SECTION 26 05 02

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: General requirements for providing basic electrical materials and methods.

B. Related Work Specified in Other Sections Includes:
1. Certain items of equipment, and various control devices including conduit and wiring which are indicated on electrical drawings to be connected, but are specified in other sections pertaining to plumbing, heating, ventilating, air conditioning, temperature control systems, process equipment, process control systems, and instrumentation. Install and connect these items to the electrical system as indicated or required in accordance with the Contract Documents.

C. Overall Application of Specifications: This Section applies to all sections of Division 26 and to other sections that include electrical equipment requirements except when in these individual sections requirements are otherwise specified to provide and install all materials necessary for a complete operational system.

D. Temporary Requirements: This Section applies to any temporary circuits, overcurrent devices, conduit, wiring, and other equipment required during changeover from existing to a new electrical system. This Section also applies to temporary rewiring of lighting and power circuits, instruments and devices.

1.02 DEFINITIONS

A. Hazardous Areas: Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502 and 503. Hazardous areas as defined by the NEC as Class I, Division 1, Group D, or Class I, Division 2, Group D; hazardous areas as follows:
1. Class 1, Division 1, Group D
   a. Wet Wells
   b. Pretreatment
2. Class 1, Division 2, Group D
   a. Pump Rooms and Dry Well
   b. Odor control

1.03 SYSTEM DESCRIPTION

A. Design Requirements: Design requirements are specified in the applicable sections.

B. Performance Requirements: Performance requirements are specified in the applicable sections.

1.04 SUBMITTALS

A. General: Provide submittals for all electrical material and devices. Including the following:

1. Submit Technical Information Brochures at start of construction or within 30 days after Award of the Contract. Each brochure shall consists of an adequately sized, hard-cover, 3-ring binder for 8-1/2" X 11" sheets. Provide correct designation on outside cover and on end of brochure. When, in the judgment of the Engineer, one binder is not enough to adequately catalog all data, an additional binder will be required and data split as directed by the Engineer. Specific shop drawing submittals may be submitted separately after technical information brochures but before any equipment is purchased; provide index and schedule of shop drawings to be submitted within the technical information brochures.
2. First sheet in the brochure shall be a photocopy of the Electrical Index pages in these specifications. Second sheet shall be prepared by the Contractor, and shall list Project Addresses and phone numbers with key personnel for this project.
3. Provide reinforced separation sheets tabbed with the appropriate specification reference number.
4. The General Contractor shall review the brochures before submitting to the Engineer. No request for payment will be considered until the brochure has been submitted and reviewed completely.
5. Submit cost breakdown "Schedule of Values" for electrical work in the Technical Information Brochures. Cost of material and labor for each major item shall be shown.
6. Acceptance: When returned to Contractor, submittals will be marked with Engineer's stamp. If box marked "returned for correction resubmit" is checked, submittal is not approved and Contractor is to correct and resubmit as noted, otherwise submittal is approved and Contractor is to comply with notation making necessary corrections on submittal and resubmit for final record.
7. Note that the approval of shop drawings, or other information submitted in accordance with the requirements hereinbefore specified, does not assure that the Engineer, or any other Owner's Representative, attests to the dimensional accuracy or dimensional suitability of the material or equipment involved, the ability of the material or equipment involved or the Mechanical/Electrical performance of equipment. Approval of shop drawings does not invalidate the plans and specifications if in conflict with the submittal. It is the contractor’s responsibility to request in writing and seek written approval from the engineer for all deviations of the plans and specifications.

B Product Data and Information: Provide complete list of electrical equipment and materials to be furnished showing manufacturer, catalog number, size, type, voltage rating and other pertinent information.

1. Provide catalog data on manufacturer's standard equipment and materials. Clearly indicate on catalog cuts the equipment and devices being proposed.
2. Identification: Provide complete schedule and listing of system and equipment identification labels with legends.

3. Material shall not be ordered or shipped until the shop drawings have been approved.
4. The Engineer's shop drawing review shall be for conformance with the design concept of the project and compliance with the Specifications and the Drawings. Errors and omissions on approved shop drawings shall not relieve the Contractor from the responsibility of providing materials and workmanship required by the Specifications and the Drawings.
5. Shop drawings shall be stamped with the date checked by the contractor and a statement indicating that the shop drawings conform to the Specifications and the Drawings. This statement shall also list all exceptions to the Specifications and the Drawings. Shop drawings not so checked and noted shall be returned.

C. CONTRACTOR's Shop Drawings: Provide shop drawings on items manufactured for the Contract.
1. Provide connection diagram and schematic for each piece of electrical equipment. A manufacturer's standard connection diagram or schematic showing more than one method of connection is not acceptable unless it is clearly marked to show the intended method of connection.
2. Provide diagrams showing connections to field equipment. Clearly differentiate between manufacturer's wiring and field wiring.
3. Provide raceway layout drawings showing conduits, boxes, and panels which contain the conductors to be provided. Include schedules listing conduit sizes and conductor content and identification.
4. Where additions and modifications are made to existing equipment, provide drawings which include both retained existing equipment and new Work.

D. Coordination Drawings: Prepare to scale coordination drawings (1/4"=1'-0"); detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including but not necessarily limited to the following:
1. Indicate the proposed locations of major raceway systems, equipment, and materials. All dimensions shall be field verified at the job site and coordinated with the work of all other trades. Include the following:
   a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
   b. Exterior wall and foundation penetrations.
   c. Fire-rated wall and floor penetrations.
   d. Equipment connections and support details.
   e. Sizes and location of required concrete pads and bases.

2. Record Documents: Prepare record documents, and in addition to the requirements specified in Division 1. As the work progresses, legibly record all field changes on a set of Project Contract Drawings, (the "Record Drawings"). Indicate installed conditions for:
   a. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch

electrical circuitry; and fuse and circuit breaker size and arrangements.

b. Equipment locations (exposed and concealed), dimensioned from prominent building lines.

c. Approved substitutions, and actual equipment and materials installed.

d. Record Drawings shall accurately show the installed condition of the following items: Power Riser Diagram(s). Equipment elevations (front views). Raceways and pullboxes. Conductor sizes and conduit fills. Control Wiring Diagram(s). Underground raceway and duct bank routing. Plan view, sizes and locations of distribution transformers and outdoor electrical equipment enclosure.

e. Submit a schedule of control wiring raceways and wire numbers, including the following information: Circuit origin, destination and wire numbers. Field wiring terminal strip names and numbers.

f. In addition to the schedule, provide point to point connection diagrams showing the same information submitted in the schedule of control wiring raceways including all designations and wire numbers. Comply with PLC tag designation on all instrumentation and control cabling in and out of PLC racks.

g. The schedule of control wiring raceways and wire numbers and the point to point connection diagrams shall be in electronic Autocad and Word format (i.e. no hand-written or drawn schedules, drawings, or diagrams will be accepted)

E. Operation and Maintenance Manuals: Prepare operation and maintenance manuals, and in addition to the requirements specified in other Divisions, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and catalog numbers of replacement parts. Complete parts list with stock numbers, including spare parts. A complete bill of material supplied, including serial numbers, ranges and pertinent data.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. A comprehensive index.
5. A complete "As Built" set of approved shop drawings.
6. A table listing of the "as left" settings for all timing relays and alarm and trip setpoints. A complete listing of As left programmable parameters for all drives, soft-starters and other microprocessor controlled equipment.
7. System schematic drawings "As Built", illustrating all components, piping and electric connections of the systems supplied under this Section.

1.05 QUALITY ASSURANCE

A. Codes: Provide all electrical Work in accordance with applicable local codes, regulations and ordinances. If there is a conflict between the requirements specified in the Contract Documents and the codes, follow the more stringent requirements as determined and approved.

B. Testing: As a minimum, provide standard factory and field tests for each type of equipment. Other tests may be specified in the applicable equipment section.

C. Labeling: Provide all electrical equipment and materials listed and approved by Underwriters Laboratories with the UL label or other OSHA recognized testing laboratories attached to it.

D. Standard Products: Unless otherwise indicated, provide electrical materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest standard design that conforms to these Specifications. When two or more units of the same class of material and equipment are required, provide the products of the same manufacturer.

1.06 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 1 and as follows:

B. Shipping and Packing: Provide materials and equipment suitably boxed, crated or otherwise completely enclosed and protected during shipment, handling, and storage. Clearly label such boxes, crates or enclosures with manufacturer's name, and name of material or equipment enclosed.

C. Acceptance at Site: Conform to acceptance requirements as required in Division 1. Repair or replace all materials and equipment damaged by handling and storage as directed at no additional Contract cost.

D. Storage and Protection: Protect materials and equipment from exposure to the elements and keep them dry at all times. Handle and store to prevent damage and deterioration in accordance with manufacturer's recommendations.

1.07 PROJECT CONDITIONS

A. General: The Drawings indicate the extent and general arrangement of the principal electrical elements, outlets and circuit layouts. Connect and install all electrical elements and devices to form a workable system as required by the Contract Documents whether the connections and installations are specifically stated in the Specifications or shown. Provide necessary materials and installation wherever required to conform to the specific requirements of the furnished equipment and for proper installation of the Work.

B. Schematics: In general the runs of feeders are shown schematically and are not intended to show exact routing and locations of raceways. Verify actual and final

arrangement, equipment locations, and prepare circuit and raceway layouts before ordering materials and equipment. Equipment locations are approximate and are subject to modifications as determined by equipment dimensions.

C. Coordination of Work: Coordinate the Work so that the electrical equipment may be installed without altering building components, other equipment or installations.

D. Coordinate arrangement, mounting, and support of electrical equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow the right of way for piping and conduit installed at the required slope.
   4. To clear connecting raceways, cables, wireways, cable trays, and busways of obstructions and of the working and access space of other equipment.

E. Coordinate the installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

F. Coordinate electrical testing of electrical, mechanical, and architectural items, so that functionally interdependent equipment and systems demonstrate successful interoperability.

G. Departure from Design: If departures are deemed necessary due to structural conditions, obstructions or other problems, provide details of such departures and the reasons for requesting approval as soon as practicable but not later than the submittal of the raceway layout drawings. Do not make any departures without written approval.

PART 2 – PRODUCTS

2.01 FLOOR MATING

A. Provide rubber insulation mats on floor in front of electrical equipment extending 18” beyond. Mats to be minimum 3 feet wide or equal to isle width. Provide OSHA approved insulating mats meeting OSHA regulation 1910.137 with 30,000 volt insulating strength (Matworks or equal, 800 336-4604).

PART 3 – EXECUTION

3.01 ROUGH-IN

A. Final Location: Verify final locations for rough-ins with field measurements, vendor shop drawings and with the requirements of the actual equipment to be connected.

B. The Drawings are not intended to show exact locations of conduit runs. Coordinate the conduit installation with other trades and the actual supplied equipment.

C. Install each 3 phase circuit in a separate conduit unless otherwise shown.

D. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Exact locations shall be determined by the Contractor and approved by the Engineer during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

E. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.

F. All floor mounted electrical equipment shall be placed on 4-inch thick (3/4-inch, 45 degree chamfer at all exposed edges) concrete pads, provide reinforcement, anchors, etc.

G. All “LB” type fitting hardware to be stainless steel or brass. All junction box hardware to be aluminum or stainless steel only.

3.02 ELECTRICAL INSTALLATIONS

A. Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
   1. Coordinate electrical systems, equipment, and materials installation with other building components.
   2. Verify all dimensions by field measurements. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.
   3. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.
   4. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
   5. Coordinate the installation of required supporting devices and sleeves to be set in cast-in-place concrete and other structural components, as they are constructed.
   6. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
   7. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
   8. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of

governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

9. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the ENGINEER for resolution.
10. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
11. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
12. Install access panel or doors where units are concealed behind finished surfaces.
13. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

B. Homeruns: Drawings show most homerun circuits to be provided. Do not combine power or control circuits into common raceways without authorization of Engineer. Changes shall be documented on record drawings. Homerun circuits shown on Drawings indicate functional wiring requirements for all circuits. Lighting and receptacle Circuits; no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.

3.03 CUTTING AND PATCHING

A. Perform cutting and patching as specified in Division 1. In addition to the requirements specified in Division 1, the following requirements apply:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
   a. Uncover Work to provide for installation of ill-timed Work.
   b. Remove and replace defective Work.
   c. Remove and replace Work not conforming to requirements of the Contract Documents.
   d. Remove samples of installed Work as specified for testing.
   e. Install equipment and materials in existing structures.
   f. Locate existing structural reinforcing where core drilled penetrations are required so as not to cut the steel reinforcing.
2. Cut, remove, and properly dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work. Deliver all the existing removed to the OWNER as directed.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
6. Patch finished surfaces and building components using new materials as specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

END OF SECTION

SECTION 26 05 11

SPECIAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install complete and make operational, electrical and process instrumentation systems for the Lee County Utilities Department as shown on the Drawings and as specified herein.

B. The work shall include furnishing, installing and testing the equipment and materials specified in other Sections of the Specifications and shown on the Drawings.

C. It is the intent of these Specifications that the electrical system shall be suitable in every way for the service required. All material and all work which may be reasonably implied as being incidental to the work of this Section shall be furnished at no extra cost. The work shall include but not be limited to furnishing and installing the following:

1. New electrical service including coordination with utility company.
2. Stand-by power generator set in skin tight enclosure with sub-base fuel tank and FDEP approved fuel level monitoring system.
3. Ductbank systems for power, fiber optic, instrumentation and control signal distribution.
4. Conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions of these specifications.
5. Conduit, wiring and terminations for all field-mounted instruments furnished under other Divisions of these specifications, including process instrumentation primary elements, transmitters, local indicators and control panels. Lightning and surge protection equipment wiring at process instrumentation transmitters.
6. Install vendor furnished cables specified under other Divisions of these specifications.
7. Pre-wired pre-fabricated electrical equipment enclosure at Master Pump Station sites.
8. A complete raceway system for the Data Network Cables and specialty cable systems. Install the Data Network Cables and other specialty cable systems furnished under other divisions in accordance with system integrator and the system manufacturers' installation instructions. Review the raceway layout, prior to installation, with the system integrator and the cable manufacturer to ensure raceway compatibility with the systems and materials being furnished.
9. Complete grounding system and special grounds as required or noted.
10. Power and signal surge suppression systems.
11. Concrete work for pad mounted equipment.
12. Instrumentation and control conduit and wiring systems and installation of field instrumentation.
13. Arc Flash evaluation, short circuit and coordination study and electrical testing of equipment including SKM file of approved studies.
14. Lightning protection, bonding and grounding systems.

15. Electronic and hard copy project record drawings, vendor operation and maintenance manuals.
16. Furnish and install field instrumentation termination cabinets, mounting stands and sunshields.
17. Custom Control panels.
18. Shipping of the complete a/c units to Corrosion Solutions Inc. for factory installation of "heresite" corrosion protective coating.
19. Fiber optic cable termination and interconnecting wiring between fiber patch panel and network switches in the electrical equipment enclosure.
20. Lee County Utilities will self-perform work required to update SCADA servers at College Parkway for new pump station.

D. Each bidder or their authorized representatives shall, before preparing their proposal, visit all areas of the existing site and structures in which work under this Division is to be performed and inspect carefully the present installation. The submission of the proposal by this bidder shall be considered evidence that their representative has visited the site and structures and noted the locations and conditions under which the work will be performed and that the bidder takes full responsibility for a complete knowledge of all factors governing the work.

E. Field verify all existing underground electrical and mechanical piping.

F. The Contractor shall prepare and furnish electrical and instrumentation conduit layout shop drawings for yard electrical, within and under all roads, buildings and structures to the Engineer for approval prior to commencing work. Layouts shall include but not be limited to equipment, pull boxes, conduit routing, dimensioning, methods and locations of supports, reinforcing, encasement, materials, conduit sizing, equipment access, potential conflicts, building and yard lighting, and all other pertinent technical specifications for all electrical and instrumentation conduits and equipment to be furnished. All layouts shall be drawn to scale on 22 x 34 sheets

G. The work shall include complete testing of all equipment and wiring at the completion of work and making any minor correction changes or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

H. A single manufacturer shall provide variable frequency drives, panelboards, main breakers, transformers, disconnect switches, etc.

I. Contractor shall provide their own temporary power for miscellaneous power (drills, pumps, etc.). No facility circuits shall be used unless approved by the engineer. Any temporary added shall be removed at job completion.

J. Complete coordination with other contractors. Contractor shall coordinate with all other contractor’s equipment submittals and obtain all relevant submittals.

K. Mount transmitters, process instruments, operator’s stations, etc. furnished under other Divisions of these specifications.

L. Concrete electrical duct encasement, including but not limited to excavation, concrete, conduit, reinforcement, backfilling, grading and seeding is included.

Excavation, bedding material, forms, concrete and backfill for underground raceways; forms and concrete for electrical equipment furnished herein is included in this Division.

1.02 MASTER PUMP STATION QUALIFICATIONS

A. The electrical contractor shall have regularly engaged in the installation of industrial electrical power systems for a minimum period of fifteen (15) years. When requested by the engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. Provide a field superintendent who has had a minimum of fifteen (15) years previous successful experience on projects of comparable size and complexity. Superintendent shall be present at all times that work under this Division is being installed or affected. A resume of the Superintendent's experience shall be submitted to Engineer before starting work.

C. Provide the services of a Lee County Utilities pre-qualified electrical contractor that has demonstrated competence in providing electrical systems installation on this type of facility. The pre-approved electrical contractors for this project qualified through the RFQ process. This list can be found on the Procurement website. Any contractor that is not on the list will have to go through the same process as the RFQ qualified contractors.

1.03 LIFT STATION QUALIFICATIONS

A. The electrical contractor shall have regularly engaged in the installation of industrial electrical power systems for a minimum period of fifteen (15) years. When requested by the engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

B. Provide a field superintendent who has had a minimum of six (6) years previous successful experience on projects of comparable size and complexity.

C. Provide the services of a pre-qualified electrical contractor that has demonstrated competence in providing electrical systems installation on this type of facility to Lee County Utilities.

1.04 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
   2. National Electrical Manufacturers Association (NEMA):
   3. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   4. Z535.4, Product Safety Signs and Labels.
   5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   6. National Fire Protection Association (NFPA): 70E.
   7. Underwriters Laboratories, Inc. (UL).

1.05 RELATED WORK

A. Excavation and backfilling, including gravel or sand bedding for underground electrical work is specified in other Divisions.

B. Cast in place concrete work, including concrete encasements for electrical duct banks, equipment pads, and reinforcing steel, is specified in other Divisions.

1.06 REFERENCE STANDARDS

A. Electric equipment, materials and installation shall comply with the latest edition of National Electrical Code (NEC) and with the latest edition of the following codes and standards:
   1. National Electrical Safety Code (NESC)
   2. Occupational Safety and Health Administration (OSHA)
   3. National Fire Protection Association (NFPA)
   4. National Electrical Manufacturers Association (NEMA)
   5. American National Standards Institute (ANSI)
   6. Insulated Cable Engineers Association (ICEA)
   7. Instrument Society of America (ISA)
   8. Underwriters Laboratories (UL)
   9. Factory Mutual (FM)
   10. International Electrical Testing Association (NETA)
   11. Institute of Electrical and Electronic Engineers (IEEE)
   12. American Society for Testing and Materials (ASTM)
   13. Electrical Safety in the Workplace (NFPA70E)
   14. State and Local Codes and Ordinances

B. All electrical equipment and materials shall be listed by Underwriter's Laboratories, Inc., and shall bear the appropriate UL listing mark or classification marking. Equipment, materials, etc. utilized not bearing a UL certification shall be field or factory UL certified prior to equipment acceptance and use. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.07 ENCLOSURE TYPES

A. Unless otherwise specified herein or shown on the Drawings, electrical enclosures shall have the following ratings:
   1. NEMA 1 for dry, non-process indoor locations.
   2. NEMA 12 for "DUST" locations.
   3. NEMA 4X 316 SS powder coated white with continuous hinge, 3 point latch, screw down door clamps for all outdoor locations, rooms below grade (buried vaults), "DAMP" and "WET" locations.
   4. NEMA 4X 316 SS powder coated white with continuous hinge, 3 point latch, screw down door clamps for "CORROSIVE" locations.
   5. NEMA 7 (and listed for use in the area classifications shown) for "Class I Division 1 Group D", "Class I Division 2 Group D" and "Class II Division 1" hazardous locations shown on the Drawings.

B. Unless otherwise specified herein or shown on the Drawings, junction boxes shall have the following ratings:
   1. NEMA rating as applicable and specified above.
   2. Have continuous hinge with quick connect door clamp. Flush mounted screw down fronts are not acceptable.

1.08 CODES, INSPECTION AND FEES

A. Equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction. Completed electrical installation shall be inspected and certified by all applicable agencies that it is in compliance with all codes.

B. Obtain all necessary permits and pay all fees required for permits and inspections.

1.09 TESTS AND SETTINGS

A. Test systems and equipment furnished under Division 26 and other divisions supplying electrical equipment. Repair or replace all defective work and equipment. Refer to section 26 08 00, Acceptance Testing and Performance Verification and the individual sections, the following minimum tests and setting shall be performed. Submit test reports upon completion of testing in accordance with Section 26 08 00, Acceptance Testing and Performance Verification.

B. Make adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.

C. The following minimum tests and settings shall be performed.
   1. Mechanical inspection, testing and settings of circuit breakers, disconnect switches, motor starters, overload relays, control circuits and equipment for proper operation.
   2. Check the full load current draw of each motor. Where power factor correction capacitors are provided the capacitor shall be in the circuit at the time of the measurement. Check ampere rating of thermal overloads for motors and submit a typed record to the Engineer of the same, including driven load designation, motor service factor, horsepower, and Code letter. If incorrect thermal overloads are installed replace same with the correct size overload.
   3. Check power and control power fuse ratings. Replace fuses if they are found to be of the incorrect size.
   4. Check settings of the motor circuit protectors. Adjust settings to lowest setting that will allow the motor to be started when under load conditions.
   5. Check motor nameplates for correct phase and voltage. Check bearings for proper lubrication.
   6. Check rotation of motors prior to testing the driven load. Disconnect the driven equipment if damage could occur due to wrong rotation. If the rotation is incorrect for the driven equipment correct motor connections at the motor terminal box.
   7. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by control schematic and wiring diagrams.
   8. Inspect each piece of equipment in areas designated as HAZARDOUS to

ensure that equipment of proper rating is installed.

9. Verify all terminations at transformers, equipment, panels and enclosures by producing a 1, 2, 3 rotation on a phase sequenced motor when connected to "A", "B" and "C" phases.
10. Check all wire and cable terminations. Verify to the Engineer connections meet the equipments torque requirements.
11. Field set all transformer taps as required to obtain the proper secondary voltage.
12. Infra-red hot spot inspection shall be made of all electrical equipment including but not limited to switchgear, transformers, switches, power and control panels, etc. This shall be done under representative load conditions before the equipment is used by the Owner.

1.10 PHASE BALANCING

A. The Drawings do not attempt to balance the electrical loads across the phases. Circuits on panelboards shall be field connected to result in evenly balanced loads across all phases.

B. Field balancing of circuits shall not alter the conductor color coding requirements as specified herein.

1.11 EQUIPMENT IDENTIFICATION

A. Identify equipment (disconnect switches, control stations, etc) furnished under Division 26 with the name of the equipment it serves. Control panels, panelboards, main breakers, junction or terminal boxes, etc, shall have nameplate designations as shown on the Drawings. Nameplates shall adequately describe the function of the particular equipment involved. Where nameplates are detailed on the drawings, inscription and size of letters shall be as shown and shop drawing submitted for approval. Nameplates for panelboards and switchboards shall include the panel designation, voltage and phase of the supply. For example, "Panel A, 277/480V, 3-phase, 4-wire". The name of the machine on the nameplates for a particular machine shall be the same as the one used on all motor starters, disconnect and P.B. station nameplates for that machine.

B. Nameplates shall be engraved, laminated plastic, not less than 1/16-in thick by 3/4-in by 2-1/2-in with 3/16-in high white letters on a black background. Attach with brass nuts and bolts.

C. Electrical systems shall be identified at junction and pull boxes, terminal cabinets and equipment racks. Electrical contractor is responsible for nameplates on electrical equipment supplied by other divisions and installed and wired by electrical including all instrumentation and controls equipment. A portion of existing equipment affected by this contract shall also receive nameplates as determined by the Engineer.

D. Nameplates shall be screw mounted to NEMA 1 enclosures. Nameplates shall be bonded to all other enclosure types using an epoxy or similar permanent waterproof adhesive. Two sided foam adhesive tape is not acceptable. Where the equipment size does not have space for mounting a nameplate, the nameplate shall be

permanently fastened to the adjacent mounting surface. Cemented nameplates shall not be drilled.

E. All voltages (e.g. 480 volts, 240 volts, etc.) within pull boxes, junction boxes etc. shall be identified on the front exterior cover. Signs shall be red background with white engraved lettering, lettering shall be a minimum of 1" high.

F. All receptacles, wall switches, lighting fixtures, photo cells, emergency lights, exit lights, etc. shall be identified with the panel and circuit to which it is connected. Identification shall be with machine generated labels with ¼" high letters.

1.12 SAFETY REQUIREMENTS

A. The Contractor shall make every effort to keep all employees and/or subcontractors aware of the danger inherent in working in dangerous proximity to the existing power lines. The minimum recommended precautionary measures are as follows:

1. Make sure that all persons responsible for operating cranes, draglines and other mobile equipment have a copy of, and are familiar with the State Department of Commerce Regulations for Use of Cranes, Draglines and Similar Equipment Near Power Lines, as well as the U.S. Department of Labor OSHA Regulations, before commencing operation of said equipment.
2. Make sure that all cranes, draglines and other mobile equipment have attached to them the black and yellow Department of Commerce warning signs required by the said Regulations of State Department of Commerce.
3. Warn all employees on the ground, new and old employees alike, of the danger of holding on to or touching a cable or other piece of equipment or machinery that is located or working close to any overhead power line.
4. If, during the course of construction, it becomes necessary for the contractor, or subcontractor, and their employees, to operate cranes, draglines, or their mobile equipment, in dangerous proximity of any overhead power lines, or in such a manner that such equipment might come close to any overhead power lines, the Contractor shall give the Power Company or overhead power line owner prior notice of such proposed operation.

1.13 ABBREVIATIONS OR INITIALS USED.

A/C	Air Conditioning
A.C.	Alternating Current
AFF	Above Finished Floor
AFG	Above Finished grade
AHU	Air Handler Unit
AIC	Amps interrupting Capacity
AL	Aluminum
AMP	Ampere
ANSI	American National Standards Institute
ATS	Automatic Transfer Switch
AUX	Auxiliary
AWG	American Wire Gauge
BKR	Breaker
^{o}C	Degrees Centigrade
CAB	Cabinet
C.	Conduit or Conductor

C.B.	Circuit Breaker
CFM	Cubic Feet per Minute
CKT.	Circuit
COND.	Conductor
Conn.	Connection
CP	Control Panel
CPT	Control Power Transformer
CT	Current Transformer
CU.	Copper
DC	Direct Current
Deg.	Degree
Disc.	Disconnect
DO	Draw Out
DPST	Double Pole Single Throw
EMT	Electric Metallic Tubing
E.O.	Electrically Operated
^{o}F	Degrees Fahrenheit
FLA	Full Load Amperes
FHP	Fractional Horsepower
FT.	Feet
FVNR	Full Voltage Non-Reversing
GFI (GFIC)	Ground Fault Interrupting
gnd.(GD.)	Ground
hp.	Horsepower
hr.	Hour
IEEE	Institute of Electrical and Electronic Engineers
in.	Inches
JB	Junction Box
KV	Kilovolt
KVA	Kilo-Volt-Amps
KW	Kilowatts
LCP	Local Control Panel
LED	Light Emitting Diode
max.	Maximum
MCB	Main Circuit Breaker
MCC	Motor Control Center
MCP	Motor Circuit Protector
min.	Minimum
MLO	Main Lugs Only
N.	Neutral
NEC	National Electric Code
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NETA	National Electrical Testing Association
NFPA	National Fire Protection Association
NIC.	Not in Contract
NF	Non Fused
No.	Number
ph	Phase
OCU	Odor Control Unit
OL	Overload

OSHA	Occupational Safety and Health Act
PB	Pullbox
Ph.	Phase
PNL	Panelboard
PR	Pair
PWR	Power
PF	Power Factor
Pri	Primary
psi	Pounds Per Square Inch
PT	Potential Transformer
PVC	Polyvinyl Chloride
RLA	Running Load Amps
RMS	Root-Means-Square
RPM	Revolutions Per Minute
Recept.	Receptacle
RTD	Resistance Temperature Device
RVNR	Reduced Voltage Non-Reversing
SCA	Short Circuit Amps
SCC	Short Circuit Current
SCCR	Short Circuit Current Rating
Sec.	Secondary
S/N	Solid Neutral
SPST	Single Pole Single Throw
SSRV	Solid State Reduced Voltage
SW.	Switch
SWBD	Switchboard
SWGR	Switchgear
TEFC	Totally Enclosed Fan Cooled
TSP	Twisted Shielded Pair
TYP	Typical
Temp.	Temperature
UL	Underwriters Laboratories
UNO	Unless Noted Otherwise
V	Volt
VFD	Variable Frequency Drive
WP	Weatherproof
XFMR	Transformer

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SLEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.

B. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain shop drawings and templates from equipment vendors or other subcontractors and locate the concealed conduit before the floor slab is poured.

C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installations of such conduit to be exposed.

Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.

D. Seal all openings, sleeves, penetration and slots as specified in Section 26 05 33.

3.02 INSTALLATION

A. Any work not installed according to the Drawings and this Division or without approval by the Engineer shall be subject to change as directed by the Engineer. No extra compensation will be allowed for making these changes.

B. Electrical equipment shall at all times during construction be adequately protected against mechanical injury or damage by water. Electrical equipment shall not be stored out-of-doors. Electrical equipment shall be stored in dry permanent shelters. If an apparatus has been damaged, such damage shall be repaired at no additional cost. If any apparatus has been subject to possible injury by water, it shall be replaced at no additional cost to the Owner, the damaged unit(s) or systems shall remain on site and returned to the manufacturer after the replacement unit(s) or systems have been delivered to the site. Under no circumstances will electrical equipment damaged by water be rehabilitated or repaired, new equipment shall be supplied and all cost associated with replacement shall be borne by the Contractor.

C. Equipment that has been damaged shall be replaced or repaired by the equipment manufacturer, at the Engineer's discretion.

D. Repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer. The entire damaged panel or section shall be repainted at no additional cost to the Owner.

E. All “LB” type fitting hardware to be stainless steel or brass. All junction box hardware to be aluminum or stainless steel only.

3.03 MANUFACTURERS SERVICE

A. Provide manufacturer's services for testing and start-up of all major electrical equipment: VFDs, ATS, Gensets, Switchgear, Etc.

B. Testing and startup shall not be combined with training. Testing and start-up time shall not be used for manufacturer’s warranty repairs.

C. The manufacturers of the above listed equipment shall provide experienced Field Service Engineer to accomplish the following tasks:

1. The equipment shall be visually inspected upon completion of installation and prior to energization to assure that wiring is correct, interconnection complete and the installation is in compliance with the manufacturer's criteria. Documentation shall be reviewed to assure that all Drawings, operation and maintenance manuals, parts list and other data required to check out and sustain equipment operation is available on-site. Documentation shall be red-lined to reflect any changes or modifications made during the installation so that the "as-built" equipment configuration will be correctly defined. Spare parts shall be inventoried to assure correct type and quantity.

2. The Field Service Engineers shall provide engineering support during the energization and check-out of each major equipment assembly. They shall perform any calibration or adjustment required for the equipment to meet the manufacturer's performance specifications.
3. Upon satisfactory completion of equipment test, they shall provide engineering support of system tests to be performed in accordance with manufacturer's test specifications.
4. A final report shall be written and submitted to the Contractor within fourteen days from completion of final system testing. The report shall document the inspection and test activity, define any open problems and recommend remedial action. The reports after review by the Contractor shall be submitted to the Engineer.

3.04 TRAINING

A. The cost of training programs to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

B. Provide detailed O&M manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

C. The training program shall represent a comprehensive program covering all aspects of the operation and maintenance including trouble-shooting of each system.

D. All training schedules shall be coordinated with and at the convenience of the Owner. Shift training may be required to correspond to the Owner's working schedule. The training shall be conducted with record "as-built" drawings sufficient for each class member.

E. The Contractor shall submit an overview of the proposed training plan. This overview shall include, for each course proposed:
1. An overview of the training plan.
2. Course title and objectives.
3. Recommended types of attendees.
4. Course Content - A topical outline.
5. Course Format - Lecture, laboratory demonstration, etc.
6. Schedule of training courses including dates, duration and locations of each class.

3.05 WARRANTY

A. The work under this Division shall include a two-year warranty. This warranty shall be by the Contractor to the Owner for any defective workmanship or material that has been furnished under this Contract at no cost to the Owner for a period of two years from the date of substantial completion of the System. This guarantee shall not include light bulbs or batteries in service after six months from date of Substantial Completion of the System.

END OF SECTION

SECTION 26 05 19

LOW VOLTAGE WIRES AND CABLES

PART 1 – GENERAL

1.01 REFERENCED STANDARDS

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

B. Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies.

C. National Electrical Manufacturers Association (NEMA): ICS 4, Industrial Control and Systems: Terminal Blocks.

D. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA): WC 57/S-73-532, Standard for Control Cables: WC 70/S-95-658, Non-Shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.

E. National Fire Protection Association NFPA-70, National Electrical Code (NEC).

F. Underwriters Laboratories, Inc. (UL44): Standard for Safety Thermoset-Insulated Wires and Cables; (UL83): Standard for Safety Thermoplastic-Insulated Wires and Cables; UL467 Standard for Safety Grounding and Bonding Equipment. UL486A Standard for Safety Wire Connectors and Soldering Lugs for use with Copper Conductors; UL 486C, Standard for Safety Splicing Wire Connections. UL510, Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.

1.02 DEFINITIONS

A. Building Wire: Copper single conductor, cross link polyethylene insulated; type XHHW-2 or thermoplastic insulated THHN and THWN;

B. Cable: Multi-conductor, insulated, with outer sheath containing either building wire or instrumentation wire.

C. Instrumentation Cable (Analog signal cable): Multiple conductor, insulated, twisted Pair/Triad, with individual Pair/Triad shield and outer overall shield and outer sheath. Used for the transmission of low current (e.g., 4-20mA DC) using No. 18 AWG conductors. Common Types, TSP: Twisted shielded pair, TST: Twisted shielded triad.

D. Control Cable: Multi-conductor, insulated, with outer sheath containing building wires, No. 16, AWG. With overall shield where specified. Type SIS and MTW approved for use in the wiring of control equipment within control panels and field wiring of control equipment within switchgear, switchboards, motor control centers; otherwise type XHHW-2.

E. Power Cable: Multi-conductor, insulated, with outer sheath containing building wire, No. 8 AWG and larger, Rated XHHW-2. No. 12-6 AWG, Rated THHN or THWN.

F. Digital signal cable: Used for the transmission of digital signals between computers, PLC's, RTU's, etc. Common Types: Ethernet UTP-unshielded twisted pair.

1.03 SUBMITTALS

A. Submit cut sheets on all major types of wires and cables including splicing tape, and terminating/splicing lugs, conductor identification systems and connectors and cable sleeves. Submit sample of all instrumentation and control cable. Sample shall be a minimum of 24" with exterior sheath clearly marked.

B. Submit sample of all cable identification systems products.

C. Submit conduit schedule identifying conduit tag numbers, locations the conduit connects and the wire count.

PART 2 – PRODUCTS

2.01 POWER CONDUCTORS

A. Branch circuits and feeder conductors for all three phase electric power shall be stranded copper type XHHW-2 cross-link polyethylene (XLP) insulation and derated to 75 degrees Centigrade for #8 AWG and larger. No. 12-6 AWG, shall be type THHN or THWN, thermoplastic insulation and derated to 75 degrees Centigrade. No aluminum wiring shall be permitted. Wire shall be in accordance to NEC and minimum No. 12, except that branch "homeruns" over 50 ft. in length shall be minimum No. 10 for 120/208V circuits. All branch lighting circuits serving HID and Fluorescent fixtures shall be minimum #10 with each circuit provided with a separate neutral. All wire shall be manufactured in the USA.

B. Motor leads from variable frequency drives to driven motor shall be shielded VFD drive cable for all VFD motors. Provide flexible VFD shielded drive cables, 3 Class-I conductor cable plus 3 trisectional green insulated ground wires. Provide electrostatic shielding of tinned copper braided shield with aluminum-polyester laminated tape shielding system. Cross-linked polyethylene insulation system and neoprene or PVC outer jacket, type TC cable as manufactured by Service Wire or equal. Shielded VFD motor cables require increased conduit sizes over standard wire installations. Contractor to verify conduit sizes.

C. Taps and Splices:

1. All power wiring taps and splices in No. 8 or smaller wire shall be fastened together by means of terminal strips except within lighting fixtures and wiring devices where conformance to NEC practices will be acceptable (Twist/screw on type connectors). All taps and splices in wire larger than No. 8 shall be made with compression type connectors and taped to provide insulation equal to wire. Tape shall be heavy duty, flame retardant and weather resistant vinyl electrical tape, minimum 7 mil premium grade with an operating temperature of 0 degree F. to 220 degree F. Provide tape meeting UL 510 and CSA standard C22.2.

2. All taps and splices in manholes or in ground pull boxes, etc. shall be approved by the engineer on a case by case basis; be made with high press long barrel double crimp compression type connectors and covered with Raychem heavy wall cable sleeves (type CTE or WCS) with type "S" sealant coating. Install sleeve kits as per manufacturer's installation instructions.

D. Color Coding:

1. All power feeders and branch circuits No. 6 and smaller shall be wired with color-coded wire with the same color used for a system throughout the building. Power feeders above No. 6 shall either be fully color-coded or shall have black insulation and be similarly color-coded with tape or paint in all junction boxes and panels. Tape or paint shall completely cover the full length of conductor insulation within the box or panel except for the wire markings.

2. Unless otherwise approved, color-code shall be as follows: Neutrals to be white for 120/208V system, natural grey for 277/480V system; ground wire green, bare or green with yellow strips. Nominal Voltage: 120/208V, Phase A -black; Phase B - red; Phase C - blue. 480/277V, Phase A brown; Phase B - orange; Phase C -yellow. All switch legs, other voltage system wiring, control and interlock wiring shall be color-coded other than those above. In existing or expansion projects, comply with existing color coding established within the facility.

2.02 INSTRUMENTATION AND CONTROL CABLE

A. Multiconductor and Multi pair Process instrumentation cable shall be #18 AWG stranded, twisted pair, 600 V, (XLP) cross link polyethylene insulated, aluminum tape pair shielding, cross link polyethylene or chlorinated polyethylene (CPE) overall sheathed and shielded, type TC instrument cable as manufactured by the American Insulated Wire Co., Belden Wire Co. or equal.

B. Multiconductor control cable shall be #16 AWG, tinned in control panels, stranded, 600V, (XLP) cross link polyethylene insulated or polyolefin, with cross link polyethylene or chlorinated polyethylene (CPE or Hypalon) overall sheathed type TC control cable except for control cable into and out of VFD cabinets. Multiconductor control cable into and out of VFD cabinets shall be as indicated above and in addition include an aluminum polyester tape overall shield and drain wire. As a contractor alternate to shielded control cable into and out of VFD cabinets, provide twisted shielded instrument cable as specified above. Contractor to provide increased conduit size as required if instrument cable alternate is used into and out of VFD cabinets.

C. Connections:

1. All conductor connections shall be on terminal strips including all spare conductors. Provide terminal strips in all cabinets; motor control centers; etc.
2. All connections of stranded wire to screw terminals shall be by insulated spade lugs, crimp fastened to wire. Provide stranded wire crimp ferrules for all stranded wire connections not requiring spade lugs for screw type terminal blocks. The stranded wire ferrule is to be crimped to all stranded wire using a

crimping tool specifically approved for crimping the size and type of ferrule.

3. All conductors shall be marked with heat shrink type "Brady" labels. Identification labels shall be permanent type and be machine printed. All terminal block terminations shall be labeled. The inside portion of the terminal cabinet doors shall display a protected terminal cabinet drawing with all connections shown and described as to color code, number assigned to connection function of conductor and destination.
4. Wire shall be guided within terminal cabinets by cable supports. All conductors shall be neatly led to terminations.
5. Instrumentation and control field cables on the unprotected side of SPD devices within the cabinet shall not run in parallel to the cables on the protected side of the SPD device. Separate cable supports (duct) will be provided.
6. Cabinets: All cabinets shall be labeled with an engraved plastic laminate label riveted to the door for NEMA 1 enclosures only, labels shall be bonded to all other enclosure types using an epoxy or similar permanent waterproof adhesive. Two sided foam adhesive tape is not acceptable.
7. No splices shall be made within a conduit run or in manholes.

D. All plant control system field wiring shall be labeled per the instrumentation and control contractor loop drawings from the field device, through the intermediate cabinets, to the PLC cabinet. The labeling system shall be consistent throughout the loop and follow the standard tag designation: PLC#-Rack#-Slot#-Point# (example PLC1-R2-S3-P4).

E. Provide for separation of instrumentation, control and power conductors. Provide a minimum of 24" inch separation for parallel run of power conduit and instrumentation or control conduit. This separation can be reduced to 8" if metallic grounded separation is provided.

2.03 INDUSTRIAL ETHERNET MEDIA CABLE

A. Multiconductor and Multi pair Data Signal cable shall be TIA 5638B Cat 5e, #22 AWG solid, twisted pair, 600V, PVC insulated, aluminum tape pair shielding, thermoplastic elastomer (TPE) overall sheathed and shielded, industrial Ethernet cable as manufactured by the Allen Bradley 1585-C8HB or equal. Option to provide premolded RJ45 patchcords Allen Bradley 1585D and 1585J is acceptable at contractor’s option.

B. Connections:

1. All conductor connections shall be to RJ45 and M12 compatible jacks.
2. All conductors shall be marked with mylar wrap type "Brady" labels. Identification labels shall be permanent type and be machine printed. All terminal block terminations shall be labeled. The inside portion of the terminal cabinet doors shall display a protected terminal cabinet drawing with all connections shown and described as to color code, number assigned to connection function of conductor and destination.
3. Wire shall be guided within terminal cabinets by cable supports. All conductors shall be neatly led to terminations.
4. Instrumentation and control field cables on the unprotected side of SPD devices within the cabinet shall not run in parallel to the cables on the

protected side of the SPD device. Separate cable supports (duct) will be provided.

5. No splices shall be made within a conduit run or in manholes.

2.04 CAT6 ETHERNET MEDIA CABLE

A. Category 6 Unshielded Twisted Pair (UTP), UL listed, and third party verified to comply with TIA/EIA 568 C Category 6 requirements. Suitable for high speed network applications including gigabit Ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket. Cable shall withstand a bend radius of 1 inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking. Manufacturer and Product: Belden; 7852A. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.

2.05 MISC ACCESSORIES

A. Tape:

1. General Purpose, Flame Retardant: 7 mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5 mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing: 30 mil, elastomer. Manufacturers and Products: 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.

PART 3 – EXECUTION

3.01 GENERAL

A. Conductor installation shall be in accordance with manufacturer's recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

D. Terminate conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors [and aluminum conductors].

F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding **18** inches on center.

H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

3.02 SPARE CONDUCTORS

A. All runs of Multi pair Process instrumentation cable and multi conductor Control cable shall have a minimum of 2 spare conductors per conduit.

B. All branch circuit feeders of #3 and smaller shall have 2 spare conductors pulled in per circuit.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

A. The terms “connect”, “ground” and “bond” are used interchangeably in this specification and have the same meaning.

B. This section specifies general grounding and bonding requirements of electrical equipment operations and to provide a low impedance path for possible ground fault currents.

C. “Grounding electrode system” refers to all electrodes required by NEC, as well as including made, supplementary, perimeter counterpoise ground, lightning protection system grounding electrodes.

1.02 RELATED WORK

A. Section 26 05 02, Basic Electrical Material and Methods: General electrical requirements.

B. Section 26 05 11, Special Electrical Requirements

C. Section 26 05 19, Low Voltage Wires and Cables

D. Section 26 41 00 Lightning Protection Systems

1.03 SUBMITTALS

A. Submit in accordance with Section 26 05 02, Basic Electrical Materials and Methods

B. Shop Drawings:
   1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
   2. Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.

C. Test Reports: Provide certified test reports of ground resistance.

D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the Project Engineer:
   1. Certification, by the Contractor, that the complete installation has been properly installed and tested.

1.04 APPLICABLE PUBLICATIONS – Latest Edition

A. American Society for Testing and Materials (ASTM)

B. Institute of Electrical and Electronics Engineers, Inc. (IEEE)

C. Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

D. National Fire Protection Association (NFPA)

E. National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):
   1. Thermoset-Insulated Wires and Cables
   2. Thermoplastic-Insulated Wires and Cables
   3. Grounding and Bonding Equipment
   4. Wire Connectors

PART 2 – PRODUCTS

2.01 GROUNDING AND BONDING CONDUCTORS

A. Equipment grounding conductors shall be UL 83 insulated stranded copper, except that sizes 2 AWG and smaller may be solid copper unless noted otherwise noted on the drawings. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes 4 AWG and larger shall be permitted to be identified per NEC.

B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes 2 AWG and smaller may be ASTM B1 solid bare copper wire.

C. Electrical System Grounding: Conductor sizes shall not be less than what is shown on the drawings and not less than required by the NEC, whichever is greater.

2.02 SPLICES AND TERMINATION COMPONENTS

A. Components shall meet or exceed UL 467 and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

2.03 GROUND CONNECTIONS

A. Above Grade:
   1. Bonding Jumpers: compression type connectors, using zinc-plated fasteners and external tooth lock washers.
   2. Ground Busbars: Two-hole compression type lugs using tin-plated copper or copper alloy bolts and nuts.

PART 3 – EXECUTION

3.01 GENERAL

A. Ground in accordance with the NEC, as shown on drawings, and as hereinafter specified.

B. System Grounding:
   1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformers.
   2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.

C. Equipment Grounding: Metallic structures (including ductwork and building steel), enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.

3.02 GROUNDING CONNECTIONS

A. Make grounding connections that are below grade by exothermic weld. Make grounding connections that are above grade but are otherwise normally inaccessible (poured columns, within walls) with exothermic weld.

3.04 SECONDARY EQUIPMENT AND CIRCUITS

A. Transformers:
   1. Exterior: Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.
   2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the ground bar at the service equipment.

B. Conduit Systems:
   1. Ground all metallic conduit systems. All conduit systems shall contain an equipment grounding conductor (except service entrance with grounded neutral). Ground conductor shall be bonded to metallic conduit systems at the entrance and exit from the conduit.

C. Boxes, Cabinets, Enclosures, and Panelboards:
   1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes.
   2. Provide lugs in each box and enclosure for equipment grounding conductor termination.
   3. Provide ground bars in panelboards, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.

D. Motors and Starters: Provide lugs in motor terminal box and starter housing or motor control center compartment to terminate equipment grounding conductors.

E. Receptacles shall not be grounded through their mounting screws. Ground with a jumper from the receptacle green ground terminal to the device box ground screw and the branch circuit equipment grounding conductor.

3.05 CORROSION INHIBITORS

A. When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.06 CONDUCTIVE PIPING

A. Bond all conductive piping systems, interior and exterior, to the building to the grounding electrode system.

3.07 GROUND RESISTANCE

A. Grounding system resistance to ground shall not exceed 2 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to the owner. Final tests shall assure that this requirement is met.

B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided. Document with test results for approval and include approved test results in the O&M Manual.

C. Below-grade connections shall be visually inspected by the Project Engineer prior to backfilling. Provide ground inspection wells at all ground rod locations.

3.08 GROUND ROD INSTALLATION

A. Drive each rod vertically in the earth, not less than 20 feet in depth.

B. Where permanently concealed ground connections are required, make the connections by the exothermic process to form solid metal joints. Make above grade accessible ground connections with mechanical pressure type ground connectors.

C. Where rock prevents the driving of vertical ground rods, drill rock then install rod. Backfill with flowable fill or concrete mix. Obtain the necessary permits if required for drilling.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SCOPE

A. The work under this sections includes conduit and equipment supports, straps, clamps, steel channel, etc, and fastening hardware for supporting electrical work. Furnish and install all supports, hangers and inserts required to mount fixtures, conduit, cables, pull boxes and other equipment furnished under this Division. All supporting devices and hardware exterior of buildings or interior of structures except in air conditioned spaces shall be stainless steel. Aluminum and nonmetallic supports (fiberglass) and hardware will be reviewed by the Engineer on a case-by-case basis.

B. All items shall be supported from the structural portion of the building. Supports and hangers shall be of a type approved by Underwriters' Laboratories. Wire shall not be used as a support. Boxes and conduit shall not be supported or fastened to ceiling suspension wires or to ceiling channels.

C. The Contractor shall furnish and install all sleeves that may be required for openings through floors, wall etc. Where plans call for conduit to be run exposed, the Contractor shall furnish and install all inserts and clamps for the supporting of conduit. If the Contractor does not properly install all sleeves and inserts required, contractor to provide cutting and patching to the satisfaction of the Engineer.

1.02 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.
   1. Section 26 05 33 – Conduit Systems

1.03 SUBMITTALS: PRODUCT DATA

A. Provide data for support channel.

1.04 QUALITY ASSURANCE

A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

PART 2 - PRODUCTS

2.01 MATERIAL

A. Support Channel: Stainless steel throughout except galvanized steel in conditioned interior areas.

B. Hardware: Stainless steel throughout

C. Minimum sized threaded rod for supports shall be 3/8”.

D. Conduit clamps, straps, supports, etc., shall be stainless steel or aluminum. One-hole straps shall be heavy duty type.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All steel conduits shall be securely fastened in place on maximum of 6 foot intervals; all PVC conduits shall be securely fastened in place on maximum of 3 foot intervals vertically and 2 foot intervals horizontally. Hangers, supports or fastenings shall be provided at each elbow and at the end of each straight run terminating at a box or cabinet. The required strength of the supporting equipment and size and type of anchors shall be based on the combined weight of conduit, hanger and cables. Horizontal and vertical conduit runs may be supported by two-hole malleable straps, clamp-backs, or other approved devices with suitable bolts, expansion shields (where needed) or beam-clamps for mounting to building structure or special brackets.

B. On concrete or masonry construction, use "Tapcon" type fasteners. For brick construction, insert anchors shall be installed with round head machine screws. In wood construction, round head screws shall be used. An electric or hand drill shall be used for drilling holes for all inserts in brick, concrete or similar construction. Steel members shall be drilled and tapped, and round head machine screws shall be used. All screws, bolts, washers, etc., used for supporting conduit or outlets shall be fabricated from stainless steel, or approved substitution.

C. Fasten hanger rods, conduit clamps, outlet, junction and pull boxes to building structure using preset inserts, beam clamps, expansion anchors, or spring steel clips (interior metal stud walls only). Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchors on concrete surfaces; sheet metal screws in sheet metal studs and wood screws in wood construction.

D. File and de-bur cut ends of support channel and spray paint with cold galvanized paint to prevent rusting. Do not fasten supports to piping, ductwork, mechanical equipment, cable tray or conduit. Do not drill structural steel members unless approved by the engineer.

E. Fabricate supports from 316 stainless steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts. Install surface-mounted cabinets and panelboards with minimum of four anchors. Provide steel channel supports to stand cabinet one inch (25 mm) off wall.

F. Furnish and install all supports as required to fasten all electrical components required for the project, including free standing supports required for those items remotely mounted from the building structure, catwalks, walkways etc.

END OF SECTION

SECTION 26 05 33

CONDUIT SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Description of System: This Section includes requirements for raceways, fittings, boxes, enclosures, and cabinets for electrical, instrumentation and control system wiring.

B. Heavy wall PVC (Schedule 80) shall be used for all raceways direct buried without concrete encasement protection. Conduits in concrete encasement use Schedule 40-PVC. Above ground in areas subject to chemical degradation (chemical storage, chemical feeder rooms, chlorine rooms, odor control and scrubber area, etc) use Schedule 80-PVC. Use aluminum conduit for exposed above grade interior area. Electrical Metallic Tubing shall be used within air conditioned spaces and in electrical rooms for power and for instrumentation and control conduits. Use rigid aluminum conduit above grade on exterior of buildings and in above grade interior wet locations. Where PVC conduit penetrates a floor from underground or in a slab; a black mastic coated rigid aluminum conduit elbow shall be used for all conduits.

C. Minimum conduit size for all systems shall be 3/4". All conduits shall be U.L. listed and labeled. Conduit sizes shown on the drawings are to aid the contractor in bidding only; the contractor is responsible for conduit sizes as required by NEC fill tables but do not provide smaller conduits than indicated. The contractor is responsible to coordinate the required conduit sizes and conductor quantities for all control and instrumentation system conduit and wiring with the controls subcontractor prior to installation.

D. Provide stainless steel or non-metallic conduit supports and type 316 stainless steel hardware in all areas except air conditioned spaces.

1.02 SUBMITTALS

A. Product Data:
   1. Product data shall be submitted on:
      a. Conduit, raceways, wireways.
      b. Conduit fittings, boxes, enclosures and cabinets.
      c. Surface metal raceway
      d. Conduit Schedule identifying conduit tag numbers, locations the conduit connects and the wire count.

PART 2 - PRODUCTS

2.01 ELECTRIC METALLIC TUBING

A. Electric metallic tubing (thin wall) shall meet Federal EMT Specifications WW-C-563 ANSI C80.3 and UL 797 with chromated and lacquered protective layer

2.02 FLEXIBLE CONDUIT

A. Flexible, Nonmetallic, Liquid-Tight Conduit: Type B
   1. Material: PVC core with fused flexible PVC jacket. UL 1660 listed for:
      a. Dry Conditions: 80 degrees C insulated conductors.
      b. Wet Conditions: 60 degrees C insulated conductors.
   2. Manufacturers and Products:
      a. Carlon; Carflex or X Flex.;
      b T & B; Xtraflex LTC or EFC.

2.04 PVC CONDUIT

A. PVC conduit shall be composed of High Impact Virgin homopolymer, PVC (polyvinyl chloride C-200 Compound), and shall conform to industry standards, and be UL 651 listed in accordance with Article 347 of National Electrical Code for underground, concrete encasement and or direct sunlight exposed use and NEMA standard TC-2. Materials must have tensile strength of 55 PSI, at 70oF, flexural strength of 11,000 PSI, compression strength of 8600 PSI. Manufacturer shall have five years' extruding PVC experience. Consistent with requirements provide PVC conduit products by one of the following manufacturers:
   1. Carlon
   2. Cantex
   3. J.M. Plastics
   4. Queen City Plastics

2.06 RIGID ALUMINUM CONDUIT

A. Provide Rigid Aluminum Conduit of 6063 alloy in temper designation T-1. The fittings are of the same alloy. Provide threaded Rigid Aluminum Conduit to Underwriters Laboratories U.L. 6A, “Standard for Electrical Rigid Metal Conduit and manufactured to ANSI C80.5.

B. Provide threaded aluminum conduit fittings, of 6063 alloy, cast copper free aluminum with integral insulated throat as manufactured by Allied, OZ Gedney, T&B, Crouse-Hinds, Killark or Appleton.

C. Provide supplementary corrosion protection for aluminum conduit imbedded in concrete or in contact with soil. Where aluminum conduits are in contact with or penetrate concrete, coast conduit with asphaltic or bitumastic type coating.

