 13) Weight.
 - 14) Photometric data:
 - a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
 - b) Luminaire dirt depreciation factor.
 - c) Candlepower distribution curves.
 - d) Average luminaire brightness.
 - e) Lumen output charts.
 - 15) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
 - a) Support methods shall be based on seismic requirements at the project site as specified in the Common Work Results for Electrical section.

- c. Luminaire substitutions:
 - 1) Provide complete literature for each luminaire substitution:
 - 2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
 - a) Photometric data:
 - (1) IES file in standard IES format.
 - (2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
 - (3) Candlepower distribution curves.
 - (4) Average luminaire brightness.
 - (5) Lumen output charts.
 - (6) Power requirements in watts and volt-amperes.
 - b) Calculations:
 - (1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
 - (a) Use surface reflectance values and luminaire light loss factors approved by the Engineer to perform all calculations.
 - c) Specification sheets:
 - (1) If lacking sufficient detail to indicate compliance with contract documents, standard specification sheets will not be accepted. This includes, but is not limited to, luminaire type designation, manufacturer's complete catalog number, voltage, LED type, CCT, CRI, specific driver information, system efficacy, L70 life rating, and any modifications necessary to meet the requirements of the contract documents.
 - 3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
 - 4) Substitutions shall comply with all applicable building and energy codes.
- 2. Driver: Provide for each driver type:
 - a. Catalog number.
 - b. Type of driver.
 - c. Output wattage.
 - d. Input voltage.
 - e. Operating voltage range.
 - f. Maximum input power.
 - g. Efficiency.
 - h. Operating line current.
 - i. Power factor.
 - j. Operating temperature range.
 - k. Current output range in ambient temperatures of 30 to 55 degrees Celsius.
 - l. Surge suppression data.

C. Record documents:

- 1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.5 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Common Work Results for Electrical section.

1.7 PROJECT OR SITE CONDITIONS

- A. As specified in the Common Work Results for Electrical section.

1.8 SEQUENCING (NOT USED)

1.9 SCHEDULING

- A. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.
- B. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.10 WARRANTY

- A. As specified in the Common Work Results for Electrical section.
- B. LED luminaire:
 - 1. 5 year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.11 SYSTEM START-UP

- A. As specified in the Common Work Results for Electrical section.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE

- A. Furnish 1 complete spare LED luminaire, with driver, of each type used.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Luminaires:
 - 1. The following or equal:
 - a. As noted on the Luminaire Schedule.
- B. Drivers:
 - 1. One of the following or equal:
 - a. Philips Advance.
 - b. Thomas Research.
 - c. eldoLED.
- C. Substitutions:
 - 1. The lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor's responsibility to ensure and prove to the Engineer at time of submittal the substitutions meet the quality and photometric requirements of the original design.

2.2 SYSTEM DESCRIPTION

- A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.
- B. Individual luminaire types are indicated on the Drawings and on the Luminaire_Schedule.

2.3 EXISTING PRODUCTS (NOT USED)

2.4 MATERIALS (NOT USED)

2.5 MANUFACTURED UNITS (NOT USED)

2.6 EQUIPMENT

A. LED Luminaires:

- 1. General:
 - a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
 - b. Provide the luminaires furnished per the Luminaire Schedule in the Drawings:
 - 1) The Specifications noted in this Section are an addition or supplement to the Luminaire Schedule.
 - c. Individual LEDs connected such that a catastrophic loss or the failure of 1 LED will not result in the loss of the entire luminaire.
- 2. Minimum ambient temperature range of 0 degrees Celsius to 40 degrees Celsius.
- 3. Minimum rated life:
 - a. Office Areas: 70,000 hours when operated at 25 degrees Celsius.
 - b. Process Areas: 60,000 hours when operated at 40 degrees Celsius.
 - c. Hazardous Areas: 50,000 hours when operated at 40 degrees Celsius.
- 4. Minimum efficacy of 70 lumens/watt.
 - a. Hazardous Areas: Minimum 60 lumens/watt.
- 5. Minimum Color Rendering Index of 70.
- 6. Tested according to IESNA LM-79 and LM-80.
- 7. Lumen maintenance projection in accordance with IESNA TM-21.
- 8. RoHS compliant.
- 9. Integral driver.
- 10. Suitable for dry, damp, or wet locations as indicated on the Drawings or on the Luminaire Schedule.
 - a. Wet or damp locations: UL 1598 listed.
- 11. Designed as a complete LED assembly. Retrofit LED lamps in luminaires not designed specifically for LED light sources shall not be used.
- 12. Exterior/outdoor luminaires:
 - a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
 - 1) Wind levels at the project site without damage.
 - 2) Seismic levels at the project site.
 - b. Corrosion-resistant hardware and hinged doors or lens retainer.
 - c. Luminaires furnished with integral photoelectrical control shall be of the luminaire manufacturer's standard design.

B. Drivers:

- 1. Dimmable, with dimming signal protocol of 0-10 VDC or DALI.
- 2. Input power source:
 - a. As indicated on the Drawings.
- 3. Drive current:
 - a. As indicated in the Luminaire Schedule.
- 4. Power factor: greater than 0.90.

5. Efficiency: greater than 80 percent.
6. Total harmonic distortion (THD) of the input current less than 20 percent.
7. Rated life of 60,000 hours in an LED luminaire operated at an ambient temperature of 40 degrees Celsius.
8. Minimum operating temperature of 0 degrees Celsius.
9. Sound rating: Class A+ or quieter.
10. UL listed Class 2 Outdoor in accordance with UL 8750.
11. In accordance with IEEE C62.41 Category A for transient protection.
12. Driver must limit inrush current:
 - a. Meet or exceed NEMA 410 driver inrush standard:
 - 1) 230 Amps per 10 Amp load with a maximum of 106 Amps squared-seconds at 120V.
 - 2) 430 Amps per 10 Amp load with a maximum of 370 Amps squared-seconds at 277V.