2.07 CONDUIT FITTINGS

A. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

B. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.

C. Fittings for EMT: Steel compression type.

D. Fittings, surface boxes and conduit bodies for Rigid Aluminum Conduit shall be

heavy cast aluminum with external raised hubs and mounting lugs;- Appleton, Crouse Hinds or approved substitution. Cover plates cast aluminum. Zinc die cast not acceptable.

E. Conduit locknuts shall be aluminum throughout except steel is acceptable within air conditioned spaces.

F. Conduit expansion fittings shall be malleable iron, and shall be hot dipped galvanized inside and outside. These fittings shall have a four-inch expansion chamber to allow approximately two-inch movement parallel to conduit run in either direction from normal. They shall have factory-installed packing and internal tinned copper braid packing to serve as an emergency bonding jumper. Unless the fitting used is listed by Underwriters' Laboratories for use "without external bonding jumpers", an external copper bonding jumper shall be installed with each expansion fitting with one end clamped on each conduit entering fitting.

G. Flexible, Nonmetallic, Liquid-Tight Conduit shall meet requirements of UL 514B with High strength plastic body, complete with lock nut, O-ring seal, threaded ferrule, sealing ring. Threaded ferrule designed to ensure high mechanical pullout strength and watertight seal. Manufacturer, Carlon; Type LN or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All raceways shall be run in neat and workmanlike manner and shall be properly supported in accordance with latest edition of NEC with approved conduit clamps, hanger rods and structural fasteners except for PVC conduit installed in exterior locations. PVC conduit installed in exterior locations shall be supported at two foot intervals. Supporting conduit and boxes with wire is not approved. All raceways except those from surface-mounted switches, outlet boxes or panels shall be run concealed from view. Exposed raceways shall be supported with clamp fasteners with toggle bolt on hollow walls, and with lead expansion shields on masonry. Rigid steel box connections shall be made with double locknuts and bushings. Where PVC penetrates a floor from underground or in slab, a black mastic coated aluminum conduit elbow shall be used on all conduits. All individual bare copper ground conductors (i.e. service, transformer, or lightning protection grounds) shall be installed in PVC conduit, not metal conduit. This does not apply to bare copper ground conductors run with feeders (as specified in this section). Conduits shall be run parallel to building walls wherever possible, exposed or concealed, and shall be grouped in workmanlike fashion. Crisscrossing of conduits shall be minimized.

B. All raceways runs, whether terminated in boxes or not, shall be capped during the course of construction and until wires are pulled in, and covers are in place. No conductors shall be pulled into raceways until construction work which might damage the raceways has been completed.

C. All raceways shall be kept clear of plumbing fixtures to facilitate future repair or replacement of said fixtures without disturbing wiring. Except where it is necessary for control purposes, all raceways shall be kept away from items producing heat.

D. All raceway runs in masonry shall be installed at the same time as the masonry so that no face cutting is required, except to accommodate boxes.

E. All raceways shall be run from outlet to outlet exactly as shown on the drawings, unless permission is granted to alter arrangement shown. If permission is granted arrangement shall be marked on field set of drawings as previously specified.

F. All underground raceways (with exception of raceways installed under floor slab) shall be installed in accordance with Section 300-5 of the NEC except that the minimum cover for any conduit shall be two feet. Included under this Section shall be the responsibility for verifying finished lines in areas where raceways will be installed underground before the grading is complete.

G. All raceways shall have an insulated copper system ground conductor throughout the entire length of circuit installed within conduit in strict accordance with NEC. Grounding conductor shall be included in total conduit fill determining conduit sizes, even though not included or shown on drawings. Grounding conductors run with feeders shall be bonded to portions of conduit that are metal by approved ground bushings.

H. Spare conduit stubs shall be capped and location and use marked with concrete marker set flush with finish grade or terminated in a manhole. Marker shall be 6" round X 6" deep with appropriate symbol embedded into top to indicate use. Also, tag conduits in panels where originating.

I. All conduit stubbed above floor shall be separated with plastic interlocking spacers manufactured specifically for this purpose, or shall be strapped to Kindorf channel supported by conduit driven into ground or tied to steel.

J. Raceways which do not have conductors furnished under this Division 26 Electrical of the specifications shall be left with an approved nylon pullcord in raceway.

K. Rigid Metallic Conduit, electrical metallic tubing, flexible steel conduit and PVC conduit shall be manufactured within the United States.

L. All connections to motors or other vibrating equipment (except dry type transformers) or at other locations where required shall be made with not less than 12" nor more than 20” of flexible liquid-tight nonmetallic conduit, using special type of connectors with strain relief fittings at both terminations of conduit. Flex connectors shall have insulated throat and shall be T & B 3100 Series or approved substitution. Use angle connectors wherever necessary to relieve angle strain on flex conduit. Connections to dry type transformers shall be made with flexible conduit. Typical length of flex conduit shall be limited to 20” unless specifically approved by the engineer.

M. PVC joints shall be solvent welded. Threads will not be permitted on PVC conduit and fittings, except for rigid steel to PVC couplings. Installation of PVC conduit shall be in accordance with manufacturer's recommendations. PVC conduit shall not be used to support fixture or equipment. Field bends shall be made with approved hotbox. Heating with flame and hand held heat guns are prohibited.

N. Expansion fittings shall be installed in the following cases: In each conduit run

wherever it crosses an expansion joint in the concrete structure; on one side of joint with its sliding sleeve end flush with joint, and with a length of bonding jumper in expansion equal to at least three times the normal width of joints; in each conduit run which mechanically attached to separate structures to relieve strain caused by shift on one structure in relation to the other; in straight conduit run above ground which is more than fifty feet long and interval between expansion fittings in such a runs shall not be greater than 100 feet for steel conduit and 50 feet for PVC conduit.

O. Electric metallic tubing (thin wall), where installed inside air conditioned buildings above grade only, shall be joined with steel fittings and steel compression connectors.

P. Conduit installations on roofs shall be kept to a bare minimum. Where required, conduit shall be rigid aluminum conduit, including couplings. Conduit shall be supported above roof at least 6 inches using approved conduit supporting devices. Supports to be fastened to roof using roofing adhesive as approved by roofing contractor.

Q. Underground cable identification: bury a continuous, pre-printed, bright colored metalized plastic (electronically traceable) ribbon cable marker with each underground conduit (or group of conduits), regardless of whether conduits are in ductbanks. Locate directly over conduits, 6" to 8" below finished grade. Delete this requirement under building slabs.

R. Provide for separation of instrumentation, control and power conductors. Provide a minimum of 24" inch separation for parallel runs of power conduit to instrumentation or control conduit with either conduit being PVC or Aluminum. This separation can be reduced to 8" if metallic grounded separation is provided (steel conduit).

U. Duct seal all conduit entrances. Foam seal is not acceptable.

V. All conduit runs shall have (1) spare conduits installed in the run sized to match the largest conduit in the run.

W. All conduit penetration into control panel cabinets shall be accomplished utilizing aluminum or stainless steel Myers Hubs consistent with the conduit type utilized.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS & DUCTBANKS

PART 1 - GENERAL

1.01 Provide underground duct banks for power and lighting feeders; instrumentation and control systems as shown or as specified herein; from point of service switchgear or equipment to the point of distribution or equipment served.

1.02 SUBMITTALS

A. Submit shop drawings or cut sheets on

1. Conduit
2. Fittings
3. Conduit Separators
4. PVC solvent
5. Precast concrete manholes
6. Composite handholes
7. Cable lubricants

1.03 DESCRIPTION OF ASSEMBLY

A. Underground duct banks shall be multiple individual conduits encased in reinforced concrete as indicated on the drawings. Conduits within building or structural foundations and protected by a concrete slab above them do not require encasement (except provide encasement or flowable fill under electrical and pump room slabs). The conduit shall be of plastic (PVC sch 40 for concrete encasement and Sch80 without concrete encasement), unless indicated or specified otherwise. The conduit used shall not be smaller than 4 inches in diameter, inside, unless otherwise noted. The concrete encasement surrounding the duct bank shall be rectangular in cross-section, having a minimum concrete thickness of three inches around all conduits. All concrete encased duct banks shall be steel reinforced as detailed. Power distribution conduits shall be separated by a minimum dimension of four inches and not less than 7.5" center to center. Power conduits shall be separated from low voltage instrumentation & control conduits by a minimum dimension of twenty four inches.

B. The concrete work shall conform to Section on "Concrete". The top of the concrete envelope shall be not less than 24 inches below grade unless otherwise indicated. Concrete shall be installed in a continuous pour to eliminate joints in the duct run. The duct bank sides shall be formed in place using suitable concrete form work or corrugated metal forms. Open trench pours will not be allowed.

C. Plastic conduit, fittings and joints shall not have been stored in the sun or weather, in any excessively heated space, or unevenly supported during storage. Use and installation shall be in accordance with the National Electrical Code requirements for the installation of non-metallic rigid conduit. Plastic conduit shall be protected against the direct rays of the sun prior to installation. Conduit shall be PVC schedule 40 manufactured by Carlon, Queen City Plastics, or approved substitution. Conduit shall be U.L. listed and conform to NEMA Standards for schedule 40 PVC conduit.

D. Trenches for duct banks shall be completely dry before setting conduits or pouring concrete. Provide well pointing as required if necessary to keep trench dry.

E. Wires and cables in manhole/handhole shall be placed on cable racks. Manhole/handhole shall be cleaned of all loose materials, dirt and debris immediately after completion of new work and shall be in a clean condition when project is completed. Cable racks shall be stainless steel or non metallic with stainless steel hardware, cable racks shall be complete with insulators. Racks shall be Underground Devices or approved substitution.

F. Back filling of trenches shall be in layers not more than 8 inches deep, and shall be thoroughly tamped. The first layer shall be earth or sand, free from particles that would be retained on a 1/4 inch sieve. The succeeding layers shall be excavated material having stones no larger than would pass through a 4-inch ring. The back fill shall be level with adjacent surface, except that in sodded or paved areas, a space equal to the thickness of the sod or paving shall be left.

G. The surface disturbed during the installation of duct shall be restored to its original elevation and condition if not refinished in connection with site work.

H. All unused conduit openings shall be plugged or capped with a suitable device designed for the purpose; caulking compound shall not be used for plugging conduit openings.

I. One No. 2 bare solid tinned copper counterpoise shall be run above all duct banks and shall be run into all manholes/handholes and grounded to 5/8" X 20' driven ground rods. Counterpoise shall run into buildings and be grounded at each structures service ground.

J. All conduits entering a building or structure shall be sealed with duct seal.

PART - 2 PRODUCTS

2.01 DUCT BANK STRUCTURES

A. Precast Concrete Construction: Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes and pullboxes.

1. General: Concrete for precast work shall have an ultimate 28-day compressive strength of not less than 4000 psi. Structures may be precast to the design and details indicated precast monolithicly and placed as a unit, or structures may be assembled sections, design and produced by the manufacturer in accordance with the requirements specified. Structures shall be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.
2. Construction: Structure top, bottom and wall shall be of a uniform thickness of not less than 4 inches. Quantity, size, and location of duct bank entrance windows shall be as required, and cast completely open by the precaster. Size of windows shall exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window

modifications made necessary by duct bank misalignment. However, the sides of precast windows shall be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. The minimum concrete cover for reinforcing steel shall be 2 inches. Provide drain sumps for precast structures a minimum of 12 inches in diameter and 6 inches deep.

3. Joints: Provide tongue-and-groove or shiplap joints on mating edges of precast components. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to AASHTO M198, Type-B. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

B. Precast Concrete manholes and pullboxes (handholes): ASTM C 478. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete manholes and pullboxes. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Metal Covers shall fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable.

C. Metal Frames and Covers: Shall be made of cast iron. Covers shall weight a minimum 100lb. Frames and covers of steel shall be welded by qualified welders in accordance with standard commercial practice. Covers shall have raised letters of identification as indicated on the drawings. Covers shall have an approved antislip surface. Covers shall be rated AASHTO H20.

D. Pulling-In Irons: Shall be steel bars bent cast in the walls and floors. In the floor they shall be centered under the cover and in the wall they shall be not less than 6 inches above or below, and opposite the conduits entering the manhole or pullbox. Pulling-in irons shall project into the box approximately 4 inches. Iron shall be hot-dipped galvanized after fabrication.

E. Cable Racks: Rack arms and insulators, shall be sufficient to accommodate the cables. Racks in manhole and pullbox shall be spaced not more than 2 feet apart, and each box wall shall be provided with a minimum of two racks. The wall bracket shall be stainless steel or fiberglass. Slots for mounting cable rack arms shall be spaced at 8-inch intervals. The cable rack arms shall be of stainless steel or fiberglass and shall be of removable type. Insulators shall be dry-process glazed

porcelain. All metal fasteners and hardware portion of racks shall be stainless steel.

F. Grounding in manholes and pullboxes: Provide No. 6 AWG bare copper grounding pigtails on walls of each manhole and pullbox. The pigtails shall be exothermically welded to the reinforcing bars and shall extend at least 8 inches into box. Two pigtails shall be provided in each box.

G. Pull Wire: Plastic rope having a minimum tensile strength of 200 pounds in each empty duct. Leave a minimum of 24 inches of slack at each end of the pull wires.

H. Composite Handholes: Only where composite handholes are indicated on the drawings, use handholes, covers and boxes of polymer concrete as manufactured by Quazite Corporation. The material shall consist of aggregate bound together with a polyester resin and reinforced with continuous woven glass strands. The covers and boxes shall be designed to be installed flush to grade with cover fitting flush to the box and shall be capable of withstanding normal shipping and installation process without chipping, cracking or structural damage. All boxes shall be manufactured with the use of male/female molds to ensure a consistent wall thickness and structural strength and shall be stackable or extra depth. The boxes and covers shall have dimensions as indicated and shall be concrete gray in color. The cover logo shall be recessed into the cover and shall read INSTRUMENTATION or ELECTRIC as indicated. The composite covers shall be designed for a static vertical load of 8,000 pounds and shall be tested, in the box, to a static load of 12,000 pounds (1.5 safety factor). The test load shall be distributed over a 10 inch by 10 inch by 1 inch thick distribution plate located at the center of the cover. The maximum deflection at a load of 8,000 pounds shall not exceed 0.50 inches. The covers shall be skid resistant and have a minimum coefficient of friction of 0.50 on the top surface for the life of the cover. Coatings will not be provided. The permanent deflection of any surface shall not exceed 10% of the maximum allowable test load deflection. The lockdown mechanism shall be capable of withstanding a minimum torque of 30 foot-pounds. All inserts and fasteners shall be of stainless steel.

PART 3 - EXECUTION

3.01 INSTALLATION: conform to NFPA 70 and ANSI C2.

A. The top of the conduit shall be not less than 24 inches below grade, for low voltage conduits and 48 inches for high voltage ducts. Run conduit in straight lines except where a change of direction is necessary. Provide not less than 3 inches clearance from the conduit to each side of the trench. A minimum clearance of 2 1/2 inches shall be provided between adjacent conduits. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve.

B. Precast manhole and pullbox Installation: Commercial precast assembly shall be set on 6 inches of level, 90 percent compacted granular fill, 3/4-inch to 1-inch size, extending 12 inches beyond the manhole or pullbox on each side. Granular fill shall be compacted by a minimum of four passes with a plate type vibrator.

C. Buried Warning and Identification Tape: Metallic core or metallic-faced, acid- and

alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3-inch-minimum width, color coded as specified below for the intended utility and warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Color and printing shall be permanent, unaffected by moisture or soil.

Warning Tape Color Codes

Yellow or red: Electric power
Orange: Instrumentation and Control

D. Conduit Placement: Duct lines shall have a continuous slope downward toward manholes/handholes and away from buildings with a pitch of not less than 3 inches in 100 feet. Except at conduit risers, accomplish changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, by long sweep bends having a minimum radius of curvature of 25 feet. Manufactured bends may be made up or one or more curved or straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 18 inches for use with conduits of less than 3 inches in diameter and a minimum radius of 36 inches for ducts of 3 inches in diameter and larger.

E. Termination and Cleaning of Conduit: Terminate conduits in end-bells where duct lines enter manholes and pullboxes. Separators shall be of precast concrete, high impact polystyrene, steel, or a combination of these. Stagger conduit joints by rows and layers to provide a duct line having the maximum strength. During construction, protect partially completed duct lines from the entrance of debris such as mud, sand, and dirt with suitable conduit plugs. As each section of a duct line is completed, draw a non-flexible testing mandrel not less than 12 inches long with a diameter 1/4 inch less than inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush having the same diameter of the duct through the duct, until duct is clear of particles of earth, sand, and gravel; then immediately install end plugs.

F. Conduit Protection at Concrete Penetrations: Conduits which penetrate concrete (slabs, pavement, and walls) shall be galvanized rigid steel; protected by a PVC sheath at the penetration; PVC sheath shall be 40-mils thick conforming to NEMA RN 1, and shall extend from at least 2 inches below the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches above concrete).

G. Cable Pulling: Pull Cables down grade with the feed-in point at the manhole or pullbox or point of the highest elevation. Use flexible cable feeds to convey cables through box opening and into duct runs. Accumulate cable slack at each box where space permits by training cable around the interior to form one complete loop. Maintain minimum allowable bending radii in forming such loops.

H. Cable Lubricants: Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables. Cable lubricants shall be soapstone, graphite, or talc for rubber or plastic jacketed cables. Lubricant shall not be deleterious to the cable sheath, jacket, or outer coverings.

I. Cable Pulling Tensions: Tensions shall not exceed the maximum pulling tension recommended by the cable manufacturer.

J. Installation of Cables in manholes and pullboxes and Handholes: Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators at a maximum of 18 inches. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space opening for future cables, except as otherwise indicated for existing installations.

K. FIREPROOFING OF CABLES IN MANHOLES: All wire and cables in manholes shall be fireproofed. Strips of fireproofing tape approximately 1/16 inch thick by 3 inches wide shall be wrapped tightly around each cable spirally in one-half lapped wrapping, or in two butt-jointed wrappings with the second wrapping covering the joints in the first. The tape shall be applied with the coated side toward the cable, and shall extend one inch into the ducts. To prevent unraveling, the fireproofing (Arc-proofing) tape shall be random wrapped with tape conforming to type FGT of specification MIL-I-15126. The fireproofing (arc proofing) tape shall consist of a flexible, conformable fabric having one side coated with a flame-retardant, flexible, polymeric coating and/or a chlorinated elastomer. The tape shall not be less than 0.050 inch thick, and shall weigh not less than 2.5 pounds per square yard. The tape shall be non-corrosive to cable sheath, shall be self-extinguishing, and shall not support combustion. The tape shall not deteriorate when subjected to oil, water, gases, saltwater, sewage and fungus. The tape shall have a tensile strength of not less than 40 pounds per inch width, and when tested under USA Standard L14.184 cut strip method. Provide certification the product retains 65 percent of its original tensile strength for the following tests for 168 hours for each requirement;

1. Immersion in distilled water,
2. Immersion in 3 percent salt water,
3. Exposure to ultra-violet light (30-watt germicidal lamp),
4. Exposure to sunlight (Type S-1 sun lamp), and exposure to concentrated sewage.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 GENERAL

A. Provide materials and installation for the identification of electrical equipment, components, cables and wiring and safety signs.

B. Related Work Specified in Other Sections Includes:
Section 26 05 02-Basic Electrical Materials and Methods; Section 26 05 19 Low-Voltage Wires and Cables; Section 26 08 00Acceptance Testing Performance Verification and Section 26 29 13 Control Panels,

1.02 REFERENCES

A. Codes and standards incorporated within this Section are:
1. ANSIC2/NFPA70E National Electrical Safety Code (NESC)
2. ANSI Z535.1 Safety Color Code
3. ANSI Z535.2 Environmental and Facility Safety Signs
4. ANSI Z535.3 Criteria for Safety Symbols
5. OSHA Occupational Safety and Health Act: specification 1910.145, Standards for Accident Prevention, Signs and Tags

1.03 SUBMITTALS: Furnish all product submittals used.

A. Product Data and Information: Furnish manufacturer's catalog data for safety signs, nameplates, labels and markers.

B. Furnish manufacturer's instructions indicating application conditions and limitations of use; and storage, handling, protection, examination and installation of product.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.
1. W. H. Brady Company
2. Seton
3. Thomas & Betts A.
4. Approved Equal

2.02 MATERIALS

A. General: Provide identification materials listed and classified by UL or tested by an acceptable Electrical Testing Company certifying the equivalence of the materials to UL listing requirements and OSHA approved.

B. Laminated Plastic Nameplates: Provide engraved three layer laminated plastic nameplates with white letters on Black background with lettering etched through the outer covering and fastened with corrosion resistant stainless steel screws. Do not use mounting cement for fastening nameplates.
   1. Provide nameplates with 1-inch high lettering for main breakers, automatic transfer switches, panelboards, transformers, VFD's, control panels and disconnect switches.
   2. Provide nameplates for each motor identifying service or function and lettering of an appropriate size to suit each motor. Submersible motor nameplates to be affixed to equipment disconnect.
   3. Provide approved directories of circuits with typewritten designations of each branch circuit in each panelboard.
   4. Provide smaller lettering for a neat, legible nameplate where the amount of lettering causes excessively large nameplates.

2.03 WIRE MARKERS: Identify wire bundles and each individual wire.

A. Wire bundles: Provide a permanent waterproof brass or rigid fiber identifying tag attached with nylon self locking "Ty-Raps".

B. Wire identification markers: Provide a printed white, heat-shrink, seamless tubing type with black bold lettering for wires size No. 10 AWG and smaller. Provide a printed self-laminating white, vinyl type with black bold lettering for wires No. 8 AWG and larger

C. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

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

E. Write-On Tags: Polyester tag, 0.015-inch thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable: Marker for Tags: Permanent, waterproof, black-ink marker recommended by tag manufacturer.

F. Manufacturers and Products:
   1. Sleeve: Raychem; Type D SCE or ZH SCE. Brady, Type 3PS.
   2. Heat Bond Marker: Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive. Self-laminating protective shield over text. Machine printed black text. Manufacturer 3M Co.; Type SCS HB.
   3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
   4. Tie-On Cable Marker Tags: Chemical-resistant white tag. Size: 1/2 inch by 2 inches. Manufacturer and Product: Raychem; Type CM SCE.

2.04 SAFETY SIGNS: Provide safety signs in accordance with OSHA standards meeting the requirements of ANSI C2, ANSI Z535.1, ANSI Z535.2 and ANSI Z535.3. Comply with NFPA 70 and 29 CFR 1910.145

A. Provide safety signs manufactured from vinyl having a minimum thickness of 60 mils with red and black letters and graphics on a white background.

B. Size: Provide 7-inch by 10-inch signs or smaller if larger size cannot be applied.

C. Mount safety signs using corrosion-resistant screws. Do not use mounting cement.

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

E. All receptacles and switches shall be identified on the inside of the cover plate by circuit number and panelboard.

F. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application and with 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.

G. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing, and with colors, legend, and size required for application and with 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

2.05 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a black background. Minimum letter height shall be 3/8 inch. Identification plates shall be furnished for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, pilot lights, disconnect switches, manual starting switches, magnetic starters, and all miscellaneous controls, switches and enclosures.

B. Process control devices and pilot lights shall have identification plates. Identification plates shall be furnished for all line-voltage enclosed-circuit breakers; the plates shall identify the equipment served, voltage, phase(s), and power source. Circuits 480 volts and above shall have conspicuously located warning signs in accordance with OSHA requirements.

C. Identification plates shall be three-layer white-black-white, engraved to show black letters on a white background. Letters shall be uppercase. Identification plates 1-1/2 inches high and smaller shall be 1/16 inch thick with engraved lettering 1/8 inch high. Identification plates larger than 1-1/2 inches high shall be 1/8 inch thick with engraved lettering not less than 3/16 inch high. Identification plates having edges of 1-1/2 inches high and larger shall be beveled:

D. Provide nameplates of minimum letter height as follows: Panelboards, switchboards, safety switches and motor control centers: 1/4-inch, identify panel name; 1/8-inch, identify voltage, phase, number of wires, and source.

E. Safety color coding for identification of warning signs shall conform to NEMA Z 535. Red identification plates reading CAUTION: 480/277 VOLTS shall be provided in switch and outlet boxes containing 277-or 480-volt circuits. An identification plate

marked DANGER: 480 VOLTS shall be provided on the outside of 480-volt enclosures. Identification plate shall use white lettering on a red laminated plastic.

F. Any equipment with externally powered wiring shall be marked with a laminated plastic name plate having 3/16-inch-high white letters on a red background as follows: DANGER – EXTERNAL VOLTAGE SOURCE.

G. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying equipment in building, and the area served by each.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install nameplates on the front of equipment, parallel to the equipment lines and secured with corrosion resistant stainless steel screws. Labels to be consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual designations. Warning Labels for Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply metal-backed, butyrate warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

B. Install laminated nameplates identifying, each electrical equipment enclosure and Individual equipment and devices. The following items shall be equipped with nameplates: All motors; motor starters, motor-control centers, pushbutton stations, control panels, time switches, disconnect switches, panelboards, circuit breakers, contactors, recorders, transmitters, instruments or relays in separate enclosures, thermostats, photocells, power receptacles, switches controlling equipment or receptacles, switches controlling lighting fixtures where the fixtures are not located within the same space as the controlling switch, termination cabinets, manholes and pull boxes, instrumentation and control terminal cabinets, pull boxes manholes and cabinets. Special electrical systems shall be identified at junction and pull boxes, terminal cabinets and equipment racks.

C. Electrical contractor is responsible for nameplates on electrical equipment supplied by other divisions and installed and wired by electrical including all instrumentation and controls equipment. A portion of existing equipment affected by this contract shall also receive nameplates as determined by the engineer.

D. Surface Preparation: Degrease and clean surfaces to receive nameplates, labels and marking paint.

E. Nameplates shall adequately identify the particular equipment involved. Nameplates for panelboards and switchboards shall include the panel designation, voltage and phase of the supply. For example, "Panel A, 277/480V, 3-phase, 4-wire". The name of the machine on the nameplates for a particular machine shall be the same as the one used on all motor starters, disconnect and P.B. station nameplates for that machine. Equipment Requiring Workspace Clearance shall be labeled According to NFPA 70 applied to door or cover of equipment.

F. Label all disconnects with nameplates as well as the location from which they are fed.

G. Rework or reuse of existing equipment will require new identification tags for some existing equipment.

H. Wire Markers: Identify each individual wire with identification tags as follows:
1. Wire identification markers: Provide wire identification markers on each wire at all termination points.
a. On power and lighting circuits: The branch circuit or feeder number as indicated on drawings
b. On control circuits terminated in motor control centers, switchgears, control panels and alike: The field device and terminal number of the opposite end connection.
c. On control circuits at each field device: The panel or compartment number and terminal number of the opposite end connection.
2. Provide oversize wire markers so that after heat shrinking the wire marker can be rotated on the wire. Rotate wire markers so that wire identification number is visible.
3. All wires whether spare or used shall be tagged.
4. Mark wire at both ends.

I. Raceway Tags
1. Provide raceway tags to identify origin and destination of conduit. Install tags at each terminus and at midpoint of run. Provide tags at minimum intervals of every 50 feet of above grade raceway except where concealed in walls. Provide 316 stainless steel tags and stainless steel straps for attachment.
2. Tag numbers to match that submitted on approved conduit schedule.

J. Safety Signs: Provide safety signs as follows or as shown:
1. Wording: "DANGER -ELECTRICAL EQUIPMENT, AUTHORIZED PERSONNEL ONLY" Location: On the outside door of all electrical equipment rooms or areas. On the outside door of all electrical equipment cabinets.
2. Wording: "DANGER -POWERED FROM MORE THAN ONE SOURCE" Location: Outside all equipment that operates from more than one power source; ATS, PLCs, Main Tie Main switchgear/MCCs, etc.
3. Wording: "NOTICE -KEEP DOOR CLOSED" Location: On all doors with another safety sign installed.
4. Wording: "CAUTION -CONTROLS & INTERLOCKS POWERED FROM MULTIPLE SOURCES". Location: On all control panel doors, MCCs I&C terminal cabinets, etc.