2.7 COMPONENTS

2.8 ACCESSORIES (NOT USED)

2.9 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Install luminaires per the manufacturer's guidelines and submitted installation calculations to meet seismic and wind requirements at the project site.
- C. Special techniques:
 1. Support luminaires from structural elements capable of carrying the total weight.
 2. Install luminaires plumb and square with building and wall intersections:
 - a. Suspend pendant-mounted luminaires that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
 - b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or ductwork.
 3. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
 - a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.
 4. Support luminaires weighing more than 25 pounds independently of the outlet box and the conduit.

5. Provide ceiling or pendent mounted luminaires with a safety chain connecting the lens, driver, and other components to the building structure.
6. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
 - a. The safety supports shall consist of number 12 AWG soft drawn galvanized wires.
7. Install luminaires in accordance with the architectural reflected ceiling Drawings:
 - a. Center luminaires on ceiling tiles unless otherwise indicated.
8. Support luminaires installed in suspended grid ceilings, independently of the grid:
 - a. Provide seismic restraint clips for all luminaires installed in suspended grid ceilings.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING (NOT USED)

3.8 FIELD QUALITY CONTROL

- A. As specified in the Common Work Results for Electrical section.

3.9 ADJUSTING

- A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by Owner or the Engineer.

3.10 CLEANING

- A. As specified in the Common Work Results for Electrical section.
- B. Clean all lenses, diffusers, and reflectors.
- C. Refinish all luminaires' trim, poles, and support brackets, where finish has been damaged.
- D. Clean all LED luminaires (new and old), used during construction for construction lighting, before substantial completion.

3.11 PROTECTION

- A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES

- A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION

SECTION 266700

LIGHTNING PROTECTION

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Design and installation of a complete lightning protection system.
 - 2. Materials and components for the lightning protection system.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. Lightning Protection Institute (LPI).
 - 1. 175 - Standard for the Design - Installation - Inspection of Lightning Protection Systems.
 - 2. 177 - Inspection Guide for Certified Systems.
- C. National Electrical Code (NEC).
- D. National Fire Protection Association (NFPA):
 - 1. 780 - Standard for the Installation of Lightning Protection Systems.
- E. Underwriters Laboratories, Inc. (UL):
 - 1. 96 - Standard for Lightning Protection Components.
 - 2. 96A - Standard for Installation Requirements for Lightning Protection Systems.

1.3 DEFINITIONS

- A. As specified in the Common Work Results for Electrical section.
- B. Specific definitions:
 - 1. LPI: Lightning Protection Institute.

1.4 SYSTEM DESCRIPTION

- A. Retain the services of a lightning protection contractor to design, furnish, and install a complete lightning protection system, connected to the facility grounding system.
- B. Lightning protection system: NFPA 780; UL 96A master labeled or LPI certified system(s) consisting of:
 - 1. Air terminals on roof(s).
 - 2. Bonding.
 - 3. Grounding electrodes.
 - 4. Interconnecting conductors.
- C. Connect the lightning protection system to the facility grounding electrode:
 - 1. Provide common ground connections as necessary to the electric and telephone service conductors.

- D. The installing contractor is responsible for all costs associated with UL or LPI application/inspection of the lightning protection system, including any costs associated with re-inspection necessary to obtain the UL 96A Master Label or LPI 177 Certification.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. Product data:
 - 1. Provide samples and pertinent catalog data for:
 - a. Air terminals.
 - b. Conductors.
 - c. Connectors.
 - d. Accessories.
 - e. Include dimensions and materials of each component, and include indication of listing in accordance with UL 96.
- C. Shop drawings:
 - 1. Including but not limited to:
 - a. Layout of air terminals with the respective configuration of the zone of protection.
 - b. Grounding electrodes, and bonding connections to structure and other metal objects.
 - c. Type, size and locations for:
 - 1) Terminal.
 - 2) Electrode.
 - 3) Conductor.
 - d. Conductor routing details.
 - e. Connection details.
 - f. Termination details.
 - g. Applicable air terminal and other calculations.
 - 2. Details showing installation of air terminals, conductors, and connectors.
- D. Certificates:
 - 1. Submit written confirmation of having obtained UL Master Label or LPI certification for each lightning protection system.
 - 2. Photocopy of UL or LPI Installers' Certificate(s) for installation of lightning protection systems.
 - 3. Proof of the manufacturer has been UL-listed for at least 5 years.
 - 4. Proof of the installer has been UL-listed or LPI-certified for at least 5 years.
- E. Record Documents:
 - 1. Provide Record Documents as specified in the Closeout Procedures section and the Common Work Results for Electrical section.
 - 2. Accurately record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors.
 - 3. Manufacturer's installation instructions.

1.6 QUALITY ASSURANCE

- A. As specified in the Common Work Results for Electrical section.
- B. Conform to the requirements of the UL or LPI and NFPA standards for lightning protection systems:
 - 1. Components shall be listed in accordance with UL 96.

- C. Manufacturer's qualifications:
 - 1. Company specializing in lightning protection equipment with minimum 5 years of experience:
 - a. Listed in section "Lightning Conductor, Air Terminals and Fittings" of the UL "Electrical Construction Materials Directory" for at least 5 years previous to this Contract's bid opening date.
 - D. Installers qualifications: Member of the UL quality control program listed in section "Lightning Protection Installation" of the UL "Electrical Construction Materials Directory" or LPI-certified installer for installation of lightning protection systems for at least 5 years previous to this Contract's bid opening date. The lightning protection system shall meet the applicable requirements of NFPA 780 and UL 96 and 96A or LPI 175 and 177.
 - E. Upon completion of installation the lightning protection contractor to have the building lightning system physically inspected by UL or in accordance with LPI requirements:
 - 1. Furnish a UL Master Label or LPI Installer Certified for the building:
 - a. Application for the UL Master Label without a physical inspection by UL is unacceptable.
- 1.7 DELIVERY, STORAGE, AND HANDLING
- A. As specified in the Common Work Results for Electrical section.
- 1.8 PROJECT OR SITE CONDITIONS (NOT USED)
- 1.9 SEQUENCING
- A. Pre-installation conference:
 - 1. Convene a pre-installation conference before commencing the Work of this Section.
 - B. Coordinate Work with other trades to ensure neat, correct, and unobtrusive installation.
 - C. Coordinate the Work of this Section with roofing and exterior and interior finish installations.
- 1.10 SCHEDULING (NOT USED)
- 1.11 WARRANTY
- A. As specified in the Common Work Results for Electrical section.
- 1.12 SYSTEM START-UP
- A. As specified in the Common Work Results for Electrical section.
- 1.13 OWNER'S INSTRUCTIONS (NOT USED)
- 1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. One of the following or equal:
 - 1. Erico.
 - 2. Thompson Lightning Protection, Inc.

3. Harger Lightning and Grounding.
4. VFC, Inc.

2.2 EXISTING PRODUCTS (NOT USED)

2.3 MATERIALS

A. Air terminals:

1. Material: Aluminum.
 - a. Aluminum components for aluminum roofing, compatible with aluminum roofing materials.
2. Size: 3/8-inch by 18-inch minimum extending a minimum of 12 inches above the object to be protected.
3. On flat or walkable roofs, provide air terminals with:
 - a. Mushroom type blunt tip incapable of impalement if fallen upon.
 - b. Spring mounted and capable of being pushed flush to the roof.
4. Air terminals on stacks and chimneys:
 - a. Protected from corrosion.
 - b. Sized in accordance with UL and NFPA requirements.
 - c. Lead-coated copper.
5. Air terminal bases:
 - a. Cast bronze with bolt pressure cable connections securely mounted with stainless steel screws and bolts.

B. Ground rods and below grade connectors:

1. As specified in the Grounding and Bonding section.

C. Ground plate: Copper.

D. Conductors:

1. Perimeters:
 - a. Aluminum.
 - 1) Aluminum components for aluminum roofing, compatible with aluminum roofing materials.
2. Down conductors:
 - a. Copper.
3. Sized in accordance with UL or LPI and NFPA requirements.
4. UL listed for the application.

E. Cable fasteners:

1. Electrolytically compatible with conductors and mounting surface:
 - a. Spaced in accordance with LPI or NFPA requirements.

F. Above grade connectors:

1. Make connections between dissimilar metals with approved bimetallic connectors.
2. Installed by trained personnel.
3. UL listed for the application.

G. Miscellaneous materials:

1. Copper of type and size recommended by the manufacturer of the lightning protection system.
2. Stainless steel bolts, screws, and other threaded fasteners.

- 2.4 MANUFACTURED UNITS (NOT USED)
- 2.5 EQUIPMENT (NOT USED)
- 2.6 COMPONENTS (NOT USED)
- 2.7 ACCESSORIES (NOT USED)
- 2.8 MIXES (NOT USED)
- 2.9 FABRICATION (NOT USED)
- 2.10 FINISHES (NOT USED)
- 2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION

- A. It is the responsibility of the lightning protection subcontractor to review the electrical system design and provide any and all additional equipment and materials needed in order to construct a master labeled UL or LPI certified lightning protection system.
- B. Verify that surfaces are ready to receive work.
- C. Protect elements surrounding Work of this Section from damage or disfiguration.

3.2 PREPARATION (NOT USED)

3.3 INSTALLATION

- A. As specified in the Common Work Results for Electrical section.
- B. Install systems in accordance with manufacturer's instructions unless otherwise specified in this Section.
- C. Installation must be made by a LPI certified master installer or an UL certified installer.
- D. Conductor installations:
 - 1. Install the lightning protection roof system(s) grounding and bending conductors exposed on flat roof areas and concealed at ridge roof areas.
 - 2. Install main downloads completely concealed and sleeved.
 - 3. Other than for the purpose of protecting downlead conductors from damage up to 6 feet above grade level, do not use exposed conduits to conceal the downloads on the exterior of the outside walls.
 - 4. Use minimum 1-inch PVC conduits to protect lightning system conductors from damage.
- E. Clearances: Ensure 6-foot minimum distance required by NEC:
 - 1. From lightning rod conductors to non-current-carrying metal parts of electrical equipment unless they are bonded to the rods.
 - 2. From lightning system conductors to open conductors of communication systems.
 - 3. From lightning protection grounding electrodes to electrodes of other grounding systems.