K. Create and submit conduit schedule. Schedule to identify conduit tag numbers, the location the conduit connects and the wire count.

END OF SECTION

SECTION 26 05 70

WIRING DEVICES

PART 1 – GENERAL

1.01 SCOPE

A. The Work of this Section shall consist of furnishing all labor, materials, and equipment necessary for installation of wiring devices and plates.

1.02 REFERENCES

A. The latest edition of the following codes or standards shall apply to the design and fabrication of the products and equipment to be supplied under this contract.
   1. NEC (NFPA 70) National Electrical Code
   2. NETA International Electrical Testing Association - Acceptance Testing Specifications
   3. NEMA 250 - Enclosure for Electrical Equipment (1,000 Volts Maximum)
   4. Local Building Codes and Standards
   5. UL 1449 3rd edition Standard for Surge Protection Devices
   6. UL 498 Standard for Safety Attachment Plugs and Receptacles

1.03 SUBMITTALS

A. Furnish submittals in accordance with Section 26 05 02 Special Electrical Requirements.

B. Shop Drawings: Complete catalog cuts of switches, receptacles, enclosures, covers, and appurtenances, marked to clearly identify proposed materials

C. Documentation showing that proposed materials comply with the requirements of NEC and U.L.

1.04 TESTING

A. Provide checkout, field, and functional testing of wiring devices in accordance with Section 26 05 11.

B. Test each receptacle for polarity and ground integrity with a standard receptacle tester.

C. Test GFCI receptacle for correct tripping operation with tester.

PART 2 – PRODUCTS

2.01 SNAP SWITCHES

A. Unless otherwise specified, each snap switch (flush tumbler-toggle) shall be of the Specification grade, heavy-duty type for mounting in a single-gang spacing,

fully rated 20 amperes, minimum, at 120-277 VAC, conforming to minimum requirements of the latest revision of the UL.

B. Switches shall operate in any position and shall be fully enclosed cup type with entire body molded phenolic or melamine. Fiber, paper of similar insulating material shall not be used for body or cover. Ivory color handles unless otherwise indicated on the drawings. Silver or silver alloy contacts. Brass contact arm.

C. Switches for hazardous locations shall be factory sealed, rated at 20 amperes, 120-277 VAC, capable of controlling 100 percent tungsten filament, fluorescent and HID lamp loads.

2.02 RECEPTACLES

A. Industrial or Hospital Grade: receptacles shall be in accordance with NEMA Publications and UL Listings. Receptacles shall be rated for 125VAC, 20 amperes, shall be polarized 3 wire type for use with 3 wire cord with grounded lead and 1 designated stud shall be permanently grounded to the conduit system (NEMA 5-20R). Receptacles shall also be fire-resistant, with nylon top (face) and bodies and bases with metal plaster ears (integral with the supporting member).

B. Provide single or duplex receptacles as shown or noted on drawings, and ivory color unless otherwise noted, with triple wipe or equivalent brass alloy power contacts for each prong. Approved manufacturers are Hubbell, Cooper, Pass & Seymour, or Leviton.

C. All receptacles shall be grounding type with a green-colored hexagonal equipment ground screw of adequate size to accommodate an insulated grounding jumper in accordance with NEC, Article 250. Grounding terminals of all receptacles shall be internally connected to the receptacle mounting yoke.

D. GFCI: Ground-fault circuit interrupting receptacles (GFCI's) shall be installed at the locations indicated and as required by the NEC. GFCI's shall be duplex, Industrial or Hospital grade, tripping at 5 mA. Ratings shall be 125 V, 20 amperes, NEMA WD-1, Configuration 5-20R, capable of interrupting 5,000 amperes without damage.

E. Provide GFCI receptacles where shown and as required. Feed-through type GFCI's serving standard receptacles will not be permitted.

F. Pedestal type boxes for receptacles shall be cast iron 3/4 inch N.P.T. tapped flanged inlet; double gang, meeting UL Standard 514.

G. Special purpose receptacles shall have ratings and number of poles as indicated or required for anticipated purpose. Matching plug with cord-grip features shall be provided with each special-purpose receptacle.

H. Receptacles for hazardous locations shall be single gang receptacles with spring door. Receptacles shall have a factory sealed chamber. The receptacles shall have a delayed action feature requiring the plug to be inserted in the receptacle and rotated before the electrical connection is made. The receptacle shall not

work with non-hazardous rated plugs. One plug shall be furnished with each receptacle. The receptacles shall be rated for 20 amps at 125 VAC.

I. SPD Receptacles: Transient voltage surge suppressing receptacles provided with a filtering capacitor for 7 to 1 average noise reduction and Two way protection for line equipment. Response time less than 1 nanosecond for un-mounted Metal Oxide Varistor (MOV); Overcurrent protection; Thermal protection; Varistor with voltage capabilities of 150V RMS

J. Outdoor mounted Receptacles shall be corrosion resistant and shall in addition to meeting the requirements of general-purpose receptacle have Nickel coated metal parts. Manufacturer; Hubbell Bryant; 20A rated HBL53CM62 Series or equal.

K. Outdoor mounted Receptacles shall be furnished with aluminum weatherproof while in use covers.

2.03 SWITCH, MOTOR RATED: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection. UL 508 listed. Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts. Minimum General Purpose Rating: 30 amperes, 600V ac. Manufacturer: Cooper Arrow Hart; Hubbell Bryant: HBL78 Series; Leviton.

2.04 PLUG CAPS & CORDS: Provide and install a matching plug cap and properly sized cord for equipment items noted on the drawings.

2.05 DEVICE PLATES

A. Provide device plates for each switch, receptacle, signal and telephone outlet, and special purpose outlet. Do not use sectional gang plates for multi-gang boxes. All Plates shall be of stainless steel.

PART 3 – EXECUTION

3.01 GENERAL: Perform work in accordance with the National Electrical Code.

3.02 CONNECTION: Rigidly attach wiring devices in accordance with National Electrical Code. Coordinate installation avoiding interference with other equipment.

3.03 GROUNDING: Ground all devices, including switches and receptacles, in accordance with NEC, ART 250.

A. Ground switches and associated metal plates through switch mounting yoke, outlet box, and raceway system.

B. Ground flush receptacles and their metal plates through grounding jumper connections to outlet box and grounding system.

END OF SECTION

SECTION 26 05 73

SHORT CIRCUIT & COORDINATION STUDY & ARC FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.01 GENERAL SCOPE

A. Provide the services of a recognized corporately and financially independent firm for the purpose of performing electrical studies and reports on all new electrical equipment supplied in this contract and on existing equipment as herein specified. It is the intent of these specifications that the study firm work in direct communication with the engineer of record with frequent updates as the work progresses. The study firm shall provide all material, equipment, labor and technical supervision required to perform the studies and reports.

B. Provide a short circuit, coordination and arc-flash study for entire electrical system. Provide a single final electrical study report incorporating the short circuit, coordination and arc flash study. The final document shall become part of the operation and maintenance manuals for the facility. The report shall be submitted on 8.5" X 11" paper bound with all field data in appendix form. Drawings within the testing report shall be on 11" X 17" paper folded to 8.5" X 11" and drawn with a computer aided design (CAD) package. The computer aided design package shall be Autocad or converted to Autocad. All adjustable breakers shall be fitted with a sticker indicating the coordination values for the equipment.

C. Provide a short circuit, coordination and arc-flash study from the Generator and Utility Service primary OCP to all points downstream. Provide system studies in latest release of SKM Power Systems software. Provide CD-Rom electronic version of SKM Power Systems software data files bound in study report for future use by owner. The electrical system studies shall be signed and sealed by a Florida registered electrical engineer. All documentation and record drawings shall be verified by the signing engineer. The signing engineer shall meet at the site with the electrical design engineer during the information gathering phase and after system evaluation to discuss remedial changes necessary for code compliance. The remedial work study changes shall be incorporated within the electrical studies at no additional cost to the owner.

1.02 APPLICABLE CODES, STANDARDS, AND REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
   2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
   3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
   4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
   5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.

6. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):
   1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
   2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
   3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
   4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
   5. ANSI C37.5 – Methods for Determining the RMS Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage, and for Simplified Calculation of Fault Currents

C. The National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code, latest edition
   2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.03 QUALIFICATIONS

A. The study firm shall be regularly engaged in the study of electrical equipment devices, installations, and systems. The lead, technical person shall be a electrical professional engineer in the state of Florida. The study firm shall provide in house electrical studies and reports as specified. The study firm shall submit proof of 5 similar studies with the above qualifications when requested. At least two of the similar project examples shall include arc flash studies with variable frequency drives.

B. Pre-qualified study firms are:
   1. Emerson Electrical Reliability Services, Inc. (239)-693-7100
   2. Industrial Electrical Testing, Inc. (904) 260-8378
   3. Crews Electrical Testing, Inc. (904) 880-8686

   Other firms will be considered by the engineer on submittal of qualifications on or before 20 days prior to bid.

PART 2 - **PRODUCT**

2.01 SHORT-CIRCUIT ANALYSIS AND COORDINATION STUDY for all new electrical equipment. Provide an integrated complete study for the total electrical system.

A. Data Collection: Study Firm shall furnish all field data as required by the power system studies. All data shall be verified on site by the signing engineer. The study firm shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Data may require combination to include present and future utility supplies, motors, and generators.

C. Load data utilized may include existing and proposed loads obtained from Contract Documents and site visits.

D. Include fault contribution of existing motors in the study, with motors < 10 hp grouped together. The testing firm shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.02 Provide a current and complete short-circuit study, equipment interrupting or withstand evaluation, and a protective device coordination study for the electrical distribution system.

A. The studies shall include all portions of the electrical distribution system from the normal and alternate sources of power throughout the low-voltage distribution system. Normal system operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly covered in the study.

B. The studies shall be submitted to the project electrical engineer prior to granting final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture.

C. The study shall be in accordance with applicable ANSI and IEEE Standards. The study input shall include the utility company's short circuit single and three phase contribution, with the X/R ratio, the resistance and reactance components of each branch impedance, motor and generator contributions, base quantities selected, and all other applicable circuit parameters.

D. Short circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at each switchgear bus, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboards, and other significant locations through the system.

E. An equipment evaluation study shall be performed to determine the adequacy of new and existing circuit breakers, controllers, surge arresters, busways, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents. Any problem areas or inadequacies in the existing equipment shall be documented back to the project engineer with recommended remedial actions. The study firm shall coordinate with the supplier of the new equipment to assure all specifications of the new equipment meet or exceed the ratings required by the study at no additional cost to the owner.

F. A protective device coordination study shall be performed to select or to check the selections of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated voltage and current transformers, and low-voltage breaker trip characteristics and settings. The coordination study shall include all voltage classes of equipment from the utility's incoming line protective device down to and including each motor control center and/or panelboard. The phase and ground overcurrent protection shall be included, as well as settings for all other adjustable protective devices.

G. The time current characteristics of the specified protective devices shall be plotted on appropriate log-log paper. The plots shall include complete titles, representative

one-line diagram and legends, associated power company's relays of fuse characteristics, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breaker trip curves, and fuse curves. The coordination plots shall indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, ANSI transformer magnetizing inrush and withstand curves per ANSI C37.91, cable damage curves, symmetrical and asymmetrical fault currents. All requirements of the current National Electric Code shall be adhered to. Reasonable coordination intervals and separation of characteristic curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a complete system basis. Sufficient curves shall be used to clearly indicate the coordination achieved to each utility main breaker, primary feeder breaker, unit substation primary protective device rated or more. There shall be a maximum of four protective devices per plot.

H. The selection and settings of the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios, manufacturer, type, range of adjustment, and recommended settings. A tabulation of the recommended power fuse selection shall be provided for all fuses in the system. Discrepancies, problem areas, or inadequacies shall be coordinated with the equipment suppliers and resolved with in the scope of the project and at no additional cost to the owner.

I. The results of the power system study shall be summarized in a final report and made part of the operation and maintenance manuals. The report shall include the following sections;
   1. Description, purpose, basis written scope, and a single line diagram of the portion of the power system which is included within the scope of study.
   2. Tabulations of circuit breaker, fuse and other equipment ratings versus calculated short circuit duties, and commentary regarding same.
   3. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection and commentary regarding same.
   4. Fault current tabulations including a definition of terms and a guide for interpretation.

2.03 The contractors certified study firm shall be responsible for setting the breakers. Each breaker shall be fitted with an engraved tag or permanent vinyl label indicating the breaker name and the settings listed: Adjustable pickups and time delays (long time, short time, ground); Adjustable time-current characteristic; Adjustable instantaneous pickup; Recommendations shall incorporate revised settings to mitigate excessive arc flash hazard.

2.04 ARC FLASH EVALUATION

A. Provide an investigation to quantify the arc-flash hazard to which workers could be exposed to throughout the facility. Establish arc-flash intensity data for all electrical equipment where there may be an occasion to open doors, remove covers or work on the electrical equipment in such a way that workers are exposed to energized conductors.

B. Provide a safety policy to include procedures and information regarding the arc flash

data developed for the site. Provide a written recommendation for PPE equipment following the simplified approach to PPE defined in NFPA 70E Annex H. The site safety manual to include procedures and methods related to energized work, PPE standards, and the arc-flash data developed in the analysis.

C. Provide arc flash evaluations in conformance to the latest edition of IEEE Std. 1584- *IEEE Guide for Performing Arc-Flash Hazard Calculations* and NFPA 70- *National Electrical Code* and NFPA 70E-*Standard for Electrical Safety in the Workplace.* The arc flash study shall be performed using computer software that uses methods based on IEEE Std. 1584. The software used must be capable of modeling all protective devices at the site and any mitigation devices used to limit the incident energy. The software used must have the capability of modeling user defined PPE descriptions and ATPV values as well as limiting the maximum clearing time where engineering judgment deems it prudent.

D. The study firm shall collect all data required for the arc flash evaluation. The existing settings and equipment types and ratings shall be field verified. Any data that should be determined to be unverifiable (due to safety or operational concern) shall be identified to the engineer and alternate means to determine the data shall be used.

E. Where the calculations determine that the breaker settings result in arc flash hazard of category three, four or with incident energy levels (>40 cal/cm^2), the study engineer shall provide recommended breaker settings or other mitigation recommendations to reduce the incident energy to the lowest level and where energized work is capable of being performed. The study firm shall document the recommended changes and provide time-current curves indicating the coordination that reflects the recommended settings. Where main switchgear incorporates fully compartmentalized breakers and insulated bus, analyze utility main and genset main breaker compartments separate from feeder breaker compartments.

F. Provide color coded labels per ANSI Z535.4; Orange=Warning, Red=Danger. Provide arc flash hazard/risk category 0-2 with an incident energy of 0-8cal/cm2 equipment with Orange “Warning” Labels. Provide arc flash hazard/risk category 3-4 with an incident energy of 8-40cal/cm2 equipment with Orange “Warning” Labels. Provide Red “Danger” labels with the words “Energized Work Prohibited” in areas of extreme hazard above 40cal/cm2. Provide labels as approved by the engineer consistent with utility standards and in accordance with the simplified PPE approach defined in NFPA 70E, Annex H.

G. Provide permanent labels for each electrical enclosure or equipment where workers could be exposed to energized conductors. Provide die-cut 4" x 6" labels with preprinted headers. Organize safety information in approved order to communicate quickly, clearly and accurately. Provide Die-cut labels made from industrial grade indoor/outdoor vinyl, providing a long label life. Labels shall not include study firm information. Label layout shall be approved by the project engineer. Provide orange Warning and red Danger labels for category 0-2, 3-4 and above incident energy categories. Study firm shall supervise installation of labels and provide a statement in the project report that the labels are approved as installed. These labels shall comply with the requirements of NFPA 70E and include at least the following information:

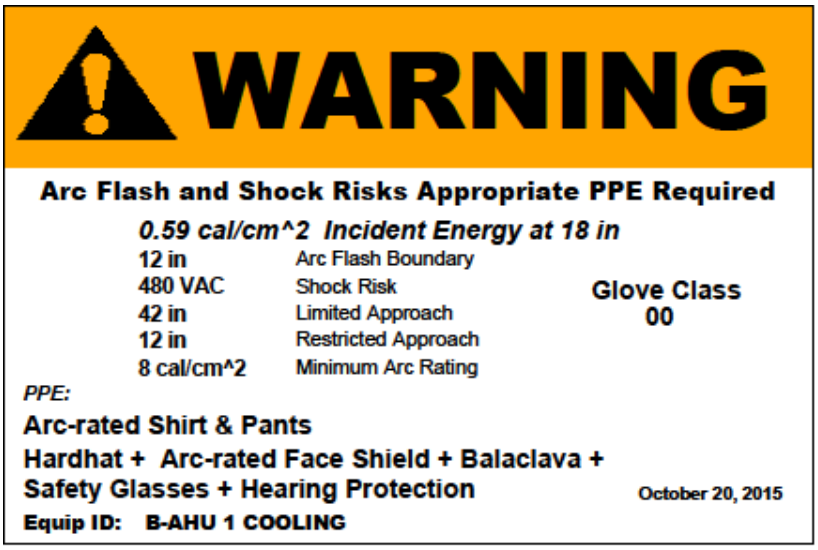
- Voltage (phase to phase).

- Flash Protection Boundary (inches).
- Incident Energy at the working distance (cal/cm^2).
- PPE Class and Description (Including glove rating).
- Restricted Approach Boundary (inches).
- Limited Shock Approach Boundary (inches).
- Prohibited Shock Approach Boundary (inches).
- Location Identification

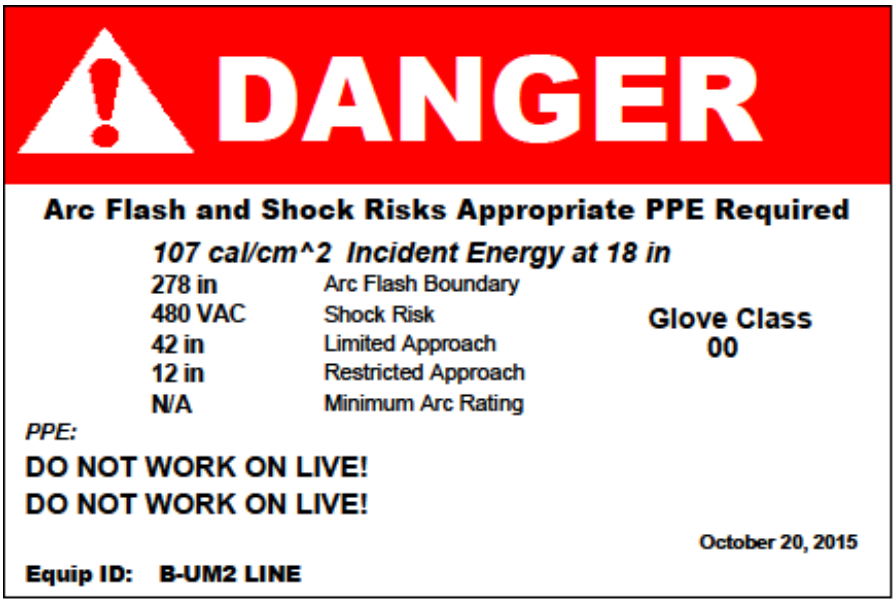
H. Provide a comprehensive report that includes the basis for and results of numerical assessments. The report shall include any significant conclusions and recommendations for corrective or mitigative action as appropriate. In addition, the report shall include the following:

- Summary of project.
- Description of system and equipment included in the assessment.
- Identification of the methods or software used.
- Date work was performed.
- Identification of the person that performed the assessment.
- Tabular data indicating; the incident energy and required PPE for all locations evaluated.
- Detailed datasheets for each location studied.
- Tabular data of recommended settings changes.
- Time-current curves for the locations with recommended settings changes.
- A one-line diagram of the computer model.

I. Sample Arc Flash Labels:


WARNING
Arc Flash and Shock Risks Appropriate PPE Required
0.59 cal/cm^2 Incident Energy at 18 in
12 in Arc Flash Boundary
480 VAC Shock Risk
42 in Limited Approach
12 in Restricted Approach
8 cal/cm^2 Minimum Arc Rating
Glove Class 00
PPE:
Arc-rated Shirt & Pants
Hardhat + Arc-rated Face Shield + Balaclava +
Safety Glasses + Hearing Protection
October 20, 2015
Equip ID: B-AHU 1 COOLING


WARNING
Arc Flash and Shock Risks Appropriate PPE Required
14 cal/cm^2 Flash Risk at 24 in
128 in Flash Risk Boundary
480 VAC Shock Risk
42 in Limited Approach
12 in Restricted Approach
40 cal/cm^2 Minimum Arc Rating
Glove Class 00
PPE:
Arc-rated Shirt & Pants + Multi Layer Flash Suit
Hardhat + Arc-rated Flash Suit Hood + Safety
Glasses + Hearing Protection
July 15, 2015
Equip ID: BUS-GEN



END OF SECTION

SECTION 26 08 00

ACCEPTANCE TESTING AND PERFORMANCE VERIFICATION

PART 1- GENERAL

1.01 GENERAL SCOPE

A. The Contractor shall engage the services of a recognized corporately and financially independent testing firm for the purpose of performing inspections and tests on all new electrical equipment supplied in this contract and on existing modified equipment as herein specified. All tests shall be documented. It is the intent of these Specifications that the testing firm work in direct communication with the engineer of record with frequent testing data updates as the work progresses.

B. The testing firm shall provide all material, equipment, labor and technical supervision to perform such tests and inspections. Testing shall be supervised by qualified professional engineering staff.

C. It is the purpose of these tests to assure that all tested electrical equipment, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications. Tests shall be performed with and in cooperation with certification tests performed by switchgear and generator manufacturer. The testing contractor shall be an integral part in assuring the coordinated testing and startup of the power system. The tests and inspections shall determine suitability for energization.

D. An itemized description of existing equipment (wellfield equipment) to be inspected and tested is as follows:
   1. Provide testing of existing feeders that are relocated, extended or disturbed in any way.
   2. Provide testing of existing breakers that are re-fed, relocated, re-cabled or disturbed in any way.

E. The above electrical testing shall be used in the development of the final testing report encompassing all new and existing electrical equipment; submitted with the operation and maintenance manuals prior to substantial completion of the project. The testing report shall be submitted on 8.5-inch by 11-inch paper bound with all field test data in appendix form plus an electronic copy in Adobe PDF format. All tested breakers shall be fitted with a sticker indicating the testing firm, date and technician performing the test.

1.02 APPLICABLE CODES, STANDARDS, AND REFERENCES

A. All inspections and test shall be in accordance with the following codes and standards except as provided otherwise herein:
   1. National Electrical Manufacturer's Association – NEMA.
   2. American Society for Testing and Materials – ASTM.
   3. Institute of Electrical and Electronic Engineers – IEEE.
   4. International Electrical Testing Association - NETA Acceptance Testing Specifications - ATS-1991.
   5. American National Standards Institute - ANSI C2: National Electrical

Safety Code.

6. State and local codes and ordinances.
7. Insulated Cable Engineers Association – ICEA.
8. Association of Edison Illuminating Companies – AEIC.
9. Occupational Safety and Health Administration – OSHA.
10. National Fire Protection Association – NFPA.
    a. ANSI/NFPA 70: National Electrical Code.
    b. ANSI/NFPA 70B: Electrical Equipment Maintenance.
    c. NFPA70E: Standard for Electrical Safety in the Workplace.
    d. ANSI/NFPA 780: Lightning Protection Code.
    e. ANSI/NFPA 101: Life Safety Code.

B. All inspections and test shall utilize the following references:
11. Project design Specifications.
12. Project design Drawings.
13. Manufacturer's instruction manuals applicable to each particular apparatus.

1.03 QUALIFICATIONS OF TESTING FIRM

A. The testing firm shall be an independent testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, supplier, and installers of equipment or systems evaluated by the testing firm.

B. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

C. The testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or be a Full Member company of the International Electrical Testing Association (NETA).

D. The lead, on-site, technical person shall be currently certified by the International Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing or be a electrical professional engineer in the state of Florida.

E. The testing firm shall utilize engineers and technicians who are regularly employed by the firm for testing services. The testing firm shall provide in house electrical studies and reports as specified. The testing firm shall have a Florida registered professional electrical engineer on staff.

F. The testing firm shall submit proof of the above qualifications when requested. Pre-qualified testing firms for this Project are:
1. Emerson Electrical Reliability Services, Inc.
2. Industrial Electrical Testing, Inc.
3. Electric Power Systems.
4. Circuit Breaker Sales & Service.

G. Other firms will be considered by the engineer on submittal of qualifications on or

before 20 days prior to Bid.

1.04 DIVISION OF RESPONSIBILITY

A. The Contractor shall perform routine insulation-resistance, continuity, and rotation test for all distribution and utilization equipment prior to and in addition to tests performed by the testing firm specified herein.

B. The Contractor shall supply a suitable and stable source of electrical power to each test Site.

C. The Contractor shall notify the testing firm when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling. However the testing firm shall visit the Site a minimum of once a week to perform coordination duties required and make reports to the engineer of the installation progress.

D. The testing firm shall notify the engineer prior to commencement of any testing.

E. Any system, material, or workmanship which is found defective on the basis of acceptance tests shall be reported to the Engineer.

F. The testing firm shall maintain a written record of all tests and, upon completion of project, shall assemble and certify a final test report.

G. Safety and Precautions:
   1. Safety practices shall include, but are not limited to, the following requirements:
      a. Occupational Safety and Health Act.
      b. Accident Prevention Manual for Industrial Operations, National Safety council.
      c. Applicable state and local safety operating procedures.
      d. Owner's safety practices.
      e. National Fire Protection Association - NFPA 70E-2009.
      f. American National Standards for Personnel Protection.
   2. All test shall be performed with apparatus de-energized. Exceptions must be thoroughly reviewed to identify safety hazards and devise adequate safeguards.
   3. The testing firm shall have a designated safety representative on the project to supervise the testing operations with respect to safety.

1.05 SUITABILITY OF TEST EQUIPMENT

A. All test equipment shall be in good mechanical and electrical condition.

B. Digital multimeters used shall be RMS sensing when the variable be measured contains harmonics or dc offset or any deviation from a pure sine wave. Accuracy of metering in test equipment shall be appropriate for the test being performed but not in excess of 2 percent of the scale used.

PART 2- INSPECTION AND TEST PROCEDURES

2.01 SWITCHGEAR, SWITCHBOARD AND PANELBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:
1. Inspect for physical, electrical, and mechanical condition.
2. Compare equipment nameplate information with latest one-line diagram.
3. Check for proper anchorage, required are clearances, physical damage and proper alignment.
4. Inspect all doors, panels, and sections for paint, dents, scratches, fit and missing hardware.
5. Verify that fuse and/or circuit breaker sizes and types correspond to Drawings.
6. Verify that current and potential transformer ratios correspond to drawings. Inspect all bus connections for high resistance.
7. Check tightness of bolted bus joints by using a calibrated torque wrench. Refer to manufacturer's instructions for proper torque levels. Inspect shipping splits for mechanical connection assuring adequate surface contact.
8. Test all electrical and mechanical interlock systems for proper operation and sequencing. Closure attempt shall be made on locked open devices. Opening attempt shall be made on locked closed devices. Key exchange shall be made with devices operated in off normal positions.
9. Clean entire switchgear using manufacturer's approved methods and materials.
10. Inspect insulators for evidence of physical damage or contaminated surfaces.
11. Verify proper barrier and shutter installation and operation.
12. Lubrication: Verify appropriate contact lubricant on moving current carrying parts. Verify appropriate lubrication on moving and sliding surfaces.
13. Exercise all active components.
14. Inspect all mechanical indicating devices for proper operation.