- F. Extend air terminals a minimum of 12 inches above object to be protected.
 - G. Maintain horizontal or downward coursing of main conductor and ensure that bends have at least an 8-inch radius and that no bend of a conductor forms an included angle of less than 90 degrees.
 - H. Grounding electrode system:
 - 1. Where a grounding electrode system is indicated on the Drawings, modify the installation to meet the applicable lightning protection standards.
 - a. Provide additional electrodes where required.
 - 2. Where a grounding electrode system is not indicated on the Drawings, install grounding electrodes per the applicable UL or LPI standards.
 - I. Interconnection of metals:
 - 1. Bond all metal bodies within 6 feet of the conductor to the system with approved fittings and conductor.
 - 2. Connections between dissimilar metals shall be made with approved bimetallic connections.
 - 3. Bond metal bodies of inductance located within 6 feet of a conductor or object with secondary bonds.
 - J. Bond all isolated metallic bodies at or below the roof subject to inductance and within 6 feet of lightning protection system conductors.
 - K. Provide necessary common grounds between the lightning protections system and the electric and telephone service entrance wires, TV and radio antenna grounds.
 - L. Ensure that air terminals are installed to withstand calculated wind force due to 100 miles per hour winds or as specified in the Wind Design Criteria section, whichever is greater with a 1.3 gust factor without structural damage and without damage to integrity of the lightning protection system.
- 3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)
- 3.5 REPAIR/RESTORATION (NOT USED)
- 3.6 REINSTALLATION (NOT USED)
- 3.7 COMMISSIONING
- A. As specified in the Commissioning section.
- 3.8 FIELD QUALITY CONTROL
- A. As specified in the Common Work Results for Electrical section.
 - B. Provide one of the following:
 - 1. The services of UL to physically inspect the entire lightning protection system and issue the UL Master Label:
 - a. Furnish UL Master Label as evidence that the installation has met with UL 96A code requirements.
 - 2. Obtain LPI system certification reports and LPI system certification.

3.9 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 269500

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1- GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Responsibilities for testing the electrical installation.
 - 2. Adjusting and calibration.
 - 3. Acceptance tests.
- B. Copyright information:
 - 1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.2 REFERENCES

- A. As specified in the Common Work Results for Electrical section.
- B. American National Standards Institute (ANSI).
- C. ASTM International (ASTM):
 - 1. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
 - 2. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
 - 3. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
 - 4. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
 - 5. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
 - 6. D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
 - 7. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
 - 8. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
 - 9. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
 - 10. D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop Weight Method.
 - 11. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - 2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
 - 3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
 - 4. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.

5. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
 6. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
 7. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
 8. C57.13 - IEEE Standard Requirements for Instrument Transformers.
 9. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
 10. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
 11. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.
- E. Insulated Cable Engineer's Association (ICEA).
- F. InterNational Electrical Testing Association (NETA).
1. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- G. International Electrotechnical Commission (IEC).
- H. Manufacturer's testing recommendations and instruction manuals.
- I. National Fire Protection Association (NFPA):
1. 70 - National Electrical Code (NEC).
 2. 110 - Standard for Emergency and Standby Power Systems.
- J. National Institute of Standards and Technology (NIST).
- K. Specification sections for the electrical equipment being tested.
- L. Shop drawings.

1.3 DEFINITIONS

- A. As specified in the Commissioning section and the Common Work Results for Electrical section.
- B. Specific definitions:
1. Testing laboratory: The organization performing acceptance tests.

1.4 SYSTEM DESCRIPTION

- A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.
- B. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.
- C. Responsibilities:
1. Contractor responsibilities:
 - a. Ensure that all resources are made available for testing, and that all testing requirements are met.
 2. Electrical subcontractor responsibilities:
 - a. Perform routine tests during installation.

- b. Demonstrate operation of electrical equipment.
- c. Commission the electrical installation.
- d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
 - 1) Providing electrical power as required.
 - 2) Operating of electrical equipment in conjunction with testing of other equipment.
 - 3) Activating and shutting down electrical circuits.
 - 4) Making and recording electrical measurements.
 - 5) Replacing blown fuses.
 - 6) Installing temporary jumpers.
- 3. Testing laboratory responsibilities:
 - a. Perform all acceptance tests specified in this Section.
 - b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

1.5 SUBMITTALS

- A. Furnish submittals as specified in the Common Work Results for Electrical section.
- B. LAN cable test form:
 - 1. LAN cable test reports:
 - a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Cable number.
 - 5) Cable length.
 - 6) Certification that the cable meets or exceeds the specified standard.
 - b. Furnish hard copy and electronic copy for all traces.
- C. Manufacturers' testing procedures:
 - 1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.
- D. Test report:
 - 1. Include the following:
 - a. Summary of Project.
 - b. Description of equipment tested.
 - c. Description of tests performed.
 - d. Test results.
 - e. Conclusions and recommendations.
 - f. Completed test forms.
 - g. List of test equipment used and calibration dates.
 - h. LAN cable test reports.
- E. Test data records:
 - 1. Include the following:
 - a. Identification of the testing organization.
 - b. Equipment identification.
 - c. Nameplate data.
 - d. Humidity, temperature and other conditions that may affect the results of the tests and or calibrations.
 - e. Dates of inspections, tests, maintenance and or calibrations.

- f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
- g. Expected results when calibrations are to be performed.
- h. Indication of as-found and as-left results as applicable.
- i. Indication of all test results outside specified tolerances.

F. Testing laboratory qualifications:

- 1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
 - a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
 - 1) Corporate history and references.
 - 2) Resume of individual performing test.
 - 3) Equipment list and test calibration data.

G. Division of responsibilities:

- 1. Submit a list identifying who is responsible for performing each portion of the testing.

1.6 QUALITY ASSURANCE

A. As specified in the Common Work Results for Electrical section.

B. Testing laboratory qualifications:

- 1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
- 2. NETA certification required.
- 3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.7 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.8 PROJECT OR SITE CONDITIONS

A. As specified in the Common Work Results for Electrical section.

1.9 SEQUENCING

A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.

B. Perform testing in the following sequence:

- 1. Perform routine tests as the equipment is installed including:
 - a. Insulation-resistance tests.
 - b. Continuity tests.
 - c. Rotational tests.
- 2. Adjusting and preliminary calibration.
- 3. Acceptance tests.
- 4. Demonstration.
- 5. Commissioning and plant start-up.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in the Common Work Results for Electrical section.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION (NOT USED)

3.2 PREPARATION

- A. Test instrument calibration:
 - 1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
 - a. The calibrating standard shall be of better accuracy than that of the equipment tested.
 - 2. The accuracy shall be traceable to the NIST in an unbroken chain.
 - 3. Calibrate instruments in accordance with the following frequency schedule:
 - a. Field instruments: 6 months maximum.
 - b. Laboratory instruments: 12 months maximum.
 - c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
 - 4. Dated calibration labels shall be visible on all test equipment.
 - 5. Maintain an up-to-date instrument calibration record for each test instrument:
 - a. The records shall show the date and results of each calibration or test.
 - 6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.
- B. Do not begin testing until the following conditions have been met:
 - 1. All instruments required are available and in proper operating condition.
 - 2. All required dispensable materials such as solvents, rags, and brushes are available.
 - 3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
 - 4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
 - 5. Data sheets to record all test results are available.

3.3 INSTALLATION

- A. Test decal:
 - 1. The testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
 - 2. The test decal shall be color coded to communicate the condition of maintenance of the protective. The color scheme for condition of maintenance of overcurrent protective devices shall be:
 - a. White: electrically and mechanically acceptable.

- b. Yellow; minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
- 3. The decal shall include the following information at a minimum:
 - a. Testing organization.
 - b. Project identifier.
 - c. Test date.
 - d. Technician identifier.

3.4 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.5 REPAIR/RESTORATION (NOT USED)

3.6 RE-INSTALLATION (NOT USED)

3.7 COMMISSIONING

A. Testing and Training Phase: Installation Testing:

1. Also called "Field Acceptance Testing".
2. Panelboards:
 - a. Cleaning:
 - 1) Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.
 - 2) Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents, or detergents when cleaning panelboards or components.
 - 3) Avoid blowing dust into panelboards. Do not use a blower or compressed air.
 - 4) Clean Supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
 - 5) Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
 - b. General:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Check panelboard circuit schedule for accuracy.
 - 3) Verify appropriate anchorage, required area clearances, and correct alignment.
 - 4) Inspect overall general condition for physical damage. Check for broken studs and loose or damaged wires, connector, terminations, etc. Check all bolts, nuts, washer, and pins for tightness. Tighten or use manufacture's replacement parts as required.
 - 5) Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.
 - 6) Check that covers are in place and fastened. Plug any open unused knockouts.
 - 7) Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect all component devices. Replace any components that show evidence of damage from moisture.
 - 8) Look for any recent changes in sprinklers or other plumbing that might expose indoor panelboards to a source of liquids. Eliminate sources of water, moisture, or liquids, or provide adequate barriers to protect panelboards from sources of water, moisture, or liquids.
 - 9) Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking. Investigate and correct sources of

- arcing or overheating. Consult the panelboard manufacturer for recommendations.
 - 10) Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breakers address for microprocessor communications packages, if equipped.
 - 11) Set adjustable circuit breakers in accordance with engineering coordination study supplied by Owner.
- c. Terminations, Connections, and Lugs:
 - 1) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - (1) Compare bolted connection resistance values to values of similar connections:
 - (a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 2) Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
 - 3) Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
 - 4) Replace overheated connections. Tighten connections to proper to proper torque levels as specified above.
- d. Conductors and raceways:
 - 1) Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
 - 2) Ensure the conductors are protected within their ampacities.
 - 3) Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
 - 4) Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with manufacturer's recommendations.
 - 5) Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.
 - 6) Inspect for frayed or broken wires. Replace or repair conductors as necessary.
 - 7) Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.
- e. Circuit breakers:
 - 1) Breakers rated less than 100 A:
 - a) Operate circuit breakers several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
 - b) Visually check circuit breakers for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
 - c) Check circuit breakers for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
 - d) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.
 - e) Inspect interchangeable trip-unit circuit breakers for tightness of trip units.

- f) Check circuit breaker terminals and connections for tightness as specified above.
 - 2) Breakers rated 100 A and higher:
 - a) Perform visual and mechanical inspection as specified in this Section.
 - b) Perform electrical tests as specified in this Section.
- 3. Dry type transformers:
 - a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify that resilient mounts are free and that any shipping brackets have been removed.
 - 5) Inspect equipment for cleanliness.
 - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 7) Verify that as-left tap connections are as specified.
 - b. Electrical tests:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
 - a) Apply voltage in accordance with manufacturer's published data.
 - (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Calculate dielectric absorption ration or polarization index.
 - 4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
 - c. Test values:
 - 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Tap connections are left as found unless otherwise specified.
 - 4) Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - b) Investigate insulation values less than the allowable minimum.
 - 5) The dielectric absorption ratio or polarization index shall not be less than 1.0.
 - 6) Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
 - 7) Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.
- 4. Low voltage cables, 600 volt maximum:
 - a. Visual and mechanical inspection:
 - 1) Compare cable data with the Drawings and Specifications.