B. Electrical Tests:
1. Perform tests on all instrument transformers.
2. Perform ground resistance tests.
3. Perform insulation resistance on each bus section, phase-to-phase and phase-to-ground for three (3) minutes. Test voltages and minimum resistances shall be in accordance with NETA recommendations.
4. Perform low ohm resistance test on ground bonding & shipping splits with ductor tester (Digital low ohm resistance meter) to insure connection is a low resistance connection. Test from one fixed bus to adjacent fixed bus through the shipping split connector to measure both connection points. Microhm values shall not vary more than 50 percent from other phase readings and meet the manufactures published data based on bus size, ampacities and material.
5. Perform an overpotential test on each bus section, each phase-to-ground, for three (3) minutes at values indicated in ANSI/IEEE C37.20.2. or manufacturer's recommended potential.
6. Perform insulation-resistance test on control wiring except where

connected to solid state components.

7. Perform control wiring performance test. Use the elementary diagrams of the switchgear to identify each remote control and protective device. Conduct tests to verify satisfactory performance of each control feature.
8. Perform secondary voltage energization test on all control power circuits and potential circuits as detailed in this specification. Check voltages levels at each point on terminal boards and at each terminal on devices.
9. Perform current injection tests on the entire current circuit in each section of switchgear. Perform current test by primary injection where possible; secondary injection if not.
10. Determine accuracy of all meters and calibrate watt-hour meters. Verify multipliers.
11. Perform phasing check on double-ended switchgear to ensure proper bus phasing from each source.
12. Control Power Transformers - Dry Type:
    a. Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
    b. Verify proper primary and secondary fuse ratings or circuit breakers.
    c. Verify proper interlock function and contact operation.
    d. Perform insulation-resistance test. Perform measurements from winding-to-winding and windings-to-ground.
    e. Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to proper secondary voltage. Check potential at all devices. Verify proper secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
13. Potential Transformer Circuits:
    a. Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to proper secondary voltage. Check for proper potential at all devices.
    b. Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.

C. Test Values: Verify Bolt-torque values, Insulation resistance, overpotential levels in conformance to NETA standards or specified by manufacturer.

2.02 CABLES - LOW VOLTAGE - 600V MAXIMUM (ALL CABLES EXCEPT 20 AND 30AMP LIGHTING AND RECEPTACLE CIRCUITS).

A. Visual and Mechanical Inspection:
1. Inspect cables for physical damage and proper connection in accordance with Drawings.
2. Test cable mechanical connections to manufacturer's recommended values or NETA Standards using a calibrated torque wrench.
3. Check cable color coding with applicable engineer's specifications and National Electrical Code standards.

B. Electrical Tests:

1. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1,000-volts dc for 3 minutes.
2. Perform continuity test to insure proper cable connection.
3. Test Values; Evaluate results by comparison with cables of same length and type. Minimum acceptable value shall be no less than 50 megohms for new feeders; 5megohms for existing reused, renovated, rerouted or extended feeders.

2.03 CIRCUIT BREAKERS (ALL BREAKERS EXCEPT 20AMP LIGHTING AND RECEPTACLE BREAKERS; TEST ALL GFCI BREAKERS)

A. Circuit Breakers - Low Voltage insulated case/molded case:
1. Visual and Mechanical Inspection:
   a. Check circuit breaker for proper mounting and compare nameplate data to drawings and specifications.
   b. Operate circuit breaker to ensure smooth operation.
   c. Inspect case for cracks or other defects.
   d. Check tightness of connections using calibrated torque wrench. Refer to manufacturer's instructions or NETA standards for proper torque levels.
2. Electrical Tests:
   a. Perform a contact-resistance test.
   b. Perform an insulation-resistance test at 1,000-volts dc from pole to pole and from each pole to ground with breaker closed and across open contacts of each phase.
   c. Determine long-time minimum pickup current by primary current injection where practical.
   d. Perform long-time delay time-current characteristic tests by passing three hundred percent (300%) rated current through each pole separately. Record trip time.
   e. Determine short-time pickup and delay by primary current injection, if applicable.
   f. Determine ground-fault pickup and time delay by primary current injection, if applicable.
   g. Determine instantaneous pickup current by primary injection using run-up or pulse method.
3. Test Values:
   a. Compare contact resistance or millivolt drop values to adjacent poles and similar breakers. Investigate deviations of more than fifty percent (50%). Investigate any value exceeding manufacturer's recommendations.
   b. Insulation resistance shall not be less than 100 megohms.
   c. Trip characteristic of breakers shall fall within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
   d. All trip times shall fall within NETA Standards. Circuit breakers exceeding specified trip time at three hundred percent (300%) of pickup shall be tagged defective.
   e. Instantaneous pickup values shall be within NETA standards.

2.04 METERING AND INSTRUMENTATION

A. Visual and Mechanical Inspection:
   1. Examine all devices for broken parts, shipping damage and tightness of connections.
   2. Verify that meter types, scales and connections are in accordance with Drawings and Specifications.

B. Electrical Tests:
   1. Determine accuracy of meters at 25/50/75/100 percent of full scale.
   2. Calibrate watt-hour meters to one-half percent (0.5%).
   3. Verify all instrument multipliers.
   4. Verify calibration of all instrumentation is accurate to the operator interface terminals.

2.05 GROUNDING SYSTEMS: (PROVIDE FOR NEW AND UPGRADED GROUNDING SYSTEMS)

A. Visual and Mechanical Inspection:

B. Inspect ground systems for compliance with Drawings and Specifications.

C. Perform ground-impedance measurements utilizing the fall-of-potential method per ANSI/IEEE Standard 81 "IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System." Instrumentation utilized shall be as Approved by NETA Standards and shall be specifically designed for ground impedance testing. Provide sufficient spacing so that plotted curves flatten. In large ground grid systems where adequate pole distance is not practical provide Tagg Slope technique or the intersecting curves method (Ref. Nos. 40 and 41 in IEEE Std. 81.) of calculating system resistance.

D. Equipment Grounds: Utilize two-point method of IEEE Standard 81. Measure between equipment ground being tested and known low-impedance grounding electrode of system:
   1. Lightning protection ground system test values within the ground system should be 5 ohms or less tested with a clamp on ground test instrument. Down conductor tests at grade level should be 2 ohms or less. Investigate high resistance connections and correct readings above these limits.
   2. The main ground electrode system impedance-to-ground should be no greater than one (1) ohms. Equipment grounds, depending on size and length of grounding conductor, should be only fractionally higher than system ground.

2.06 GROUND-FAULT SYSTEMS

A. Visual and Mechanical Inspection:
   1. Inspect for physical damage and compliance with Drawings and Specifications.
   2. Inspect neutral main bonding connection to assure:
      a. Zero-sequence sensing system is grounded.
      b. Ground-strap sensing systems are grounded through sensing

device.
c. Ground connection is made ahead of neutral disconnect link on zero-sequence sensing systems.
d. Grounded conductor (neutral) is solidly grounded.

3. Inspect control power transformer to ensure adequate capacity for system.
4. Manually operate monitor panels (if present) for: Trip test; No trip test; Non-automatic reset.
5. Record proper operation and test sequence.
6. Set pick-up and time-delay settings in accordance with the settings provided by the manufacturer.

B. Electrical Tests:

1. Measure system neutral insulation resistance to ensure no shunt ground paths exist. Remove neutral-ground disconnect link. Measure neutral insulation resistance and replace link.
2. Determine the relay pickup current by current injection at the sensor and operate the circuit interrupting device.
3. Test the relay timing by injecting three hundred percent (300%) of pickup current, or as specified by manufacturer.
4. Test the system operation at fifty-seven percent (57%) rated control voltage, if applicable.
5. Test zone interlock systems by simultaneous sensor current injection and monitoring zone blocking function.
6. On multiple source, tie breaker, etc., systems, devise a simulation scheme that fully proves correct operation.

C. Test Parameter:

1. System neutral insulation shall be a minimum of one hundred (100) ohms, preferable one (1) megohm or greater.
2. Relay timing shall be in accordance with manufacturer's published time-current characteristic curves but in no case longer than one (1) second for fault currents equal to or greater than 3,000 amperes.
3. Relay pickup value shall be within 10 percent of setting and in no case greater than 1,200A.

2.07 MOTORS (1 hp and Greater)

A. Visual and Mechanical Inspection:

1. Inspect for physical damage.
2. Inspect for proper anchorage, mounting, grounding, connection and lubrication.
3. When applicable, perform special tests as air gap spacing and pedestal alignment.

B. Electrical Tests - Induction Motors:

1. Perform insulation resistance tests in accordance with ANSI/IEEE Standard 43.
2. Motors 200 hp and Less - Test duration shall be for one minute with resistances tabulated at 30 and 60 seconds and calculate the dielectric absorption ratio. Motors larger than 200 hp perform tests for ten minutes

and calculate polarization index. Minimum acceptable polarization index for Class B or F insulated motors shall be 2.0.

3. Perform insulation resistance test on pedestal per manufacturer instructions.
4. Perform insulation resistance test on surge protection device in accordance with this Specification.
5. Check that the motor space heater circuit is in proper operating conduction.
6. Check all protective devices in accordance with other sections of these Specifications.
7. Perform a rotation test to ensure proper shaft direction if the motor has been disconnected.
8. Measure running current and evaluate relative to load conditions and nameplate full load amperes. Verify proper overload relays.

2.08 MOTOR CONTROL (ALL MOTORS)

A. Visual and Mechanical Inspection:
   1. Inspect for physical damage, proper anchorage, and grounding.
   2. Inspect equipment for compliance with drawings and specifications.
   3. Motor-running protection
      a. Compare overload heater rating with motor full-load current rating to verify proper sizing.
      b. If motor-running protection is provided by fuses, verify proper rating considering motor characteristics and power-factor correction capacitors if applicable. Check tightness of bolted connections using calibrated torque wrench.

B. Electrical Tests:
   1. Insulation tests:
      a. Measure insulation resistance of each bus section phase-to-phase and phase-to-ground for three (3) minutes. Test voltage shall be in accordance with NETA Standards.
      b. Measure insulation resistance of each starter section phase-to-phase and phase-to-ground with the starter contacts closed and the protective device open. Test voltage shall be in accordance with NETA Standards.
      c. Measure insulation resistance of each control circuit with respect to ground.
   2. Test motor overload units by injecting current through overload unit and monitoring trip time at three hundred percent (300%) of motor full-load current.
   3. Three phase power unbalance: Run motor at full load steady state conditions and take current readings on all three leads. Roll the motor leads maintaining the proper rotation and take motor current readings on all three possible hook-ups. Choose the least unbalance hookup for each motor. The maximum acceptable unbalance is 10 percent at full load. If the unbalance cannot be corrected by rolling leads, the source of the unbalance must be located and corrected. If on the three possible hook ups, the leg of "greatest unbalance" (furthest from the average) stays on the same power lead then most of the unbalance is being caused by the

power source. However, if the leg of greatest unbalance moves on each of the hookups with a particular motor lead, the primary source of unbalance is on the motor side of the starter. Check for damaged cable, leaking splices, poor connections, or faulty motor winding.

2.09 TRANSFORMERS - DRY TYPE TRANSFORMERS - SMALL DRY TYPE, AIR-COOLED (600 VOLT AND BELOW)

A. Inspect for physical damage, broken insulation, tightness of connections, defective wiring, and general condition.

B. Thoroughly clean unit prior to making any tests.

C. Perform insulation-resistance test. Perform test verification for impedance.

D. Energize primary winding with system voltage. Measure secondary voltage with the secondary load disconnected. Record results.

2.10 THERMOGRAPHIC SURVEY (PROVIDE FOR ALL NEW OR MODIFIED SWITCHGEAR, BUS DUCTS, TRANSFORMERS, POINTS OF POWER CONNECTION EQUAL TO OR GREATER THAN 30AMPS, MCC'S AND DISTRIBUTION CENTERS)

A. Visual and Mechanical:
   1. Remove all necessary covers prior to scanning.
   2. Inspect for physical, electrical, and mechanical condition.

B. Equipment to be Scanned:
   1. All new and existing equipment with ratings of 30 amps or more.

C. Provide report indicating the following:
   1. Problem area (location of "hot spot").
   2. Temperature rise between "hot spot" and normal or reference area.
   3. Cause of heat rise.
   4. Phase unbalance, if present.
   5. Areas scanned.

D. Test Parameters:
   1. Scanning distribution system with ability to detect 1^{o}C between subject area and reference at 30^{o}C.
   2. Equipment shall detect emitted radiation and convert detected radiation to visual signal.
   3. Infrared surveys should be performed during periods of maximum possible loading but not less than twenty percent (20%) of rated load of the electrical equipment being inspected.
   4. Provide photographs and/or the thermogram of the deficient area as seem on the imaging system.

2.11 LOW VOLTAGE SURGE SUPPRESSORS

A. Visual and mechanical inspection:
   1. Verify suppressors are installed with minimum length leads to the

protected equipment. Verify connections to bus.

2. Verify ground connections to ground bus.

B. Electrical tests:

1. Test clamping voltage and verify meets specified ratings; test in accordance with ANSI C62.33 section 4.4 and 4.7.

2.12 LOW VOLTAGE AIR SWITCHES (DISCONNECT SWITCHES, MANUAL AND AUTOMATIC TRANSFER SWITCHES)

A. Visual and mechanical inspection:

1. Compare equipment nameplate data with drawings and specs.
2. Inspection for mechanical and physical damage. Cleaning of interior, insulators, arc chutes.
3. Testing of mechanical operator. Cleaning and lubrication of contacts and mechanism, as applicable.
4. Verification of contact alignment and wipe. Verify phase barrier insulation.
5. Inspect anchorage, alignment, grounding, and required clearances.
6. Documentation of fuse and types are in accordance with drawings, short circuit studies and coordination study.
7. Verification of tightness of accessible bolted electrical connections by calibrated torque-wrench method.
8. Verification of presence of expulsion-limiting devices on all holders having expulsion-type elements.
9. Verification of interlocking systems for proper operation and sequencing.
10. Verify proper lubrication on current carrying and moving sliding parts.

B. Electrical tests:

1. Contact resistance testing across each switch blade and fuse holder.
2. Measurement of fuse resistance.
3. Insulation resistance testing on each pole, phase-to-phase and phase-to-ground with switch closed and across each open pole for one minute.
4. ac or dc overpotential testing phase-to-phase and phase-to-ground.
5. Verification of proper space heater operation.

END OF SECTION

SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 – GENERAL

1.01 DESCRIPTION-this section specifies the furnishing, installation and connection of the dry type general-purpose transformers.

1.02 RELATED WORK

A. Section 26 05 11, Special Requirements for Electrical Installations:
B. Section 26 05 33, Conduit Systems:
C. Section 26 05 19, Low-Voltage Wire and Cables
D. Section 26 05 26, Grounding And Bonding For Electrical Systems:

1.03 SUBMITTALS

A. In accordance with Section 26 05 02 Basic Electrical Materials and Methods.

B. Shop Drawings:
1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Include electrical ratings, impedance, dimensions, weight, mounting details, decibel rating, terminations, temperature rise, no load and full load losses, and connection diagrams.
3. Complete nameplate data including manufacturer's name and catalog number.

C. Manuals:
1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets and wiring diagrams.

1.04 REFERENCES

A. National Fire Protection Association (NFPA) 70-08 National Electrical Code (NEC)

B. National Electrical Manufacturers Association (NEMA): ST 20-97 Dry-Type Transformers for General Applications

PART 2 – PRODUCTS

2.01 GENERAL PURPOSE DRY TYPE TRANSFORMERS

A. Unless otherwise specified, dry type transformers shall be in accordance with NEMA, NEC and as shown on the drawings. Transformers shall be UL listed or labeled.

B. Dry type transformers shall have the following features:

1. Self-cooled by natural convection, isolating windings, indoor, dry type. Autotransformers will not be accepted.
2. Rating shall be as shown on the drawings. Ratings shown on the drawings are for continuous-duty without the use of cooling fans.
3. Transformers shall have copper windings.
4. Insulation systems:
   a. Transformers 30 KVA and larger: UL rated 220 degrees C system having an average maximum rise by resistance of 150 degrees C in a maximum ambient of 40 degrees C.
   b. Transformers below 30 KVA: Same as for 30 KVA and larger or UL rated 185 degrees C system having an average maximum rise by resistance of 115 degrees C in a maximum ambient of 40 degrees C.
5. Core and coil assemblies:
   a. Rigidly braced to withstand the stresses caused by short circuit currents and rough handling during shipment.
   b. Cores shall be grain oriented, non-aging, and silicon steel.
   c. Coils shall be continuous windings without splices except for taps.
   d. Coil loss and core loss shall be minimum for efficient operation.
   e. Primary and secondary tap connections shall be brazed or pressure type.
   f. Coil windings shall have end fillers or tie downs for maximum strength.
6. Certified sound levels determined in accordance with NEMA, shall not exceed the following:

Transformer Rating	Sound Level Rating
0 - 9 KVA	40 dB
10 - 50 KVA	45 dB
51 - 150 KVA	50 dB
151 - 300 KVA	55 dB
301 - 500 KVA	60 dB

7. Nominal impedance shall be as per NEMA.
8. Single phase transformers rated 15 KVA through 25 KVA shall have two, 5 percent full capacity taps below normal rated primary voltage. All transformers rated 30 KVA and larger shall have two, 2-1/2 percent full capacity taps above, and four, 2-1/2 percent full capacity taps below normal rated primary voltage.
9. Core assemblies shall be grounded to their enclosures by adequate flexible ground straps.
10. Enclosures:
    a. Not less than code gage steel.

b. Outdoor enclosures shall be NEMA 4X stainless steel powder coated white or NEMA 3R stainless steel painted grey.
c. Temperature rise at hottest spot shall conform to NEMA Standards, and shall not bake and peel off the enclosure paint after the transformerhas been placed in service.
d. Ventilation openings shall prevent accidental access to live components.
e. Thoroughly clean and paint enclosure at the factory with manufacturer's prime coat and standard finish.

11. Standard NEMA features and accessories including ground pad, lifting provisions and nameplate with the wiring diagram and sound level indicated on it.
12. Dimensions and configurations shall conform to the spaces designatedfor their installations.
13. Transformers shall meet the minimum energy efficiency values per NEMA TP1 as listed below:

kVA Rating	Output efficiency (%)
15	97
30	97.5
45	97.7
75	98
112.5	98.2
150	98.3
225	98.5
312	98.6

PART 3 – EXECUTION

3.01 INSTALLATION

A. Installation of transformers shall be in accordance with the NEC, as recommended by the equipment manufacturer and as shown on the drawings.

B. Install the transformers with adequate clearance at a minimum of 4 inches from wall and adjacent equipment for air circulation to remove the heat produced by transformers.

C. Install transformers on vibration pads designed to suppress transformer noise and vibrations.

D. Use flexible metal conduit to enclose the conductors from the transformer to the raceway systems.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 – GENERAL

1.01 SCOPE

A. The CONTRACTOR shall provide panelboards and general purpose dry-type transformers, complete and operable, in accordance with the Contract Documents.

B. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.02 REFERENCES: The latest edition of the following codes or standards shall apply.

A. NEC (NFPA 70) National Electrical Code
B. NEMA 250 Enclosure for Electrical Equipment (1,000 Volts Maximum)
C. UL 50 - Standard for Safety for Enclosures for Electrical Equipment
D. UL 67 - Panelboards

1.03 SUBMITTALS: General: Submittals shall be in accordance section 26 05 02 Basic Materials and Methods.

A. Breaker layout drawings with dimensions and nameplate designations
B. Drawings of conduit entry/exit locations.
C. Assembly ratings including: Short circuit rating, Voltage; Continuous current
D. Cable terminal sizes
E. Descriptive bulletins
F. Product sheets

PART 2 – PRODUCTS

2.01 GENERAL: Provide panelboards by Square-D or Cutler Hammer.

A. Panelboard shall be dead front factory assembled. Panelboards shall comply with NEMA PB-1-Panelboards, as well as the provisions of UL 50 - Safety Enclosures for Electrical Equipment and UL 67 - Panelboards. Panelboards used for service equipment shall be UL labeled for such use. Lighting panelboards shall be rated for 120/208-volt, 3-phase operation or 120/240-volt for single phase operation as indicated. Power panelboards shall be rated for 480 volts, 3-phase, 3 wire operation as indicated.

B. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.

C. Panelboards rated 240 VAC or less shall have short circuit ratings not less than 10,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

D. Panelboards rated 480 VAC shall have short circuit ratings not less than 42,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

E. Panelboards shall be labeled with a UL short circuit rating. Series ratings are not acceptable.

2.02 CONSTRUCTION

A. All lighting and power distribution panels shall have copper bus bars density rated for maximum of 1,000 amps/sq-in. Enclosures for panelboards shall be galvanized and painted steel except enclosures for panelboards located in corrosive, damp or wet locations shall be stainless steel and NEMA-4X

B. Breakers shall be one, two, or three pole as indicated, with ampere trip ratings as required by the equipment. Breakers shall be quick-make and quick-break, inverse time trip characteristics, to trip free on overload or short circuit, and to indicate trip condition by the handle position. Double and triple pole breakers shall be of the common trip, single handle type.

C. The panels shall have hinged doors with combination catch and latch. The front panels shall be so arranged that when the plates are removed, the gutters, terminals and wiring will be exposed and accessible. The doors shall have inner doors within the plates to have only the breaker operating mechanism exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.

D. All circuit breakers shall be interchangeable and bolt on type capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units. Plug-in circuit breakers are not acceptable.

E. Panelboards shall be UL listed.

F. Size of wiring gutters and gauge of steel shall be in accordance with NEMA Standards Publication No. PBI 57 and UL Standards No. 67. Cabinets shall be minimum 20" wide for all panels.

PART 3 – EXECUTION

3.01 GENERAL

A. Surface mount panelboards on wall, as indicated on project drawings, at an elevation convenient for operation and as required in the latest NEC.

B. Install typewritten or computer generated circuit directory in panelboards. The directory shall be coordinated with the identification of equipment as shown on the contract drawings and clearly indicating the serving load.

END OF SECTION

SECTION 26 24 20

ELECTRIC MOTORS

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section describes materials, installation and testing of induction motors and applies to motors which are provided as part of equipment specified in other sections. Contractor shall furnish motors in conformance to this section and with the individual specification sections of the driven equipment for a complete and operable system. It shall be the contractor's responsibility to bring to the attention of the engineer any conflict between this section and the driven equipment section for engineer's resolution prior to purchase; in general most stringent best quality governs.

B. Motors which are an integral part of standard manufactured driven equipment (submersible pumps, motor valve operators) may be exempt from this specification where necessary and required by the manufacturer of the equipment.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 26 29 23 Variable Frequency Drives
B. Section 26 08 00 Acceptance Testing & Performance Verification

1.03 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions.

B. Show complete nameplate data, horsepower, current, voltage, phase, and frequency ratings, NEMA design, Frame Size, starting code letter or locked rotor KVA, efficiency and power factor, winding insulation class and treatment, rated ambient temperature, service factor, mounting arrangements, size and location of conduit entry, location and size of grounding lug, and coatings.

C. Submit guaranteed full load efficiency.

1.04 FACTORY TESTS

A. Tests shall comply with NEMA Standard MG1-12.51 and MG 1-23.46.

B. For high efficiency motors, provide certified test results of percent efficiency and power factor data at full, 75% and 50% load.

C. Test thermally protected motors in accordance with NEMA Standard MG 1 winding temperature and trip current tests.

1.05 CONTROLLER COORDINATION

A. Where motor controllers are furnished, provide reviewed shop drawings to the controller manufacturer for coordination and sizing of the controller.

1.06 QUALITY ASSURANCE

A. NEMA Compliance: Unless otherwise indicated, comply with NEMA standard MG 1.

B. U.L. Listing: Motors for applications in hazardous locations shall bear the U.L. label listing its use in accordance with NEC.

C. ANSI/IEEE 112; Test Procedures for polyphase induction motors.

PART 2 – PRODUCTS

2.01 GENERAL MOTOR DESIGN REQUIREMENTS

A. All motors furnished shall be designed, manufactured, and tested in accordance with the latest applicable standards of NEMA, ANSI, IEEE, and ASTM. As a minimum requirement, all motors shall conform to the latest applicable sections of NEMA Standard No. MG-1. Motors must meet or exceed CEE Premium Efficiency™ full load efficiencies. The Consortium for Energy Efficiency (CEE), a national, non-profit public benefits corporation, promotes the manufacture and purchase of energy-efficient products and services.

B. Per CEE Premium Efficiency™ Criteria, minimum efficiencies for TEFC motors shall be equal to or greater than those shown below:

HP	1200 RPM	1800 PM	3600 RPM
1	82.5	85.5	78.5
1.5	87.5	86.5	85.5
2	88.5	86.5	86.5
3	89.5	89.5	88.5
5	89.5	89.5	89.5
7.5	91.7	91.7	91.0
10	91.7	91.7	91.7
15	92.4	92.4	91.7
20	92.4	93.0	92.4
25	93.0	93.6	93.0
30	93.6	93.6	93.0
40	94.1	94.1	93.6
50	94.1	94.5	94.1
60	94.5	95.0	94.1
75	95.0	95.4	94.5
100	95.4	95.4	95.0
125	95.4	95.4	95.4
150	95.8	95.8	95.4

200	95.8	96.2	95.8

C. Unless otherwise specified or specifically required by the manufacturer of the equipment to be driven, alternating current motors shall be single speed, non-reversing, squirrel cage induction motors, NEMA design B. Motors 15 horsepower and larger shall be NEMA starting code F or G. Motors smaller than 15 horsepower may be manufacturers' standard starting characteristics. Stator windings shall be copper.

D. The connected load (maximum horsepower required) of each motor shall not exceed its nameplate horsepower rating (exclusive of service factor) under any operating condition.

E. Connection box shall be cast metal with gaskets between the box and housing and between the box and cover. Provide a grounding terminal in the connection box.

F. Open dripproof and weather-protected motors shall have a service factor of 1.15. Inverter Duty (VFD) rated motors shall have a service factor of 1.15 for sine wave power and 1.0 for inverter power. Totally enclosed fan cooled motors shall have a service factor of 1.15.

G. Unless otherwise noted, motors shall be rated for continuous duty at an ambient temperature of 40^{o}C and at an altitude of 3,300 feet. High ambient Motors shall be rated for continuous duty at an ambient temperature of 65^{o}C. Motors shall have 120-volt heating elements.

H. Non-submersible Motors shall have 120-volt heating elements.

I. Open dripproof and weather-protected motors 7.5 HP and larger shall have stainless steel screens over openings.

J. Motors installed in hazardous areas shall be Totally enclosed, explosion proof, suitable for use in Class 1, Division I, Group D hazardous locations, with UL label.

K. Provide motors with a guaranteed maximum noise level of 90dBA, measured at three feet from the motor surface per IEEE 85, when running at no-load connected to sine wave power.

L. Unless otherwise noted, motors shall be premium efficiency type. The efficiency shall be determined by IEEE 112 method B using sine wave power for motors up to 300 horsepower and method F for motors above 300 horsepower. Efficiency shall be listed on the nameplate in accordance with NEMA MG 1 12.53.

M. As a minimum all motors shall have manufacturer's standard tropical protection. Motors in wet locations shall be moisture sealed. Motors with form-wound coils shall have vacuum-pressure impregnated windings.

N. Motors designated to be Totally Enclosed Fan Cooled (TEFC) shall be rated for IEEE-841-2001 standards or Coro-duty where listed in pump sections of

specifications. TEFC motors shall be premium efficient, all cast iron including conduit box and fan cover guard, with stainless steel nameplate and plated hardware, with internal bearing caps and an inpro/seal on the drive end. Motor finishes shall be rated for 250hour salt spray. TEFC motors shall have a 5 year warranty.