- 2) Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
- 3) Inspect bolted electrical connections for high resistance by one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- 4) Inspect compression applied connectors for correct cable match and indentation.
- 5) Inspect for correct identification and arrangement.
- 6) Inspect cable jacket insulation and condition.
- b. Electrical tests:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:
 - a) Applied potential shall be 500 volts dc for 300 volt rated cable and 1,000 volts dc for 600 volt rated cable.
 - b) Test duration shall be 1 minute.
 - 3) Perform continuity tests to insure correct cable connection.
 - 4) Verify uniform resistance of parallel conductors.
- c. Test values:
 - 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Insulation-resistance values shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - b) Investigate values of insulation-resistance less than the allowable minimum.
 - 3) Cable shall exhibit continuity.
 - 4) Deviations in resistance between parallel conductors shall be investigated.
5. Low voltage molded case and insulated case circuit breakers:
 - a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage and alignment.
 - 4) Verify the unit is clean.
 - 5) Operate the circuit breaker to ensure smooth operation.
 - 6) Inspect bolted electrical connections for high resistance by one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 7) Perform adjustments for final protective device settings in accordance with the coordination study.
 - b. Electrical tests:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.

- 2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
 - a) Apply voltage in accordance with manufacturer's published data.
 - b) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Perform a contact/pole-resistance test.
 - 4) Determine long-time pickup and delay by primary current injection.
 - 5) Determine short-time pickup and delay by primary current injection.
 - 6) Determine ground-fault pickup and delay by primary current injection.
 - 7) Determine instantaneous pickup value by primary current injection.
 - 8) Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
 - 9) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
 - a) Reset all trip logs and indicators.
 - 10) Verify operation of charging mechanism.
- c. Test values:
- 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - b) Investigate values of insulation-resistance less than the allowable minimum.
 - 4) Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
 - a) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
 - 5) Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
 - a) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
 - 6) Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
 - 7) Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
 - 8) Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 9) Pickup values and trip characteristics shall be within manufacturer's published tolerances.
 - 10) Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.

- 11) The charging mechanism shall operate in accordance with manufacturer's published data.
6. Instrument transformers - current transformers:
 - a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Verify correct connection of transformers with system requirements.
 - 4) Verify that adequate clearances exist between primary and secondary circuit wiring.
 - 5) Verify the unit is clean.
 - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 7) Verify that all required grounding and shorting connections provide contact.
 - 8) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - b. Electrical tests:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
 - a) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - 3) Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
 - 4) Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
 - 5) Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
 - 6) Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
 - 7) When applicable perform insulation-resistance tests on the primary winding with the secondary grounded:
 - a) Test voltages shall be in accordance with NETA ATS tables.
 - 8) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
 - 9) Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
 - a) That grounding point should be located as specified by the Engineer in the Contract Documents.
 - c. Test values:
 - 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:

- a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 4) Polarity results shall agree with transformer markings.
 - 5) Ratio errors shall be in accordance with IEEE C57.13.
 - 6) Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
 - 7) Measured burdens shall be compared to instrument transformer ratings.
 - 8) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
 - 9) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
 - a) In the absence of the manufacturer's published data, use the test equipment manufacturer's published data.
 - 10) Test results shall indicate that the circuits have only 1 grounding point.
- 7. Instrument transformers - voltage transformers:
 - a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Verify correct connection of transformers with system requirements.
 - 4) Verify that adequate clearances exist between primary and secondary circuit wiring.
 - 5) Verify the unit is clean.
 - 6) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 7) Verify that all required grounding and connections provide contact.
 - 8) Verify correct primary and secondary fuse sizes for voltage transformers.
 - 9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - 10) Perform as-left tests.
 - b. Electrical tests - voltage transformers:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform insulation-resistance tests winding-to-winding and winding-to-ground:
 - a) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.
 - b) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - 3) Perform a polarity test on each voltage transformer to verify the polarity marks on H₁- X₁ relationship as applicable.
 - 4) Perform a turns ratio test on all tap positions.
 - 5) Measure voltage circuit burdens at transformer terminals.
 - 6) Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
 - a) The dielectric voltage shall be in accordance with NETA ATS tables.
 - b) Apply the test voltage for 1 minute.
 - 7) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturers published data.
 - 8) Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:

- a) That grounding point should be located as specified by the Engineer in the Contract Documents.
 - c. Test values:
 - 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 4) Polarity results shall agree with transformer markings.
 - 5) Ratio errors shall be in accordance with IEEE C57.13.
 - 6) Measured burdens shall be compared to instrument transformer ratings.
 - 7) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary winding is considered to have passed the test.
 - 8) Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
 - a) In the absence of the manufacturer's published data, use the test equipment manufacturer's published data.
 - 9) Test results shall indicate that the circuits have only 1 grounding point.
- 8. Metering devices, microprocessor based:
 - a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Inspect meters and cases for physical damage.
 - 3) Clean front panel.
 - 4) Verify tightness of electrical connections.
 - 5) Record the following:
 - a) Model number.
 - b) Serial number.
 - c) Firmware revision.
 - d) Software revision.
 - e) Rated control voltage.
 - 6) Verify operation of display and indicating devices.
 - 7) Record passwords.
 - 8) Verify the unit is grounded in accordance with the manufacturer's instructions.
 - 9) Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.
 - b. Electrical tests:
 - 1) Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
 - 2) Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital and analog.
 - 3) After initial system energization, confirm measurements and indications are consistent with loads present.
 - c. Test values:
 - 1) Nameplate data shall match the Contract Documents.
 - 2) Tightness of electrical connections shall ensure a low resistance connection.

- 3) Display and indicating devices shall operate per manufacturer's published data.
 - 4) Measurement and indication of applied voltages and currents shall be within the manufacturer's published tolerances for accuracy.
 - 5) All auxiliary input/output features shall operate per settings and manufacturer's published data.
 - 6) Measure and indications shall be consistent with energized system loads.
9. Grounding systems:
- a. Visual and mechanical inspection:
 - 1) Inspect ground system for compliance with the Contract Documents, and the NEC.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 4) Inspect anchorage.
 - b. Electrical tests:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
 - 3) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
 - c. Test values:
 - 1) Grounding system electrical and mechanical connections shall be free of corrosion.
 - 2) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 3) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 4) The resistance between the main grounding electrode and ground shall be as specified in the Grounding and Bonding section.
 - 5) Investigate point-to-point resistance values that exceed 0.5 ohm.
10. Rotating machinery, ac induction motors and generators:
- a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate information with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging
 - 5) Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

- 6) Verify correct application of appropriate lubrication and lubrication systems.
- 7) Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.
- b. Electrical tests - AC Induction:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform insulation-resistance test in accordance with IEEE 43:
 - a) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio for 60/30 second periods.
 - b) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
 - 3) On machines rated at 2,300 volts and greater, perform dielectric withstand voltage tests in accordance with:
 - a) IEEE 95 for dc dielectric withstand voltage tests.
 - b) NEMA MG1 for ac dielectric withstand voltage tests.
 - 4) Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
 - 5) Perform insulation-resistance test on insulated bearings in accordance with manufacturer's published data.
 - 6) Test surge protection devices as specified in this Section.
 - 7) Test motor starter as specified in this Section.
 - 8) Perform resistance tests on resistance temperature detector (RTD) circuits.
 - 9) Verify operation of motor space heater, if applicable.
- c. Test values:
 - 1) Inspection:
 - a) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
 - b) Filter media shall be clean and installed in accordance with the manufacturer's published data.
 - c) Cooling fans shall operate.
 - d) Slip ring alignment shall be within manufacturer's published tolerances.
 - e) Brush alignment shall be within manufacturer's published tolerances.
 - f) Brush rigging shall be within manufacturer's published tolerances.
 - 2) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 3) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 4) Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.
 - 5) The recommended minimum insulation-resistance ($IR_{1 \text{ min}}$) test results in megohms shall be in accordance with NETA ATS tables.
 - a) The polarization index value shall not be less than 2.0.
 - b) The dielectric absorption ratio shall not be less than 1.4.
 - 6) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
 - 7) Investigate phase-to-phase stator resistance values that deviate by more than 5 percent.
 - 8) Power factor or dissipation factor values shall be compared to manufacturer's published data:

- a) In the absence of manufacturer's published data, compare values of similar machines.
 - 9) Tip-up values shall indicate no significant increase in power factor.
 - 10) If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
 - 11) Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
 - a) In the absence of manufacturer's published data, compare values of similar machines.
 - 12) Test results of surge protection devices shall be as specified in this Section.
 - 13) Test results of motor starter equipment shall be as specified in this Section.
 - 14) RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
 - 15) Heaters shall be operational.
 - 16) Vibration amplitudes of the uncoupled and unloaded machine shall be in accordance with manufacturer's published data:
 - a) In the absence of manufacturer's published data, vibration amplitudes shall not exceed values in NETA ATS tables.
 - b) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.
- 11. Motor starters, low voltage:
 - a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate information with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify the unit is clean.
 - 5) Inspect contactors:
 - a) Verify mechanical operation.
 - b) Verify contact gap, wipe, alignment, and pressure is in accordance with manufacturer's published data.
 - 6) Motor-running protection:
 - a) Verify overload element rating/motor protection settings are correct for its application.
 - b) If motor running protection is provided by fuses, verify correct fuse rating.
 - 7) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 8) Lubrication requirements:
 - a) Verify appropriate lubrication on moving current-carrying parts.
 - b) Verify appropriate lubrication on moving and sliding surfaces.
 - b. Electrical tests:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
 - a) Test voltage shall be in accordance with manufacturer's published data.
 - b) Refer to NETA ATS tables in the absence of manufacturer's published data.

- 3) Test motor protection devices in accordance with manufacturer's published data.
- 4) Test circuit breakers as specified in this Section.
- 5) Perform operational tests by initiating control devices.
- c. Test values:
 - 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - b) Investigate values of insulation-resistance less than the allowable minimum.
 - 4) Motor protection parameters shall be in accordance with manufacturer's published data.
 - 5) Circuit breaker test results shall as specified in this Section.
 - 6) Control devices shall perform in accordance with system design requirements.
12. Motor control centers, low voltage:
 - a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, grounding and required clearances.
 - 4) Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
 - 5) Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and the coordination study.
 - 6) Verify that current and voltage transformer ratios correspond to those indicated on the Drawings.
 - 7) Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.
 - 8) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 9) Verify operation and sequencing of interlocking systems:
 - a) Attempt closure on locked-open devices.
 - b) Attempt to open locked-closed devices.
 - c) Make/attempt key-exchanges in all positions.
 - 10) Lubrication requirements:
 - a) Verify appropriate lubrication on moving current-carrying parts.
 - b) Verify appropriate lubrication on moving and sliding surfaces.
 - 11) Inspect insulators for evidence of physical damage or contaminated surfaces.
 - 12) Verify correct barrier and shutter installation and operation.
 - 13) Exercise all active components.
 - 14) Inspect all indicating devices for correct operation.