O. In addition to nameplate information required by NEMA Standard MG 1-10.37 through 39, show on the nameplate the bearing numbers for both bearings, efficiency, power factor at full load and the maximum recommended kVAR of power capacitors to result in a 90 percent power factor. Provide all motors with stainless steel nameplates.

P. Equip all motors with thermal protection in accordance with NEMA Standard MG 1. Control leads shall be color-coded, brought out to the motor conduit box or a separate terminal box for connection.

1. Provide three series connected, thermal switches, one in each winding. Provide normally closed and normally open switches as shown on the electrical elementary drawings. Where not shown provide normally closed switches.

2.02 BEARINGS

A. Bearings for standard duty motors shall be rated for a minimum of 24,000 hours (B-10 rating); Heavy duty specified motors bearings shall be rated for a minimum of 40,000 hours (B-10 rating). Where unspecified provide bearings with B-10 ratings as follows: Less than 50hp provide 24,000hr B-10 rating; 50hp to 200hp provide B-10 rating of 40,000hr; greater than 200hp provide B-10 rating of 100,000hr.

B. Bearings shall be ball or roller anti-friction type. Fractional horsepower through 2 horsepower motors shall be furnished with life time lubricated bearings. Horizontal motors larger than 2 horsepower shall be furnished with relubricatable ball bearings.

C. Vertical Motors

1. Vertical motors shall be designed for vertical operation and shall have thrust bearings with a rated B-10 life of 40,000 hours as defined by Anti-Friction Bearing Manufacturers Association (AFBMA).

2. Thrust bearings for motors 75 horsepower and larger shall be oil lubricated. Guide bearings may be anti-friction, grease lubricated or oil lubricated.

3. Equip grease lubricated bearings with fittings in each bearing housing. Fittings shall be accessible without removal of any covers or guards. Provide drains to prevent over-lubrication.

D. Equip motors with a non-reversing ratchet as required or as indicated.

E. Bearing Protection

1. Provide bearing protection from shaft currents for all motors 20hp or greater and driven by variable frequency drives. The device shall divert shaft currents to ground or insulate the shaft so currents will not flow through bearings. The device shall be maintenance free. Provide current diverter seal equal to Inpro-Seal type CDR.

2.03 INSULATION AND TEMPERATURE RISE

A. Unless otherwise noted, provide Class F insulation limited to Class B temperature rise at unity service factor.

B. All motors indicated to be heavy duty motors in the individual equipment specifications of the contract documents shall be provided with minimum Class "H" insulation system limited to Class "B" temperature rise at unity service factor.

2.04 VOLTAGE

A. Generally provide alternating current motors 1/2 horsepower and smaller at 115 volts single phase 60 Hz, and motors 3/4 horsepower and larger at 460 volts three phase 60 Hz. Contractor shall coordinate exact requirements.

2.05 COATING

A. Do not coat cast aluminum frame motors.

B. Motors housed within equipment enclosures, such as exhaust fans, air handling units, and air conditioners, may have factory's standard prime and finish coats.

C. Coat cast-iron frame motors. Apply prime coat at the factory which shall be compatible with field applied finish coats.

D. Field apply finish coat(s) specified in the applicable equipment section.

2.06 INVERTER DUTY RATED MOTORS

A. Inverter duty rated motors (variable frequency drive (VFD) controlled motors) shall have a nameplate that states "SUITABLE FOR VFD APPLICATION". VFD motors shall not have a critical vibration frequency within the operating range of the VFD. Provide VFD rated motors with special balance option. Provide balance to .0005in for high thrust and 3600rpm motors; .0010in for all other motors.

B. Except where noted, the motor features defined by this specification shall be in addition to any mechanical and electrical feature defined in the fixed speed motor section.

C. Motor insulation shall be an "Inverter Grade" system designed to meet the voltage spike limits defined by NEMA MG1, Part 31, 1993. The insulation system must include the use of High Dielectric magnet wire which exceeds the dielectric withstand levels provided by double film or heavy film magnet wire. Complete insulation of the slot, cell and phase groups is required. The system shall be

rated for class F rise or better. The winding insulation system shall be equal to Phelps Dodge Thermaleze Quantum Shield. The system shall exhibit an insulation pulse endurance life expectancy of 150% at 60HZ when compared to typical heavy film insulation systems. The system shall exhibit an insulation pulse endurance life expectancy from fast rise time IGBT inverters of 100% at a 2.0KHZ carrier frequency.

D. Motors shall be capable of operating at 1.0 service factor on Inverter Power. Nameplate Sinewave service factor shall be 1.15 or greater.

E. Motor temperature rise shall not exceed class F insulation limits, with 115C allowable winding hot spot temperature, when operated on Inverter Power across its nameplate speed and torque envelope. Sinewave temperature rise shall be class F or better.

F. The 2 pole 4 pole 6 pole 8 pole motors shall be capable of operating a Variable Torque centrifugal pump load from base speed down to 10% of base speed. Motor shall be nameplated for 6-60 Hertz operation. Hazardous location motors may be nameplated 10-60 Hertz.

G. Stator core designs shall be of high rigidity with reinforced end turn construction to minimize mechanical fatigue of the winding, and to reduce resonant noise. Single dip and bake cycles are not acceptable.

H. Winding thermal protection, utilizing normally closed contacts (or normally open where shown on the electrical drawings) shall be sized to match the maximum safe operating temperature of the insulation system. Hazardous location motors shall have winding thermal protection sized as required to meet U.L. or as auxiliary devices where not required by U.L.

I. Maximized copper content shall be utilized to achieve high motor efficiency and thermal transfer. Table 1 lists the minimum NEMA nominal efficiency levels that must be nameplated on the motor. Low loss electrical steel shall be utilized in the stator and rotor core assemblies.

J. Nameplate data for adjustable speed operation shall be stamped on a stainless steel data plate and permanently attached to the motor frame. The minimum amount of adjustable speed data shall include:
   1. Application Type - Variable Torque and/or Constant HP.
   2. Maximum approved continuous HP.
   3. Approved speed range.
   4. Typical motor volts per hertz.
   5. S.F. on inverter power.

PART 3 – EXECUTION

3.01 STORAGE

A. Protect motors from exposure of elements for which they are not designed. Install and energize temporary electrical service to motors with electrical heaters.

B. Unless protected by manufacturer's packing, upon delivery, carefully wrap each motor in three layers of 8-mil minimum polyethylene. Secure the wrap with adhesive tape to minimize the entrance of moisture. For base mounted motors, wrap the entire assembly.

3.02 FIELD OPERATING TESTS

A. Run each motor with its control as nearly as possible under operating conditions to demonstrate correct rotation direction, alignment, wiring size, proper overload relay sizing, speed and satisfactory operation. Test interlocks and control features to verify correct wiring and operation.

B. Record current in each phase of each motor 1 horsepower and larger and include in the maintenance manual. Repair or replace motor or driven equipment if current exceeds motor nameplate value.

END OF SECTION

SECTION 26 27 13

ELECTRIC SERVICE

PART 1 - GENERAL

1.01 DESCRIPTION OF SYSTEM

A. The Electrical Utility Company will provide the electrical service of the characteristics as shown on the Drawings. This Contractor's work will begin where the Utility Company's work ends.

B. The Contractor shall furnish all labor, materials, etc., necessary for a complete approved electrical service as required for this project, including inspection and approval by the Utility and local Inspection Departments (if any) and inform the Engineer prior to energizing power lines.

C. This Contractor shall notify the Utility Company in writing, with two copies to the Engineer, no later than ten (10) days after signing contracts as to when this Contractor anticipates the building power service will be required.

D. The contractor is responsible for complete application, coordination and scheduling of the electrical service with FPL. Contractor is required to complete all service applications and deliver to County project manager to acquire proper signatures.

1.02. CONSTRUCTION FACILITIES

A. The facilities and equipment required to provide all electrical power for construction, lighting and balancing and testing consumed prior to final acceptance of the project shall be provided under this section of the specifications. All wiring, outlets and other work required to provide this power at the site and within the building for all trades shall be arranged for, furnished and installed under this section of the specifications including any fee, charge or cost due the utility company for temporary power installation or hook-ups.

B. Facilities shall be furnished in a neat and safe manner in compliance with governing codes, good working practices and OSHA regulations.

1.03. UNDERGROUND ELECTRICAL SERVICE

A. Furnish and install underground service from power company pad-mount transformers or pole base handholes to main service equipment. Seal conduit with duct-seal where entering building.

B. The underground service shall comply with all the requirements of the NEC, local Utility Company and local enforcing authority.

1.04. UTILITY COMPANY FEES, CHARGES AND COSTS

A. It is the contractor's responsibility to contact the required Utility Company to determine if any fees, charges or costs will be due the Utility Company, as required by the Utility Company for temporary power, installations, hook-ups, etc. This fee, charge or cost shall be turned over to the County Project manager for payment.

1.05 SUBMITTALS

A. Submit product data on:
   1. Aluminum Meter base and CT, UTB and STB cabinet if applicable.
   2. Copy of Contractors notice to FPL
   3. Copy of Contractors transmittal of FPL invoice to County

PART 2 – PRODUCTS

2.01 METERING

A. Meter bases shall be furnished and installed by this contractor. Provide aluminum meter bases. Metering bases and conduits must be installed in accordance with the Utility Company requirements.

B. FP&L requirements. Work to be completed under this section shall be in accordance with FP&L documentation and standards.

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 26 28 11

CIRCUIT BREAKERS AND FUSIBLE SWITCHES – LOW VOLTAGE

PART 1 – GENERAL(NOT USED)

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Provide Cutler Hammer or Square-D circuit breakers to match equipment provided. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions.

2.02 MOLDED CASE CIRCUIT BREAKERS – 800 A AND BELOW

A. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.

D. Circuit breakers 400ampere frame and below shall be have thermal-magnetic trip units and inverse time-current characteristics.

E. Circuit breakers 800ampere through 1200-ampere frame shall have microprocessor-based rms sensing trip units.

2.03 QUICK-MAKE/QUICK-BREAK FUSIBLE SWITCHES

A. Protective devices shall be quick-make/quick-break fusible switches. Fusible switches 30 amperes through 600 amperes frames shall be furnished with rejection Class “R” or “J” type fuse clips unless otherwise scheduled. Fusible switches 800 amperes through 1200 amperes shall be furnished with Class L fuse clips. Switches shall incorporate safety cover interlocks to prevent opening the cover with the switch in the ON position or prevent placing the switch in the ON position with the cover open. Provide defeater for authorized personnel. Handles shall have provisions for padlocking and shall clearly indicate the ON or OFF position. Front cover doors shall be padlockable in the closed position.

PART 3 – EXECUTION(NOT USED)

END OF SECTION

SECTION 26 29 13

CONTROL PANELS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Furnish all labor, equipment, and materials for control panels as indicated on the drawings and specified herein. The panel supplier shall be a UL listed panel shop and all panels shall be UL-508 certified and labeled.

B. Control panel equipment shall be coordinated to provide all the specified control as indicate in the elementary diagrams or specified herein.

C. The Contractor shall be responsible for coordinating and interfacing with equipment and instrumentation supplied under other sections of the Contract Documents that are an integral part of the plant control systems. This interfacing shall be incorporated in the detailed systems drawings and data sections to be submitted by the contractor prior to rough-in work.

1.02 SUBMITTALS

A. The contractor shall submit to the Engineer for approval complete shop drawings, wiring diagrams, data, and operation and maintenance manuals of all equipment to be furnished under this section.

B. Coordination and Shop Drawings: Prepare and submit coordination drawings for installation of products and materials fabricated. Coordination and shop drawings shall be prepared using a computer aided drafting system compatible with Autodesk Autocad version 2014 or greater. Coordination and shop drawings shall be submitted on hard copy and electronic CD-Rom (dwg) format.

1. Submit component interconnect drawings showing the interconnecting wiring between each component including equipment supplied under other sections requiring interfacing with the control system. Diagrams shall show all component and panel terminal board identification numbers, and external wire and cable numbers. Note, this diagram shall include all intermediate terminations between field elements and panels (e.g., terminal junction boxes, pull boxes, etc.). Diagrams' device designations, and symbols shall be in accordance with NEMA ICS 1-101.
2. Panel Wiring Diagrams: Elementary diagrams shall be similar to those diagrams shown in the drawings, but with the addition of all auxiliary devices such as additional relays, alarms, fuses, lights, fans, heaters, etc.
3. Panel wiring diagrams shall identify wire numbers and types, terminal numbers, tag numbers and PLC I/O identification (address) numbers. Wiring diagrams shall show all circuits individually; no common diagrams shall be allowed.
4. Submit arrangement and construction drawings for consoles, control panels, and for other special enclosed assemblies for field installation. Include dimensions, identification of all components, preparation and finish data, nameplates, enough other details to define the style and

overall appearance of the assembly and a finish treatment. Drawings shall show the location of all front panel mounted devices to scale, and shall include a panel legend and a bill of materials. The panel legend shall list and identify all front of panel devices by their assigned tag numbers, all nameplate inscriptions, service legends and annunciator inscriptions. The bill of materials shall list all devices mounted within the panel that are not listed in the panel legend, and shall include the tag number, description, manufacturer and complete model number for each device.

5. Submit installation, mounting, and anchoring details for all components.

C. Operation, Maintenance and Repair Manuals
   1. Submit operation and maintenance manuals.

D. Panel Record Drawings
   1. Provide one set of laminated approved panel record drawings inside each control panel.
   2. Include one loose set of laminated approved panel record drawing inside of each control panel door data pocket.

1.03 CODES AND STANDARDS

A. Equipment, materials, and workmanship shall comply with the latest revisions of the following codes and standards
   1. Instrumentation: Instrument Society of America (ISA).
   2. National Electrical Code (NEC).
   3. Wiring: ISA S5.3 and S5.4, latest issue.
   4. Control Panels and equipment: NEMA, UL and ANSI.
   5. Control Logic: Joint Industrial Council (JIC).
   6. UL508A and UL508A-SB

PART 2 - PRODUCTS

2.01 GENERAL

A. Control panels shall be UL508A/SB compliant. Control panels with resident voltages greater than 120V shall be marked with a short circuit current rating (SCCR). The SCCR shall be equal to or more than the short circuit current available at the panel line terminals and in no case be less than 10,000A SCCR. The panel designer shall verify the available short circuit required.

B. The electrical control equipment shall be mounted within a pad-lockable NEMA Type 4X wall mount for exterior installation locations and freestanding for interior installation locations, dead-front enclosure constructed of not less than 304 stainless steel powder coated white and shall be equipped with a 3-point latch with all hardware and exterior components construction of 300 series stainless steel (except control panels in air conditioned spaces and electrical room may be NEMA 1 painted steel). Provide data pocket. The enclosure shall be powder coated white. Bottom entry ONLY of cables shall be permitted. The enclosure shall be fitted with legs to allow conduit entry into the bottom of the enclosure. Flat bottom enclosures set on concrete pads with open window cutting of

enclosure bottom for conduits is strictly prohibited. The enclosure shall be equipped with sunshields for exterior installation locations, an inner dead front door and shall incorporate a removable, aluminum or stainless steel back panel on which control components shall be mounted. Back panel shall be secured to enclosure with collar studs. Utilize stainless steel threaded standoffs welded to exterior of control panel to secure sunshields. All hardware shall be stainless steel. Provide safety hardware to hold the door in an open position.

C. Components: All motor branch circuit breakers; motor starters and DIN rail mounted control relays shall be of highest industrial quality, securely fastened to the removable back panels with screws and lock washers. Back panels shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any component.

D. A circuit breaker shall be provided on each control panel as a means of disconnecting power to the control panel. The circuit breaker operating handle shall be installed on the right side of the cabinet not in the door. The door shall be interlocked from opening when the circuit breaker is in the on position. Do not provide door interlock for lift stations. The circuit breaker operating handle shall have an interlock defeat mechanism for qualified personnel to gain access to the panel without shutting off power.

E. Control transformers shall be installed where shown to provide 120VAC and 24VAC for control circuits. Transformers shall be fused on the primary and secondary circuits. The transformer secondary shall be grounded on one leg.

F. All control panel wiring shall be identified at both ends with type written heat shrinkable wire markers with the numbering system shown on the control submittal drawings.
   1. Control wiring shall be stranded tinned copper, minimum size #16 AWG (except for shielded instrumentation cable may be #18 AWG), with 600 volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation.
   2. Wire shall be guided within control and terminal cabinets by cable supports (duct). Instrumentation and control field cables on the unprotected side of SPD devices within the cabinet shall not run in parallel to the cables on the protected side of the SPD device. Separate cable supports (duct) will be provided.
   3. All conductors shall be neatly led to terminations. All connections of stranded wire to screw type terminal blocks shall be by insulated spade lugs, crimp fastened to wire. Provide stranded wire crimp ferrules for all stranded wire connections not requiring spade lugs for screw type terminal blocks.

G. The control panel shall be provided with nameplates identifying each component, selector switches, pilot lights, etc. Nameplates shall be permanently affixed using an epoxy process. Nameplates shall be laminated plastic, engraved white letters with a black background. List the manufacturer of the control panel cabinet and the control panel builder.

H. Corrosion Inhibitor Emitter: Provide an industrial corrosion inhibitor emitter on all exterior mounted control panels that will protect internal components of the

control panel from corrosion one year. Provide a year supply of spare emitters, for each control panel.

I. Terminal strips shall be provided for all signals as indicated on the drawings plus all spare conductors as specified. Terminal strips shall be switch type with integral fuses equal to Allen Bradley 1492-H6. Wiring from the control panel to the terminal strips shall be factory installed. All spare conductors shall be terminated and identified. All terminals over 200V phase to phase shall be covered with approved plastic shields.

J. RELAYS

1. Control circuit switching shall be accomplished with relays. These relays, for interfacing and control applications, shall be the compact general purpose plug-in type having low coil inrush and holding current characteristics. An LED status-indicating light shall be provided with each relay. Contact arrangements shall be as noted or shown, and shall be rated for not less than 10 amperes at 120V ac or 28V dc. Coil voltage shall be as noted or shown. Non-latching relays shall have a single coil. Latching relays shall have two coils, unlatching being accomplished by energizing one coil, and latching being accomplished by energizing the other coil. Relays shall have plain plastic dust covers, test buttons, and mounting sockets with screw terminals and holddown springs. Relays shall be UL recognized. Relays shall be Square D, Allen Bradley, Omron or approved equal.
2. Time on delay functions shall be accomplished with Square-D 9050JCK60V20 timer relays. Provide RK electronics CFB24D-7-2M relay for time off delay applications. Units shall be adjustable time delay relays with the number of contacts and contact arrangements as shown. A neon status-indicating light shall be provided with each relay. Contacts shall be rated for 10 amperes at 120V ac. Integral knob with calibrated scale shall be provided for adjustment of time delay. Initial setting shall be as shown with time delay range approximately three times the initial setting. Time delay rangeability shall be at least 10:1. Operating voltage shall be 120V ac, plus 10 percent, -15 percent at 60-Hz. Operating temperature shall be -20 degrees F to 165 degrees F. Repeat timing accuracy shall be plus or minus 10 percent over the operating range. Units shall be Amerace Corp., Control Products Division, Agastat Series 7000, Cutler-Hammer Series D87, Square D, Allen Bradley, Omron or approved equal.
3. All relays shall have a screw terminal interface with the wiring. Terminals shall have a permanent, legible identification. Relays shall be mounted such that the terminal identifications are clearly visible and the terminals are readily accessible.

K. Panel Operating Controls and Instruments

1. All operating controls and instruments shall be securely mounted on the interior deadfront as detailed on panel enclosure drawings. All controls and instruments shall be clearly labeled to indicate function.
2. Indicator lamps shall be 30mm LED full voltage push to test type and mounted in NEMA 4X (800H) modules, as manufactured by Allen Bradley or SKPI as manufactured by Square D. Lamp modules shall be equipped to operate at 24 or 120 volt input. Lamps shall be easily replaceable from

the front of the control compartment door without removing lamp module from its mounted position. Units shall be heavy-duty, oiltight, push to test industrial type with screwed on prismatic glass lenses in colors as shown, and shall have factory engraved legend plates. LED's shall be high illumination type (5ma at 130V ac).

3. Selector switches shall be 30mm heavy-duty, oiltight, industrial type selector switches with contacts rated for 120V ac service at 10 amperes continuous. Units shall have standard size, black field, legend plates with white markings, as indicated. Operators shall be black knob type. Units shall have the number of positions and contact arrangements and spring return function (if any) as shown. Units shall be single-hole mounting, accommodating panel thickness from 1/16-inch minimum to 1/4-inch maximum. Units with up to four selection positions shall be Allen Bradley 800H, Square D Type K, Cutler-Hammer Type T, or equal.
4. 22mm devices are not acceptable.

L. Process Meters
1. Provide digital programmable process meters with a loop powered display designed for a 4-20MA current loop. Provide minimum 0.5" high, 4-1/2" digit LED display to indicate amplitude of current in the current loop. In general, a loop current of 4ma corresponds to a display indication of 0 percent and a loop current of 20ma corresponds to a display indication of 100 percent. The meter shall be provided with programmable internal scaling adjustment. Provide units with NEMA-4X faceplate rating constructed of silicone coated Lexan and gasketed for NEMA 4 requirements; circuit boards coated for moisture resistance. Provide panel meters for each analog process variable; Pressure, level and flow as indicated equal to Yokogawa, Red Lion, or equal.

M. Phase Monitors
1. Provide ATC Diversified and or Macromatic.

N. Uninterruptable Power Supply (UPS)
1. Provide 24VDC input, 12/24VDC dual output UPS. Puls UB10.241 UPS, no equal.

PART 3 - EXECUTION

3.01 MOUNTING OF EQUIPMENT AND ACCESSORIES

A. Install and mount equipment in accordance with the Contract Documents, and installation detailed shop drawings. Mount equipment so that they are rigidly supported, level and plumb, and in such a manner as to provide accessibility; protection from damage; isolation from heat, shock and vibration; and freedom from interference with other equipment, piping, and electrical work.

B. Mount local equipment in cabinets or existing panels as specified. Mount associated terminals on a common panel or rack; all terminals over 200V phase to phase shall be covered with plastic shields.

C. Provide services of panel manufacturer to test the completed system after

installation to assure that all components are operating within the specified range and all interlocks are functioning properly. Panel manufacturer shall certify functional operation and calibration in written startup report. Perform field tests on all completed control assemblies to demonstrate conformance to specifications and functional compatibility.

END OF SECTION

SECTION 26 29 17

WALK-IN ELECTRICAL EQUIPMENT ENCLOSURE

PART 1- GENERAL

1.01 GENERAL

A. Provide a fully integrated equipment enclosure, one which is self-contained, pre-engineered, all new, packaged custom designed with power systems and environmentally conditioned. The enclosure is designed to house the specified electrical equipment, PLC control systems(provided by others) and associated equipment. Provide minimum aisle space and clearance around the equipment that is designed per latest National Electrical Code.

B. The housing superstructure shall be self supporting and totally independent from the interior equipment. Interior equipment does not act as walls or roof. The housing supports and withstands all imposed loading as prescribed by the references herein. No loading is transferred to the interior equipment in any way. Provide structure designed for lifting from lugs located along the base perimeter. Base and floor system to be factory leveled and designed to withstand loading combinations, while maintaining the deflection criteria, when supported at lift points only. Provide removable lifting lugs.

C. Unless otherwise specified all metallic components shall be of corrosion resistant materials or permanently coated for a comparable service life in a corrosive environment.

D. The Equipment Building manufacture shall be an ISO9001 certified facility, with five or more years experience in furnishing complete Packaged Electrical Room Systems. This includes design, manufacturing, wiring, testing and startup of the completed system including but not limited to, Motor Controls, VFD's, HVAC and electrical distribution systems. The Equipment Building shall be a factory fabricated and assembled metal modules designed to house and environmentally protect electrical and electronic controls, instrumentation and equipment as specified. It is a portable structure, totally self-supporting. The Electrical Equipment Room shall be shipped to site completely assembled with equipment installed, wired and factory tested. The enclosure shall be transported to the job site by common carrier and designed to be offloaded with a crane. Provide a minimum of four removable lifting lugs. When properly fixed to the concrete floor base, it will provide wind load protection in compliance with the Florida Building Code requirements. Building manufacturer shall provide a drawing of anchorage to slab signed and sealed by a Florida Structural Professional Engineer verifying wind load.

E. Provide the Electrical Equipment Room integrated building by TAW Custom Equipment 6312 78th Street, Riverview, FLORIDA 33578**;** 866-387-0077 or approved equal.

1.02 REFERENCES

A. All Division 26 Specifications and Drawings.

B. Section 01 33 00, Submittal Procedures.

1.03 STANDARDS: THE ENCLOSURE SHALL BE DESIGNED AND MANUFACTURED IN ACCORDANCE WITH INDUSTRY STANDARDS AS OUTLINED BELOW.

A. National Electric Manufacturers Association (NEMA).

B. American Institute of Steel Construction (AISC).

C. NFPA 70 - National Electrical Code (NEC).

D. Florida Building Code latest edition (FBC).

E. American National Standards Institute / American Society of Civil Engineers (ANSI/ASCE).

F. American Iron and Steel Institute (AISI).

G. American Welding Society (AWS).

H. Steel Structures Painting Council (SSPC).

I. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

J. Additional Codes and Standards as Identified.

1.04 DELIVERY, STORAGE, AND HANDLING

A. The equipment enclosure shall be shipped to the job site complete as one unit and with all equipment and electrical devices within assembled with interconnecting wiring complete. The manufacturer shall supervise off loading at the site in the presence of the Contractor.

1.05 CERTIFICATIONS

A. The enclosure shall be designed accordance with ASCE 7-10 “minimum design for building and other structure” and shall conform to the latest edition of the Florida Building Code FBC 2010 with all applicable amendments by Lee County Building Department. The enclosure shall be designed for the following parameters:

1. Ultimate wind speed = 170 mph (3-second gust).
2. Risk category =III.
3. Exposure category = C.

B. The enclosure anchorages to concrete foundation shall be designed and provided by the enclosure manufacturer for the wind conditions specified above.

All anchors shall be designed by a professional engineer registered in the State of Florida. All anchors shall be epoxy adhesive Type 316 stainless steel. The enclosure fabricated aluminum base frame shall be bolted to concrete slab with epoxy adhesive anchors. All imbedded concrete adhesive anchor bolts shall be type 316 stainless steel minimum ¾ in diameter.

C. Enclosure manufacturer shall provide shop drawings and design calculations signed and sealed by a professional engineer registered in the State of Florida for the enclosure, components and anchorages. The enclosure/building complements and cladding shall be designed for the conditions specified in ASCE 7-10, Florida Building Code (FBC), and Lee County building Department Requirements. Components and Cladding shall be designed for the following parameters for internal wind pressures coefficients in accordance of ASCE 7-10 provision for "components and cladding",

1. Condition I, (GCpi= +0.18, -01.18).

D. The enclosure shall bear a Department of Community Affairs (DCA) insignia and be assigned a metal building number (MB#) in accordance with Florida State Statute 553.

PART 2- PRODUCTS

2.01 DESIGN DATA

A. Provide Electrical Equipment Building as a Self-Framing Structure utilizing a Custom Equipment designed and factory formed wall, and roof panel system. Provide wall and roof panels formed from marine grade, 5052-H32, aluminum of minimum 1/8'' thick except thickness of: roof to be 3/16'' thick and suitable for periodic maintenance foot traffic; interior walls .090''. Each panel is individually prepared and painted white using oven baked, electro-statically applied acrylic powder coat system. Construction details ensure a weather-tight assembly that does not depend on gaskets. Panels create a rigid, self-supporting, self-framing structure offering a uniform wall exterior appearance.

B. The building shall be sized as required and as shown on the Drawings to house the equipment and provide adequate clearance and work space as required by the National Electric Code.

C. The base shall be constructed from structural stainless steel or aluminum to form a rigid frame for both lifting and anchoring to concrete slab to meet wind load rating. Supporting cross members will support a steel plate deck that will support required equipment. Structural stainless steel or aluminum will be prepared for painting using an Abrasive Blasting method to remove rust and scale to the Society for Protective Coatings Standard NACE-4/SSPC-SP 7. Prepared metal will have 2 coats 5-8 mils thick of black Rust-Oleum 9100 System High Performance Epoxy. Steel decking shall be coated with skid resistant gray. The floor frame shall be elevated off the concrete pad with 3/8'' thick continuous neoprene pads between the I-beam structure and the concrete pad. The structure shall include the earthquake/hurricane tie down restraint points and drillings for grounding attachments. The enclosure anchorages to concrete

foundation shall be Type 316 stainless steel epoxy grout hardware and provided by the enclosure manufacturer.

D. The enclosure shall be air-conditioned incorporating packaged ductless split systems. Each unit shall be a backup of the other. Only one unit operates at a time. The units alternate operation every 24hours. On the failure of one unit the other unit shall automatically function to maintain climate control and the control system shall notify the operator of the failure through the PLC controls. Unit shall be sized taking into account the heat generated from internal equipment contribution as well as external ambient conditions to provide internal temperatures between 75 and 85 degrees Fahrenheit year round. Unit shall be capable of starting in low ambient conditions. Provide low noise HVAC units equal to Mitsubishi Mr. Slim model MSZ.

E. Walls and ceiling to be insulated with glass fiber thermal batt insulation or equivalent of sufficient quantity to yield a minimum thermal resistance rating of R-11. Interior wall panels shall be manufactured in accordance with Paragraph 2.01-A of marine grade 5052-H32 aluminum minimum thickness 0.090". Interior panels shall be riveted or screwed to the interior ribs with stainless steel or aluminum fasteners. Interior walls and supporting panels are designed to handle interior loads of 400 lbs/linear foot of wall length without impeding wind loading capability.

F. The enclosure will have two man doors with minimum dimension 3'-0" x 7'-0", one at each end of the structure. Doors will be insulated, double walled aluminum, and fastened using a full length SS hinge. All man-doors will be equipped with lockable, panic-type door hardware and automatic door closers. Provide a drip shield above all doors. Provide door jams with adjustable gasketing material around the interior of the door frame to ensure proper sealing of the doors. Door thresholds are provided with flexible gaskets for weather protection at the bottom of the door. Provide "Danger High Voltage / Keep Out" Signs on each door.

2.02 INTERNAL EQUIPMENT:

A. The Equipment Building shall be supplied with twin tube LED fixtures with protective lenses. Illumination will be a minimum of 65 foot candles measured 3 foot above the floor. Lights will be placed as close as practical to the center of each building. Two fixtures will contain battery backup to furnish emergency lighting during a power failure. Interior lighting will be operated by 3-way switches located inside and next to each man-door. Provide exterior GFI duplex receptacles as shown.

B. Provide automatic transfer switch(Cummins Sole Source), main utility service circuit breaker, panelboards, transformers, variable frequency drives, cabinets space for programmable logic controllers and other internal equipment as shown on the drawings and specified under Division 26 of these Specifications. All wiring will be run in surface mounted EMT conduit or in enclosed raceways. Provide 120 volt enclosure lighting and receptacle circuits with green ground wire and wired with 12 AWG, stranded, copper wire as specified in Division 26 Specifications. Provide metal troughs below electrical equipment with powder

coated white finish and removable covers to route field conductors. Adequately size troughs to completely conceal wiring extending from electrical equipment enclosures to building conduit/cable floor entryways.

C. Building manufacturer shall furnish, test, and install the motor control equipment VFDs, Electrical Distribution system in the factory prior to shipping equipment to job site. The building manufacturer shall provide onsite controls coordination assistance to the controls system integrator for PLC setup and testing that is specified elsewhere in these specifications. All provided equipment shall be mounted, wired and tested in the factory prior to shipment to site. Demonstrate final testing to the engineer prior to shipment. Provide 2 week notice of test date. Provide one source responsibility for a completely integrated and tested system to ensure minimal field install time. Provide Electrical Grade rubber matting complete length of equipment on each side.

END OF SECTION

SECTION 26 29 23

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 FURNISHING OF EQUIPMENT

A. Unless specifically noted otherwise, variable frequency motor drives for all equipment requiring them shall be furnished under this section. The drive manufacturer shall furnish all required controls as specified herein and as functionally required by the instrumentation and controls section.

B. The manufacturer shall be Square D Altivar 660 or Ativar 320 Process Drive series. No equal.

C. Provide Altivar 660 drives with necessary modifications to provide a two second power loss ride through.

D. Provide all drives with conventional analog and digital control interface for control. Provide Ethernet TCP/IP network communications for monitoring to the plant control system for Altivar 660 VFD's.

E. Provide equipment purchased from the manufacturer's representative authorized to represent the manufacturer in the projects territory, Lee County Florida.

F. The manufacturer shall factory fabricate the drive cabinets to match the plan lineup and available space indicated

1.02 DESCRIPTION OF SYSTEM

A. Factory-assembled, metal-enclosed VFD motor control units for distribution and control of power from incoming line terminals to outgoing feeder terminals, installed and tested in place. Where shown on drawings, furnish and install VFD units in freestanding NEMA 12 gasketed, ventilated and filtered motor control cabinets as herein specified. The motor control shall be supplied from a 3-phase, 3-wire 60 cycle power system as shown. A U.L. label shall be provided on each Section indicating compliance with UL Standards. The adjustable frequency drives and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of ETL, UL, ANSI, and NEMA.

B. VFD Motor Control Units shall include all protective devices and equipment as listed on drawings or as included in these specifications, with necessary interconnections, instrumentation, and control wiring.

C. The VFD manufacturer shall be responsible for providing a system for the specific installation intended, including considerations of conductor distances from the drive to the motor. Each VFD drive shall include an output dv/dt filter system within the VFD cabinet to limit voltage peak and voltage rise time at the motor terminals. The filters must limit the voltage rise time and voltage peak at the motor terminals to those required by NEMA MG1-1993, Section IV, Part 30 with voltage peak less than 1000 volts and rise time greater than 2 microseconds.

1.03 QUALITY ASSURANCE

A. Reference Standards:
1. American National Standard Institute (ANSI):
a. ANSI Y32.2-1975, Graphic Symbols for Electrical and Electronic Diagrams.
b. ANSI Z55.1-1967 (R1973) Gray finishes for Industrial Apparatus and Equipment.

2. National Electrical Manufacturers Association (NEMA):
a. NEMA ICS-1, 2, 3, 4, 5, 6, controls and systems.

3. National Fire Protection Association (NFPA):
a. NFPA 70-2008, National Electric Code (NEC).
b. NFPA-70E-2009 Standard for Electrical Safety in the Workplace.

4. Underwriters' Laboratories, Incorporated (UL):
a. UL Electrical Construction Materials List, motor controllers motor-control centers (NJAV), (HJOT) and (NLDX).

1.04 SUBMITTALS

A. Product Data:
1. Layouts showing concrete pad dimensions, conduit entrance and available space, bus duct connections, electrical ratings, nameplate nomenclature, and single-line diagrams in accordance with ANSI Y32.2 indicating connections and controls with numbered terminals.
2. Frame sizes and Interrupting Capacity of unit.
3. Horsepower rating and rated voltage of unit.
4. Manufacturer's written recommendation for storage and protection, installation instructions and field test requirements.
5. Manufacturer's instructions for tightening bus connections, performing cleaning, and operating and maintaining motor control unit.
6. Submit written verification that overall dimensions are within the maximum dimensions indicated on plans.
7. Submit manufacturer’s recommended spare parts list.

B. Shop Drawings:
1. Complete master wiring diagrams, elementary schematics and control schematics shall be submitted for approval before proceeding with manufacture. Suitable outline drawings shall be furnished as part of this submittal. Standard or typical pre-printed sheets or drawings simply marked to indicate applicability to this contract will not be acceptable. Shop drawings shall be job specific.
2. A complete drawing indicating each point of interface with the process control system and the type of signal provided or accepted at each point.
3. A complete drive programmer’s manual.
4. A drawing showing the layout of the VFD local control panel indicating every device mounted on the door with complete identification.
5. Provide shop drawings on 11" X 17" paper and drawn with a computer aided design (CAD) package. The computer aided design package shall be Autocad or converted to Autocad format. Submittals shall include hard copy and CD-ROM media electronic copies (dwg format).

1.05 WARRANTY

A. The equipment manufacturer shall provide a two year warranty from initial startup and demonstration of the complete automatic controlled drive pump system to the engineer. The equipment manufacturer shall guarantee that the equipment furnished is suitable for the purpose intended and free from defects of design, material and workmanship. In the event the equipment fails to perform as specified, the equipment manufacturer shall promptly repair or replace the defective equipment without any costs to the owner (including labor, transportation, handling and shipment costs). Warranty shall not cover damage to the equipment caused by external sources and operator errors; however the units shall be protected from power line surges and electrical fault conditions and therefore the warranty shall apply to power line transient surge, ground faults, line to line faults, EMI and RFI interference and other external electrical disturbance caused damage.

B. The VFD manufacturer shall maintain as part of a national network, engineering service facilities within 150 miles of the project to provide start-up service, emergency service calls, repair work, and service contracts.

1.06 SPARE PARTS

A. Provide spare parts as follows: one set of all fuse types, one each type relay, SPD, Phase Monitor, 2 sets of replacement filters, one complete set of VFD inverter fans and VFD enclosure fans, one set of pilot lights (LED type), one of each type thermal module or switch. In addition provide circuit boards for: Gate Interface Board, PreCharge Board, Power Interface Board, Control Board, Power Module, Heatsink Fan, HIM module. Provide one spare of all I/O and dual port Ethernet/IP DLR communications boards.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide 75hp and above VFD's as manufactured by Square D Altivar 660 Process Drive series with clean power drive. Provide 20hp and below VFD's as manufactured by Square D Altivar 320 Process Drive series with clean power drive. Provide clean power controller utilizing a front end MTE Matrix broadband filter with harmonic cancellation techniques. The VFD shall contain a built in cut-out circuit to automatically take the filter offline on low power loads. Provide Ethernet communications capability. Provide hard wired control where shown on the drawings.

B. The VFDs shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a three-step operation. Adjustable Current Source VFDs are not acceptable. IGBT type Transistors shall be used in the inverter section. GTOs and SCRs are not acceptable. The VFDs shall be current regulated. VFDs permitting instantaneous over current trips other than for output short circuit are not acceptable.

C. All VFDs shall utilize a vector torque control strategy to regulate motor flux to optimize motor torque without the need for encoders. VFDs requiring voltage, dwell and current adjustments to achieve improved torque control are not acceptable.

D. The manufacturer shall supply variable frequency drives compatible with the pump motors for operation of these motors at motor full load amps. The drives shall vary the output frequency from minimum to maximum pump speed typically 6-60hz.

E. The drive shall be of sufficient capacity and provide a quality of output waveform so as to achieve full rated and continuous output of the pump motor. All drives shall be factory built-up units complete with all necessary and specified components, as hereinafter defined, which shall be supplied by the drive manufacturer as a unit. Each built-up drive shall be tested by the drive manufacturer prior to shipment from the factory and a certificate of the test provided.

2.02 ENVIRONMENTAL CONDITIONS

A. The drive shall accept plant power nominal AC voltage of 480V AC +10% -10%, 3 phase, 60 Hertz $\pm$ 3%.

B. The operating ambient condition shall have a temperature range of 0 to 40 degrees Celsius with a relative humidity of up to 95% (non-condensing).

2.03 CONSTRUCTION TECHNIQUES

A. The drive shall be of modular design to provide for ease and speed of maintenance including removal of modules, with one maintenance technician.

B. All components shall be mounted in a NEMA type 12, gasketed, ventilated and filtered enclosure properly sized to dissipate the heat generated by the power electronics. The enclosure shall be painted with corrosion resistant coatings with finish paint of ANSI 49 Gray. Ether top or bottom entry of cables shall be permitted.

C. The DC bus shall be filtered by series inductor & capacitors to provide ripple free dc.

D. Circuit breakers. The operating mechanism shall be designed so that the door can be padlocked in the "Off" position. Protection for the VFD's power circuit shall be provided by use of circuit breakers and type "J" input fuses.

E. The drive shall meet any one of the following standards; CSA, ETL, UL.

F. All VFD's must be tested/run under load until rated operating temperatures is achieved.

G. Provide VFDs with shock hazard shielding methods for all exposed terminals, bus bars and termination points. The low voltage terminals, buss bars, lugs etc. shall be physically guarded, insulated and/or isolated to insure safety to maintenance personnel and for reduced arc flash hazard.

H. Provide VFDs with approved ventilation air filter frame mounting and hardware assemblies.

I. The VFD shall be furnished with a diagnostic indicator to show low bus/line and high bus/line voltage conditions, timed current overload and inverter output fault. Drive ready and Drive run status indication shall be standard.

2.04 ACCESSORIES

A. The Altivar 660 unit shall include an incoming, UL listed, circuit breaker. A three position switch (hand-off-auto) mounted on the controller door provides manual selection of local or auto control. The "Hand" position allows manual local keypad run/stop and speed control of the VFD; the speed control shall be via a keypad mounted on the door calibrated from 0-100% speed. The door of the VFD cabinet shall contain but not be limited to the following devices:

1. Key Pad and alpha numeric displays providing programming and manual control of the drive.
2. VFD fault indicating light.
3. Hand auto switch.
4. Power On indicating light.
5. VFD Run indicating light.
6. Motor High Temperature indicating light.
7. Process parameter control indicating light (Ex: Low Level shutdown).

B. The Altivar 320 unit shall include a dial and escape button mounted on the unit drive to navigate the menus and set drive speed control calibrated from 0-100% speed. The unit shall contain but not be limited to the following devices:

1. Integrated Alpha numeric displays providing programming and manual control of the drive.
2. VFD fault indicating light.
3. VFD Run indicating light.

C. Provide 24Vdc logic module and 24Vdc power supply within the drive to hold the drive logic active during power interruptions.

2.05 OPERATING CHARACTERISTICS

A. The variable frequency drive shall convert single or 3 phase, 60 Hertz input power to an adjustable frequency and voltage (from 6 Hertz to 60 Hertz with a frequency stability of +/- 1% of setting) for controlling the speed of AC induction motors. The converter will be of the voltage source design using current controlled PWM techniques. The input power factor of the drive shall be a minimum of .95 at all speeds and loads.

B. The output voltage shall vary proportionally with the output frequency to maintain a constant volts/Hertz value up to nominal frequency. Above nominal frequency, the output voltage shall remain constant.

C. The modulating control scheme shall closely approximate actual sine wave current throughout the speed range of the drive. The regulator shall be fully digital with microprocessor control of frequency, voltage, and current. The frequency resolution of the drive shall be .01 Hertz. All drive adjustments and custom programming shall be capable of being stored in a non-volatile memory (EEPROM).

D. Current limit. A current limit circuit shall be provided to limit motor current to a preset adjustable maximum level by reducing the drive operating speed or acceleration rate when the limit is reached. Range of adjustment shall be from 50 to 115%.

E. The power unit's logic common shall be at ground potential.

F. Short circuit and ground fault protection. The VFD shall have an instantaneous electronic trip circuit to protect the VFD from output line-to-line and line-to-ground short circuits. The VFD must be capable of withstanding without damage to the VFD, short circuits at 480V plus 10% (528V). Opening of the VFD's input and/or output line switches during drive operation shall not result in damage to the drive.

G. The VFD shall be capable of providing 110% motor name plate service factor current for one minute. The VFD shall include an instantaneous overcurrent trip. The VFD shall not restart after electronic overcurrent trip until manually reset. Except for overcurrent, the drive will first attempt to restart on the inverter up to a maximum of three times on "Auto-Restart" before faulting out and waiting for operator reset.

H. Altivar 660 Power loss ride-through. The VFD shall be capable of continued operation during an intermittent loss of power for 2.0 second (120 cycles). The essential drive and pump relay logic integrated within the drive shall be powered through the 24VDC VFD power source during the power interruption for the 2 second duration. The VFD drive will resume normal operation within 0.5sec if power is reapplied during the 2 second ride through duration.

I. Auto restart after power outage. The VFD shall be capable of starting into a spinning motor. The VFD shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the VFDs shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor in the preset method of starting.

J. Transient and surge voltage protection. Transient and surge voltage protection shall be provided through use of Metal Oxide Varistors (MOV's) and phase-to-ground filter capacitors.

K. Auto restart after fault. The VFD shall automatically attempt to restart after a malfunction or an interruption of power. If the drive reaches the limit of restarts without successfully restarting and running for 90 seconds, the restart circuit shall lockout and drop out the fault relay. Two Form C contacts shall be provided.

L. Motor overload protection. Provide electronic motor overload and single phase protection integral to the inverter.

M. Frequency jump points: Provide (3) selectable frequency jump points in 1.0hz increments, to be used to avoid critical resonance frequencies of the mechanical system.

N. Application programming dedicated to pumps.

1. The VFD shall provide Pump Control & Monitoring Functions for Centrifugal pump characteristics and configurations.
    a. Pump monitoring function in order to define data relevant for pump (acceleration, low speed, high speed, etc.)
    b. Application Units function in order to define units used in applications.
    c. Pump Cyclic Start Protection in order to protect the pump against too many restarts in a dedicated time period.
    d. Multi-pump functions.

2. The VFD shall provide Pump Protection Functions
    a. Anti-Jam function in order to remove automatically clogging substances from the pump impellers.
    b. Pipe Cleaning function in order to start pump regularly to avoid sedimentation in pump impeller
    c. Cavitation Pump Protection
    d. Inlet protection in order to avoid system dry running.
3. The VFD shall provide Application control functions
    a. Stop and Go function in order to reduce consumption of VFD in case of pump inoperation.
    b. Pipe Fill function in order to manage a smooth control during pipe filling and to lessen the effects of water hammer.
    c. Sleep wake-up function in order to manage periods of the application when process demand is low and when it is not needed.
    d. Low demand function in order to define periods of the application when process demand is low in order to save energy.
4. The VFD shall provide Pump curve input to help optimize pump performance.
    a. Input and storage of the pump characteristics including 5 points of the pump curve.
    b. A best efficiency point (BEP) function in order to run in optimum conditions and detect deviation from this point.

2.06 CONTROLS

A. Provide an operator panel with a detachable UL Type 12/IP65 rated bi-color backlit graphical user interface terminal with keypad and capacitive wheel for monitoring, annunciation, and configuration for Altivar 660 VFD. The graphical display shall change to a red backlit color when an alarm occurs. The display provides indication of any selected drive functions; speed, load, motor volts, motor amps, diagnostic information, programming functions, etc. The keypad provides a means of programming and manually controlling the drive. Programming only keypads are not acceptable. The key pad shall be used to input the following setup adjustments:
    1. Minimum speed, 1 to 85%
    2. Maximum speed, 50 to 100%
    3. Linear accel, 2-25 seconds
    4. Maximum output voltage, adjustable
    5. Volts/Hertz, adjustable.
    6. Local setpoint reference.
    7. Current Limit Setpoint.
    8. Selectable carrier frequencies, V/Hz, and critical frequency avoidance lockout.
    9. Multiple attempt restarts

B. Remote Controls: The VFD drives shall be hardwired to the plant control system as detailed on the single line drawing. The Ativar 660 VFD drives shall have a dedicated Ethernet connection to the plant control system with all parameters within the drive accessible to the control system. As a minimum provide the following inputs and outputs for remote operator control from the plant computer system.
    1. Drive Digital inputs
        a. Start/Stop
        b. Drive Reset

2. Drive Digital outputs
    a. VFD in remote and Ready.
    b. Drive running
    c. VFD internal fault.
    d. VFD external fault
3. Analog inputs/outputs
    a. Motor speed feedback output
    b. Remote speed Setpoint input

C. Internal Control Wiring: Each control wiring conductor shall have heat shrink identification labels on each end of termination. Terminations shall be made to screw terminal strips. All points of terminal strips are to be labeled to match conductor labeling.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine area to receive motor-control units to assure adequate clearance for motor control unit installation. Check that concrete pads are level and free of irregularities for motor control centers.

B. All workmanship utilized in the manufacture and installation of this system shall be of the highest quality and performed in a manner which is consistent with all accepted practices for industrial controls.

C. The supplier shall construct and verify proper operation of the assembled system under simulated conditions with motors of similar characteristics; before shipment to the site.

3.02 INSTALLATION

A. Install motor control units in accordance with manufacturer's written instructions, and NEC.

B. The installing contractor shall guarantee that installation of the system is in accordance with the manufacturer's instructions.

3.03 START UP SUPERVISION AND TRAINING

A. The system supplier shall provide a factory trained and authorized service technician to inspect all final connections and check the system prior to start-up of the pump drive system. The service technician shall coordinate with the systems integrator for complete functional check-out of the system. The factory authorized person shall provide written certification that the installation meets or exceeds all factory recommendations for proper operation.

B. Copies of the Operating and Maintenance manuals shall be prepared specifically for this installation and shall include all required specification sheets, drawings, equipment lists, descriptions, etc. that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

C. A factory representative who has complete knowledge of proper operation and

maintenance shall be provided for training to instruct representatives of the owner and the Engineer in proper operation and maintenance. Training subjects shall include, operator training, system repair, maintenance and detailed software training. Training shall be conducted after system startup, testing, and control tuning procedures are complete, and before final completion. If there are difficulties in operation of the equipment due to the installation or fabrication, additional instruction days shall be provided as deemed necessary by the engineer and at no cost to the owner.

END OF SECTION

SECTION 26 32 13

DIESEL ENGINE DRIVEN GENERATOR SETS

PART I - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install, put into operation, and field test the diesel engine driven generator unit, and controls as shown on the Drawings and specified herein. The equipment installation shall be coordinated in detail by the Genset distributor. The distributor shall supervise the installation of the equipment from off loading to startup.

B. The installation, supervision, and the coordination of testing and startup of the system shall be provided by the installing contractor. The installing contractor shall be responsible for the complete coordination of the installation. The installing contractor shall be responsible to include all necessary equipment and services into the base bid for installation. Where shown on the drawings, accessory materials include but are not limited to sub-base tank, sound attenuated enclosure, exhaust muffler system, battery charger, ETC.

C. These Specifications are intended to give a general description of what is required, but do not cover all details which will vary in accordance with the requirements of the equipment as offered. It is, however, intended to cover the furnishing, the shop testing, and delivery and complete installation and field testing, of all materials, equipment and appurtenances for the complete units as herein specified, whether specifically mentioned in these Specifications or not.

D. For all units there shall be furnished and installed all necessary and desirable accessory equipment and auxiliaries whether specifically mentioned in these Specifications or not. The genset supplier is responsible for field testing of the entire installation and instruction of the regular operating personnel in the care, operation and maintenance of all equipment.

E. Provide per the project scope all equipment as shown on the drawings including but is not limited to supplying engine generator sets complete, Automatic transfer switch complete, sub-base fuel tank, sound attenuated enclosure, muffler, line circuit breakers, etc.

F. The generator Unit shall be as manufactured by Cummins-Onan, no equal, with a standby rating of ___kW, ____kVA, 1800RPM, 0.8 power factor, 277/480Volt, 3 phase, 60 Hertz, 4 wire including radiator fan and all parasitic loads.

G. The generator unit shall bear a UL2200 label.

1.02 RELATED SECTIONS

A. Section 26 36 00-Automatic Transfer Switches

B. Section 26 05 02-Basic Materials and Methods

C. Section 26 05 19-Low Voltage Wire and Cables

D. Section 26 05 26-Grounding and Bonding for Electrical Systems

1.03 DESCRIPTION OF SYSTEMS

A. A complete package shall be provided by the generator set distributor, maintaining single source responsibility. The complete package shall include the automatic transfer switch specified in other sections. The Contractor shall utilize the authorized distributor, who shall be responsible to furnish, document, instruct and supervise installation, adjust, and test the complete system as shown on the plans and specified herein.

B. The Contractor shall furnish and install all interconnecting wiring as show on the authorized distributor's shop drawings, accessories, and the like whether or not specifically detailed on the plans or in the specifications. It shall be the responsibility of the contractor to ascertain such items from the authorized distributor and include these costs in his bid. No additional payment will be made for items not specifically shown or detailed in the contract documents but needed for a complete installation.

C. The equipment must be purchased from the manufacturers authorized representative authorized to represent the manufacturer in the project's territory. The unit shall be shipped to the jobsite by an authorized engine distributor having a parts and service facility within a 150 mile radius of the jobsite. In addition, and in order not to penalize the Owner for unnecessary or prolonged periods of time for service or repairs to the emergency system, the bidding generator set supplier must have no less than eighty percent (80%) of all engine replacement parts locally available at all times. Certified proof of this requirement shall be furnished to the Engineer upon request

D. Emergency warranty service response shall be guaranteed to be a maximum of four-hours between the time of emergency notification and arrival of service personnel on site. An emergency service condition shall be considered to exist when any failed standby power system hardware or software prevents or threatens to prevent the facility from fulfilling its intended purpose as determined by the owner or engineer. Non-emergency service requests shall be responded to within 2 business days. Telephone support for operating procedures and non-hardware problems shall be provided on an unlimited basis during the warranty period.

E. All materials and parts comprising the units shall be new and unused, of current manufacture, and of the highest grade, free from all defects or imperfections. Workmanship shall conform to the best modern practices. Only new and current models will be considered. The units offered under these Specifications shall be the product of a firm regularly engaged in the production of engine-generator equipment and shall meet the requirements of the Specifications set forth herein.

1.04 SUBMITTALS

A. Submit to the Engineer for review in accordance with division 26 Sections of the specifications, complete sets of installation drawings, schematics, and wiring diagrams which shall show details of installation and connections to the work of other Sections, including foundation drawing showing location and size of foundation bolts for the spring type vibration isolators and brochures covering each item of equipment. Drawings must be created specific the project, manufacturers standard drawings are not acceptable.

B. In the event that it is impossible to conform with certain details of the Specifications due to different manufacturing techniques, describe completely all nonconforming aspects. Approval by the Engineer is required.

C. The submittal data for each unit shall include, but not necessarily be limited to, the following:
   1. Installation drawings showing plan and elevations of the complete generator unit; foundation plan; exhaust silencer; starting battery; battery charger; fuel tank; and all other items requiring space for installation. Layout and stub-up locations of electrical and fuel systems.
   2. Interconnect wiring diagram of complete emergency system, including generator, switchgear, fuel tank level monitor/transmitter, battery charger, remote alarm indications.
   3. Engine mechanical data at varying loads up to full load, including heat rejection, exhaust gas flows, combustion air and ventilation air flows, noise data, fuel consumption, etc.
   4. Generator electrical data including temperature and insulation data, cooling requirements, excitation ratings, voltage regulation, voltage regulator, efficiencies, waveform distortion and telephone influence factor.
   5. Engine Data:
      a. Manufacturer
      b. Model
      c. Number of cylinders
      d. RPM
      e. Bore x stroke
      f. Piston speed, RPM
      g. Make and model and descriptive literature of electric governor
      h. Fuel consumption rate curves at 25,50,75,100% loads
      i. Engine continuous pump drive duty rating
      j. Gross engine horsepower to produce generator standby rating (including fan and all parasitic loads).
      k. Manufacturer's and dealer's written warranty.
      l. Emissions data
   6. Generator Data:
      a. Manufacturer
      b. Model
      c. Rated KVA
      d. Rated kw
      e. Voltage
      f. Temperature rise above 40 degree C ambient

g. Generator efficiency including excitation losses and at 80 percent power factor
h. Generator resistances, reactances and time constants.
i. Generator current decrement curve.
j. Generator motor starting capability.
k. Generator thermal damage curve.
l. Line circuit breaker.