- 15) Verify that filters are in place and/or vents are clear.
 - 16) Perform visual and mechanical inspection of instrument transformers as specified in this Section.
 - 17) Perform visual and mechanical inspection of surge arresters as specified in this Section.
 - 18) Inspect control power transformers:
 - a) Inspect for physical damage, cracked insulation, broken leads, and tightness of connections, defective wiring, and overall general condition.
 - b) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
 - c) Verify correction functioning of grounding contacts.
 - 19) Perform visual and mechanical inspection of all motor control center components as specified in this Section.
- b. Electrical tests:
- 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
 - a) Perform test in accordance with NETA ATS tables.
 - 3) Perform an dielectric withstand test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
 - 4) Perform ground-resistance tests:
 - a) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
 - 5) Control power transformers:
 - a) Perform insulation-resistance tests, winding-to-winding and winding-to-ground:
 - (1) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
 - b) Perform secondary wiring integrity test:
 - (1) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
 - (a) Verify correct potential at all devices.
 - c) Verify correct secondary voltage by energizing primary winding with system voltage:
 - (1) Measure secondary voltage with the secondary wiring disconnected.
 - 6) Verify operation of space heaters.
 - 7) Perform electrical tests of all motor control center components as specified in this Section.
- c. Test values:
- 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer's published data:

- a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - b) Investigate insulation values less than the allowable minimum.
 - c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - 4) Bus insulation shall withstand the over potential test voltage applied.
 - 5) Instrument transformer test values shall be as specified in this Section.
 - 6) Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
 - 7) Meter accuracy shall be in accordance with manufacturer's published data.
 - 8) Control power transformers:
 - a) Insulation-resistance values of control power transformers shall be in accordance with manufacturer's published data:
 - (1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - (2) Investigate insulation values less than the allowable minimum.
 - (3) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - b) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
 - c) Secondary voltage shall be as indicated on the Drawings.
 - 9) Heaters shall be operational.
 - 10) Test values for motor control center components shall be as specified in this Section.
13. Variable frequency drive systems:
- a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify the unit is clean.
 - 5) Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
 - 6) Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
 - 7) Motor running protection:
 - a) Verify drive overcurrent setpoints are correct for their application.
 - b) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
 - c) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
 - 8) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 9) Verify correct fuse sizing in accordance with manufacturer's published data.
 - 10) Perform visual and mechanical inspection of input circuit breaker as specified in this Section.
 - b. Electrical tests:
 - 1) Perform resistance measurements through bolted connections with low resistance ohmmeter.
 - 2) Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.

- 3) Test for the following parameters in accordance with relay calibration procedures specified in NETA ATS or as recommended by the manufacturer:
 - a) Input phase loss protection.
 - b) Input overvoltage protection.
 - c) Output phase rotation.
 - d) Overtemperature protection.
 - e) Direct current overvoltage protection.
 - f) Overfrequency protection.
 - g) Drive overload protection.
 - h) Fault alarm outputs.
- 4) Perform continuity tests on bonding conductors as specified in accordance with NETA ATS.
- 5) Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
- 6) Perform operational tests by initiating control devices:
 - a) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
 - b) Verify operation of drive from remote start/stop and speed control signals.
- 7) Perform electrical tests of input circuit breaker as specified in this Section.
- 8) Measure fuse resistance.
- c. Test values:
 - 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
 - 4) Test values for input circuit breaker shall be as specified in this Section.
 - 5) Relay calibration results shall be as specified in this Section.
 - 6) Continuity of bonding conductors shall be in accordance with NETA ATS.
 - 7) Control devices shall perform in accordance with system requirements.
 - 8) Operational tests shall conform to system design requirements.
 - 9) Investigate fuse resistance values that deviate from each other by more than 15 percent.
14. Surge arresters, low-voltage:
 - a. Visual and mechanical inspection:
 - 1) Compare equipment nameplate data with the Contract Documents.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, grounding, and clearances.
 - 4) Verify the arresters are clean.
 - 5) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter.
 - b) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - (1) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - 6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

- 7) Verify that stroke counter is correctly mounted and electrically connected, if applicable.
 - 8) Record stroke counter reading.
 - b. Electrical tests:
 - 1) Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - 2) Perform an insulation-resistance test on each arrester, phase terminal- to- ground:
 - a) Apply voltage in accordance with manufacturers published data.
 - b) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Test grounding connection as specified in this Section.
 - c. Test values:
 - 1) Compare bolted connection resistance values to values of similar connections:
 - a) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 3) Insulation-resistance values shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - b) Investigate insulation values less than the allowable minimum.
 - 4) Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
15. Fiber-optic cables:
- a. Visual and mechanical inspection:
 - 1) Compare cable, connector, and splice data with the Contract Documents.
 - 2) Inspect cable and connections for physical and mechanical damage.
 - 3) Verify that all connectors and splices are correctly installed.
 - b. Optical tests:
 - 1) Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
 - a) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
 - b) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
 - 2) Perform connector and splice integrity test using an optical time domain reflectometer.
 - 3) Perform cable attenuation loss measurement with an optical power loss test set:
 - a) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
 - b) Test multimode fibers at 850 nanometer and 1,300 nanometer.
 - c) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
 - 4) Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
 - a) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.

- 5) Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
 - a) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.
 - b) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.
- c. Test values:
 - 1) Cable and connections shall not have been subjected to physical or mechanical damage.
 - 2) Connectors and splices shall be installed in accordance with industry standards.
 - 3) The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
 - 4) Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
 - 5) Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

3.8 FIELD QUALITY CONTROL (NOT USED)

3.9 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in the Common Work Results for Electrical section.
- B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.11 PROTECTION

- A. As specified in the Common Work Results for Electrical section.

3.12 SCHEDULES (NOT USED)

END OF SECTION