7. Generator Unit Control Data:
   a. Actual electrical diagrams including schematic diagrams, and interconnection wiring diagrams for all equipment to be provided. Control panel schematics
   b. Legends for all devices on all diagrams
   c. Sequence of operation explanations for all portions of all schematic wiring diagrams
8. Generator Unit and Accessories:
   a. Weight of skid mounted unit
   b. Overall length
   c. Overall width
   d. Overall height
   e. Exhaust pipe size
   f. CFM of air required for combustion and ventilation
   g. Heat rejected to jacket water and lubricating oil...BTU/hr
   h. Heat rejected to room by engine and generator...BTU/hr
   i. Jacket water heater connection diagram.
   j. Automatic load transfer switch(es).

D. Submit to the Engineer operating and maintenance data as specified in 26 05 02 Basic Electrical Materials and Methods of this specification. Submit to the Engineer the equipment Manufacturer's Certificate of Installation, Testing and Startup Report.

1.05 SPARE PARTS

A. The Manufacturer shall furnish one (1) complete spare replacement sets of all filter elements required for the generator unit.

PART 2 - PRODUCTS

2.01 RATINGS

A. The rating of the generator set shall not exceed the Manufacturer's published standby rating. The gross engine horsepower required to produce the standby rating shall not exceed the Manufacturer's published continuous duty rating by more than 150 percent. Continuous duty rating shall be as defined in BS5514 or DIN6271 but in no case shall it exceed the Manufacturer's published continuous duty rating for the engine as used in continuous rated pump drive applications. The gross engine horsepower required for the generator set standby rating described above shall include all parasitic demands such as generator inefficiencies, fuel pumps, water pumps, radiator fan (for fan cooled models) and all accessories necessary to the unit's proper operation while operating at rated load and at a rotative speed not to exceed 1800 rpm.

B. The diesel engine driven generator set shall be capable of producing the specified standby kw rating for continuous electrical service during interruption of the normal utility source and shall be certified to this effect by the Manufacturer for the actual unit supplied.

C. The generator set shall operate at 1800 rpm and at a voltage of: 277/480, 3-Phase, 4-wire, 60 hertz. The complete generator set shall be rated per ISO8528 standby rating, based on site conditions of: Altitude 100 meters, ambient temperatures of 50 degrees C, based on temperature measured at the alternator inlet. The generator set rating shall be based on stationary emergency/standby service and marked as applicable per NFPA110.

D. Performance:
   1. Voltage regulation shall not exceed one percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
   2. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.25%.
   3. Generator sets shall be designed to allow operation at full rated load in an ambient temperature under site conditions, based on highest ambient condition.
   4. The engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
   5. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
   6. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples. Telephone influence factor shall be less than 40.
   7. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.
   8. The generator set shall share real and reactive load proportionally within plus or minus 3% with all other generator sets in the system.
   9. The time required to automatically start, accelerate to rated speed and voltage, synchronize and parallel all generator sets to the system bus on a normal power failure shall not exceed 15 seconds, assuming that the water jacket heaters are operating properly.
   10. The generator set and complete sound attenuated enclosure sound levels shall be tested by the manufacturer per ANSI S1.13. Data documenting performance shall be provided with submittal documentation.

2.02 CONSTRUCTION

A. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.

B. All switches, lamps, and meters in the control system shall be oil-tight and dust-tight. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.

C. All outdoor equipment shall be enclosed with corrosion-protected materials. Steel components used in enclosures shall be powder coated and baked, and shall provide fade and corrosion resistance in compliance to Dry film thickness shall be SHD3363 of 2H+ all a minimum of 1.8 Mils, gloss at 60degrees per ASTMD523 of 80+/- 10, pencil hardness per ASTM D3363

2.03 CONNECTIONS

A. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept two hole compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.

B. Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.

2.04 ENGINES

A. The engine shall be full compression ignition, four cycle, single acting, solid injection engines, either vertical or "V" type. Speed shall not exceed 1800 revolutions per minute at normal full load operation. The engine governor shall be +/- 0.25 percent accuracy electronic type governor.

B. The engine shall be capable of satisfactory performance on No. 2 fuel oil (ASTM Designation D396). Diesel engines requiring a premium fuel will not be considered.

C. The engine shall be capable of operating at light loads for extended periods of time and shall provide a means to reduce carbonization. Periodic cleaning of exhaust ports shall not be required.

D. The engine shall be equipped with spin on fuel filters, lube oil filters, intake air filters, lube oil cooler, fuel transfer pump, engine driven water pump, and unit mounted instruments. The engine shall be provided with low oil pressure, high water temperature and overspeed safety shutdowns.

E. Injection pumps shall be pressure time common rail type. The system shall be self bleeding and self priming in design. The fuel system shall provide redundant overspeed protection with one governor having a dual flywheel fuel limiting mechanical control and the other fail safe electric control. The governors shall be located within the fuel pump body without external linkages or adjustments. Fuel injection pumps shall be positive action, constant-stroke pumps, activated by a cam driven by gears from the engine crankshaft. Fuel lines between injection

pumps and valves shall be of heavy seamless tubing. Digital Electronic fuel injection systems shall be considered equal to common rail type pressure injection systems.

F. The fuel system shall be equipped with spin on fuel filters having replaceable elements. Filter elements shall be spin on canister elements, easily accessible and removable from their housing for replacing without breaking any fuel line connections, or disturbing the fuel pump, or any other part of the engine. All fuel filters shall be conveniently located in one accessible housing, ahead of the injection pumps so that the fuel will have been thoroughly filtered before it reaches the pump. No screens or filters requiring cleaning or replacement shall be used in the injection pump or injection valve assemblies. The engines shall be equipped with a built-in gear-type, engine-driven fuel transfer pump, capable of supplying fuel through the filters to the injection pump at constant pressure. The engine shall be provided with a Racor type fuel water separator, sized as determined by engine manufacturer, to filter fuel continuously while unit is in operation.

G. The engine shall be provided with removable wet-type cylinder liners of close grained alloy iron, heat treated for proper hardness as required for maximum liner life. The cylinder block shall be a one piece stress relieved grey iron casting.

H. The engine shall have a gear-type lubricating oil pump for supplying oil under pressure to main bearings, crank pin bearings, pistons, piston pins, timing gears, camshaft bearings, valve rocker mechanism and governor. Effective lubricating oil filters shall be provided and so located and connected that all oil being circulated is continuously filtered and cleaned. Filters shall be spin on canister elements, easily accessible, easily removed and cleaned and shall be equipped with a spring-loaded by-pass valve as an insurance against stopping of lubricating oil circulation in the event the filters become clogged. The engine shall have a suitable water cooled lubricating oil cooler and dipstick oil level indicator.

I. The engine shall be provided with one or more engine mounted dry type air cleaners of sufficient capacity to protect effectively the working parts of the engine from dust and grit. The air cleaner shall be replaceable, easily accessible with restriction indicators.

J. Provide fuel ramping control to limit black smoke and frequency overshoot.

K. The engine shall be radiator and fan cooled. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable.

L. Provide fuel cooler, suitable for operation of the generator set at full rated load in ambient temperature.

M. Provide Racor Crankcase Ventilation System.

N. A digital electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous states. The governor control logic shall be based in the engine ECM and must communicate with the alternator and set control. Third party and private labeled governors are not acceptable.

2.05 COOLING SYSTEMS

A. The engine shall be furnished with a unit mounted radiator type cooling system having sufficient capacity for cooling the engine when the diesel generator set is delivering full rated load in an ambient temperature of 122 degrees F. The engine shall be provided with a thermostatic valve placed in the jacket water outlet between the engine and the cooling source. This valve shall maintain the proper jacket water temperature under all load conditions.

B. Radiator shall be sized based on a core temperature which is 10 degrees C higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The cooling system shall be filled with a 50/50-ethylene glycol/water mixture by the equipment manufacturer. Rotating parts shall be guarded against accidental contact.

C. Closed circuit jacket water systems shall be treated with a rust inhibiter as recommended by the engine Manufacturer.

D. A unit mounted thermal circulation type water heater incorporating a thermostatic switch shall be furnished to maintain engine jacket water to 70 degrees F. The heater shall be rated as shown on the drawings.
   1. Heater shall be UL499 listed and labeled.
   2. Install on the engine with SAEJ20 compliant materials. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches.
   3. Installation shall be specifically designed to provide proper venting of the system.
   4. Install using isolation valves to isolate the heater for replacement of the heater element. The design shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
   5. Provide a thermostat, installed at the engine thermostat housing. Provide for a single AC power connection to the coolant heater system.

2.06 EXHAUST SYSTEMS

A. The engine exhaust silencer shall be a critical grade and provided by the genset manufacturer. Silencer shall be sized and approved by the engine manufacture and supported by acoustical and pressure loss calculation not to exceed 55db max at the property line.

B. All exhaust equipment must be rated to withstand temperatures of approximately 1,000 degrees F. A flexible stainless steel pipe connection shall be provided between the engine exhaust stack and exhaust piping. One silencer raincap with counter weight shall be provided for each silencer. The exhaust system shall be mounted inside genset enclosure.

2.07 AUTOMATIC STARTING SYSTEM

A. A DC electric starting system with positive engagement shall be furnished. The starting motor voltage shall be as recommended by the engine Manufacturer.

B. An engine control shall be furnished as an integral part of the electric set to start and stop the engine as signaled by the automatic transfer controls on the generator control unit. The control shall start the engine by adjustable timed cranking cycles for a total period of not less than one minute. The crank and rest cycles shall be individually adjustable. The starting circuit shall open, and the control shall activate an alarm circuit if the engine does not start. The control shall be equipped with automatic safety shutdowns so that upon signal of a low oil pressure, high water temperature, or overspeed condition of the engine, the control shall immediately stop the engine. The control shall be equipped with digital display to indicate any of the engine failures and also with a 3-position control switch identified for "automatic-off-manual" externally mounted.

C. Engine Cranking Batteries: The batteries shall be of the lead acid type, and shall be of domestic manufacture. The battery shall be rated S.A.E. type "D", diesel engine starting type and of sufficient size and capacity in a fully charged condition to crank start the engine generator for the maximum allowed crank cycle, (minimum 20-second cranking periods) six consecutive times at 20 degrees F with out recharging between cranks. The batteries shall be mounted in suitable covered racks. Battery rack location will be as shown on the Shop Drawings. The electrical Contractor shall provide the required lengths of all interconnecting battery cables. Minimum wire size and type shall be 2/0 welding cable.

D. Battery Chargers:
1. Provide a 10amp battery charger. Chargers shall be UL 1236-BBHH listed and CSA or CUL certified for use in emergency applications. The charger shall be compliant with UL991 requirements for vibration resistance.
2. The charger shall be capable of charging a fully discharged battery without damage to the charger. It shall be capable of returning a fully discharged battery to fully charged condition within 24 hours. The charger shall be UL-labeled with the maximum battery amp-hour rating that can be recharged within 24 hours.
3. The charger shall incorporate a 4-state charging algorithm, to provide trickle charge rate to restore fully discharged batteries, a bulk charge rate to provide fastest possible recharge after normal discharge, an absorption state to return the battery to 100 percent of charge, and a float stage to maintain a fully charged battery and supply battery loads when the generator set is not operating. In addition, the charger shall include an

equalization timer. Charge rates shall be temperature compensated based on the temperature directly sensed at the battery.

4. The DC output voltage regulation shall be within plus or minus 1%. The DC output ripple current shall not exceed 1 amp at rated output current level.
5. The charger shall include the following features:
   a. Two line alphanumeric display with programming keys to allow display of DC output ammeter and voltmeters (5% accuracy or better), display alarm messages, and perform programming;
   b. LED indicating lamp(s) indicating normal charging condition (green), equalize charge state (amber), and fault condition (red);
   c. AC input overcurrent, over voltage, and undervoltage protection;
   d. DC output overcurrent protection;
   e. Alarm output relay;
6. Locate Charger in the automatic transfer switch.

2.08 ALTERNATOR, EXCITER AND ACCESSORIES

A. Rating: The alternator shall be rated ___KW, ___KVA at 0.8 p.f., 1800 RPM 3 phase, 60 Hertz, 277/480 volts, at a maximum temperature rise of 80 degrees C (both armature and field) by resistance at full rated load in ambient air of 40 degrees C. The alternator shall be wound for 2/3rds pitch for harmonic mitigation. The alternator shall conform to NEMA Standard MG-1. As an alternate to the 80 degree C rise alternator (if not a standard option), the manufacturer shall upsize the diesel generator such that at the derated capacity of ___kw, the heat rise on the alternator will be 80 degree C rise or better.

B. Performance: The instantaneous voltage dip shall not exceed 25 percent of rated voltage when full load, at rated power factor, is suddenly applied. Recovery of stable operation shall occur within 1 second. Steady state modulation shall not exceed +/- l/2 percent. Provide documentation of submitted unit meeting performance criteria with shop drawing submittals.

C. The alternator shall be capable of starting across the line, ___ HP motors that are 85% efficient with a power factor of 0.8 in ___ equal steps with no more than 10% instantaneous voltage dip and 2% frequency dip. Provide documentation of submitted unit meeting performance criteria with shop drawing submittals.

D. Construction:
   1. The alternator and exciter shall be dripproof, with split sleeve, or ball race bearings. A shaft-mounted brushless exciter shall be a part of the assembly. The stator core shall be built up of high grade silicon steel laminations precision punched, and individually insulated. Armature lamination followers and frame ribs shall be welded integral with the frames for support of the stator core. A directional blower shall be mounted on the unit to draw cooling air from the exciter and over the rotor poles and through louvered openings on the opposite end.

   2. The exciter shall be a fast response type, with a rotating 3-phase full-wave bridge. The exciter shall have a low time constant and large capacity to minimize voltage transients under severe load changes.

3. Alternator stator and exciter stator windings shall be a full Class H insulated system (generator rated for class B temperature rise of 80 degrees) vacuum impregnated with epoxy resin which after curing shall have additional treatment of epoxy for resistance to an environment of moisture and salt air.

4. Alternator rotor poles shall be built up of individually insulated silicon steel punchings. Poles shall be wound and bonded with high strength epoxy resin. Cage connections to the amortisseur rings shall be brazed for strong construction and permanent electrical characteristics. Each pole shall be securely bolted to the rotor shaft with bolts sized for the centrifugal forces on the rotor. Alternator windings shall be braced for full line to ground fault currents, on a solid grounded neutral system.

5. Provide an anti-condensation heater for the alternator for generator sets installed outdoors or in unheated environments.

2.09 ACCESSORIES AND ATTACHMENTS

A. Terminal boxes: The unit shall contain a controls terminal box properly sized and provided with terminal strips and interposing relays and devices to properly interface genset controls with remote controls and instrumentation. The generator shall have separate AC and DC low voltage terminal boxes with suitably marked terminal strip for required connections.

B. All required P.T.'s, C.T.'s and protective relays shall be supplied by the engine-generator Manufacturer.

C. Vibration isolation: Provide spring type vibration isolation.

D. Provide a molded case line circuit breaker. Provide breaker with solid state adjustable functions for long time, and instantaneous trip. Instantaneous adjustment trip setting range 2-10 or greater. Provide line circuit breaker with a 100% continuous current rating.

2.10 GENERATOR ASSOCIATED CONTROLS

A. Voltage Regulator: The generator Manufacturer shall furnish a hermetically sealed, silicon controlled rectifier type voltage regulator employing a zener reference with a plus or minus one percent regulation for the generator. The regulator shall include 3 phase voltage sensing, automatic short circuit protection and shall include automatic underfrequency protection to allow the generator to operate at no load at less than synchronous speed for engine start-up and shutdown procedures. Switches and/or fuses shall not be used to provide this protection. An over-voltage sensing module with manual reset shall be furnished with the regulator. A volts per Hz., sensing module shall be provided as part of the regulation system. A voltage adjustment rheostat for 5 percent voltage adjustment on the unit shall be provided.

B. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at 300% of rated current for not more than 10 seconds.

2.11 GENERATOR SET INSTRUMENTATION

A. The generator set shall be provided with a microprocessor-based control system which is designed to provide automatic starting, monitoring, and control functions, both local and remote, for the generator set. The control shall be mounted on the generator set. Controls shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered. The control shall be UL508 listed, and meet IEC8528 part 4. All switches, lamps, and meters shall be oil-tight and dust-tight, and the enclosure door shall be gasketed. The entire control shall be tested and meet the requirements of IEEE-587 for voltage surge resistance.

B. The front display of the genset control panel unit shall include the following:

1. 1% accuracy generator set AC output instruments; Ammeter, Voltmeter, Frequency Meter, Wattmeter, KW-hour meter, Power Factor Meter. Selector switches to allow viewing of voltage and amperes for each phase shall be provided. For 3-phase/4-wire systems the voltmeter shall indicate line to line and line to neutral conditions. Running Time Meter and Start Counter.
2. Generator Set Mode Selector Switch: Switch shall provide hand, off, and automatic functions for control of the generator set.
3. Control Reset push-button switch with indicating lamp. Lamp shall flash to indicate that generator set is locked out due to a fault condition.
4. Lamp test push-button switch. Operation of this switch shall cause all lamps on the panel to be simultaneously tested.
5. Emergency Stop switch. The emergency stop switch shall be a red, mushroom head switch which maintains it's position until manually reset.
6. Precision voltage and frequency adjust raise/lower switches. Switches shall allow the generator set frequency and voltage to be adjusted plus or minus 5% when the generator set is operating independently of the system bus. Voltage and frequency adjustment switches shall be located adjacent to the generator set and bus metering, for ease of use by the operator.
7. Provide an alarm and status indicating panel to indicate the genset conditions to the operator via LED display; provide the following ***alarm*** condition indicators:
   Low DC Voltage
   High DC Voltage
   Weak Battery
   Low Oil Pressure Alarm
   Low Fuel - main tank
   Fuel tank leak
   High Engine Temp Alarm Amber
   Ground Fault
   Overcurrent Alarm

8. The alarm and status indicating panel shall indicate the following genset *shutdown* conditions to the operator:
   Breaker Failure
   Not in Auto
   High Engine Temp
   Low Oil Pressure
   Overcurrent
   Short Circuit
   Loss of Excitation
   Reverse Power
   Overcrank
   Overspeed
   Under Frequency
   Under Voltage
   Over Voltage
   Low Coolant Level
   Emergency Stop
9. The alarm and status indicating panel shall indicate the following genset *status* conditions to the operator:
   Genset Ready (in auto and ready)
   Generator Running (ready to load)
10. In addition, provisions shall be made for indication of three (3) customer-specified alarm or shutdown conditions.
11. Provide controller with optional run relay package to enable direct hardwired connection to SCADA system. Provide the following status and alarms conditions to the PLC:
    Generator Common Warning(parameter 1540)
    Generator Common Fault(parameter 1541)
    Generator Not in Auto
    Low Fuel - main tank
    Fuel tank leak

2.12 GENERATOR ENCLOSURE

A. Provide an Outdoor Weather-Protective Sound Attenuating Generator Housing. The generator set shall be provided with a sound-attenuated housing which allows the generator set to operate at full rated load in the ambient conditions previously specified. The enclosure shall reduce the sound level of the generator set while operating at full rated load to a maximum of 72 dBA at any location 7 meters from the generator set in a free field environment. Housing configuration and materials used may be of any suitable design which meets application needs, except that acoustical materials used shall be oil and water resistant. No foam materials shall be used unless they can be demonstrated to have the same durability and life as fiberglass.

B. The enclosure shall include hinged doors for access to both sides of the engine and alternator, and the control equipment. Key-locking and padlockable door latches shall be provided for all doors. Door hinges shall be stainless steel.

C. The enclosure shall be provided with an exhaust silencer which is mounted inside of the enclosure, and allows the generator set package to meet specified

sound level requirements. Silencer and exhaust shall include a raincap and rainshield.

D. The entire enclosure shall be sheathed in aluminum. Provide aluminum enclosure finish painted with the manufacturer's standard color.

E. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be stainless steel or non-metallic corrosion resistant, and designed to minimize marring of the painted surface when removed for normal installation or service work.

F. The Generator enclosure shall be designed accordance with ASCE 7-10 "minimum design for building and other structure" and shall conform to the latest edition of the Florida Building Code. The enclosure shall be designed for the following parameters: Basic wind speed = 170 mph; Risk Category =III; Exposure category = C.

G. Generator enclosure/tank anchorages to concrete foundation shall be designed for the wind conditions specified above and designed by a professional engineer registered in the State of Florida. All anchors shall be Type 316 stainless steel. Enclosure manufacturer shall provide shop drawings for the enclosure, components and anchorages. Generator enclosure/building complements and cladding shall be designed for the conditions specified in ASCE 7-10, Florida Building Code (FBC) and Lee County Building Department Requirements. Components and cladding shall be designed for the following parameters for internal wind pressure coefficients in accordance with ASCE 7-98 provision for "components and cladding", Condition I, (GCpi=+0.18,-0.118)

2.13 SUB-BASE FUEL TANK

A. Provide where shown on the drawings, a UL listed Double Wall diesel fuel storage tank. The fuel tank shall be an integral part of the enclosure/generator mounting frame. Fuel tank shall have a capacity of no less than 1100 gallons usable to provide 48 hours of run time under 100% generator full load conditions. Fuel tank provided shall comply with and be constructed in accordance with the requirements of Underwriters Laboratories UL-142 "Special Purpose Protected Secondary Containment Generator Base Tank"; N.F.P.A. 30, 37 & 110; Florida Department of Environmental Protection (FDEP) and the Steel Tank Institute. Fuel tank venting in compliance with NFPA and UL

B. Complete assembly shall be manufactured using minimum 3/16" sheet steel for the inner tank and 3/16" 304 Stainless Steel for outer tanks. Fuel tank and containment basin are to be leak tested at 3-PSI air as outlined in UL-142 standards. The interstitial space shall be monitored using a float type level switch and shall indicate the presences of fuel in the annular space by use of normally open contacts that are to be wired back to the generator set control panel for visual/audible indication.

C. Fuel tank provided shall have the following devices but by no means be limited to those as specified. A 2" Manual fuel fill cap, with means to padlock fill cap, mechanical fuel level gauge, low level alarm set at 40% of tank capacity, rupture basin alarm with normally open contacts, fuel supply and return ports with full length pick-up tubes. A foot or check valve shall be installed on the generator

supply to prevent loss of prime during idle conditions. A rectangular double-walled electrical stub-up area is to be provided and located directly under the generator circuit breaker to provide a pass-through for field installation of electrical load conductors. Tank color shall match the generator enclosure.

D. The tank shall be elevated off the concrete pad with integral tank supports that provide a 2 inch air space to control moisture accumulation. The tank supports shall be arranged so that moisture is not trapped in the channel of the supports. Provide 3/8”TH x 6”W continuous neoprene pads between the tank supports and the concrete pad. The tank shall include the hurricane tie down restraint points and drillings for grounding attachments.

E. Provide a level gauge near the fill location. Provide a drop tube and leak alarm switch located in the interstitial space area of the tank indicating inner tank failure and wire to genset control panel.

F. Provide DEP approved Fuel management system, Pneumercator TMS 2000. The system shall include an audible and visual high level alarm station at the fill location set to alarm at 90% of tank capacity. System shall include Pneumerator TMS200 manufacturer level transmitter. The alarm station shall be housed in a NEMA 4X SS powder coated white enclosure. Provide a high level alarm float switch in the tank and wire to the generator controller and remote annunciation alarm console. Fuel level transmitter (4-20ma) output wired to the Pump Station PLC. Provide 6-channel optional analog output card.

G. The contractor shall coordinate with the owner and provide all tank permit applications and reviews as required by the FDEP and proper fire district regulating authority and properly permitted.

H. All tanks shall be labeled by product, capacity and manufacturer per NFPA requirements.

PART 3 - EXECUTION

3.01 SERVICES

A. Furnish the services of a competent and experienced Manufacturer's field service technician who has complete knowledge of proper operation and maintenance of the equipment to inspect the installed equipment, supervise the initial test run, coordinate checkout of the interlocks between ATS and the Genset and to provide instructions to the plant personnel. The first visit will be for checking and inspecting the equipment after it is installed.

B. Provide instruction of plant personnel in operation and maintenance of the equipment. This instruction period shall be scheduled at least ten days in advance with the Owner and shall take place prior to final acceptance and after substantial completion by the Owner.

C. The final copies of operation and maintenance manuals specified in division 1 Sections must be delivered to the Engineer prior to scheduling the instruction period with the Owner.

D. The distributor of the Genset shall provide installation coordination services to insure a properly installed and coordinated system including all coordination with the electrical and instrumentation contractor for proper interfacing. As a minimum the Genset Distributor shall coordinate the installation with factory trained technicians with weekly site visits from the time the genset arrives on site to the time it is fully operational. Also the technician shall provide on site coordination of all conduit stub ups, fuel line stub-ups, pad dimensions, embedment etc prior to slab pour. It is the intent of these specifications that the Distributor of the Genset provide complete system coordination including but not limited to; fuel system with venting and filling requirements; exhaust system requirements; cooling and ducting system; power; control, battery and grounding systems, switchgear system; testing and acceptance certification. The site technician shall submit written reports of the coordination efforts weekly to the engineer and meet with the engineer as requested. The technician shall certify the units installed per manufacturers recommendation prior to test runs or functional testing.

3.02 INSTALLATION

A. The genset installer shall install suitable jacket water additives as furnished by the engine Manufacturer and approved by the Engineer, for prevention of both scale formation and corrosion in the water jackets and cooling system components which are in contact with the engine jacket water. These additives shall be added to the cooling system prior to running the field acceptance test.

B. The Contractor shall install the complete exhaust system, together with the silencer, the piping and insulation, and the complete supporting system. Where the exhaust passes through the roof or side wall, furnish and install suitable thimble and "rain skirt".

C. The engine generator set and associated equipment shall be shop primed and finish coated in accordance with the Manufacturer's standard practice prior to shipment. An adequate supply of touch-up paint shall be supplied by the Manufacturer.

D. Neoprene pads shall be installed to isolate the fuel tank bottom from making direct contact with the concrete equipment pad. Provide a neoprene pad or strip- for all points that come in contact with the concrete equipment pad.

3.03 TESTING

A. The engine-generator set shall be given the Manufacturer's standard load bank test at full rated load and power factor at the factory.

B. Prior to final acceptance of the generator set, all equipment furnished under this Section shall be field tested to show it is free of any defects and that the generator set can operate satisfactorily under full load test using resistance type load banks. The genset testing shall be for four (4) continuous hours. Any defects which become evident at this time shall be corrected before acceptance.

C. During the field tests, readings will be taken at thirty (30) minute intervals of the following: oil temperature, exhaust temperature, water temperature, volts, amps, frequency, fuel pressure, manifold pressure, and oil pressure, KW, KWH.

D. The owner shall provide fuel for start-up and testing of the generator system.

3.04 WARRANTY

A. The complete electrical standby power system; generator set, controls, and associated switches, and accessories, as provided by the factory distributor including the ancillary equipment shall be warranted by the manufacturer against defects in materials and workmanship for a period of five years or 1500 genset run hours, whichever occurs first from the date of system startup. Coverage shall include parts, labor, travel expenses and labor to remove reinstall defective equipment under terms of the Manufacturer's comprehensive standard warranty. No deductibles shall be applied to the warranty except for starting batteries and water jacket heater being warranted for one year.

END OF SECTION

SECTION 26 36 00

AUTOMATIC TRANSFER SWITCHES

PART 1-GENERAL

1.01 GENERAL

A. Automatic transfer switches shall be furnished as shown on plans, with full load current and voltage rating as shown, normal and emergency. The transfer switch shall be capable of switching all classes of load, and shall be rated for continuous duty when installed in a non-ventilated enclosure NEMA ICS 6 or 4X that is constructed in accordance with Underwriters' Laboratories, Inc., Standard UL-1008. Provide transfer switches by Cummins no equal. The generator set manufacturer shall warrant transfer switches to provide a single source of responsibility. Transfer switches shall be rated to carry 100 percent of rated current continuously in the enclosure supplied, in ambient temperatures of -40 to +60 degrees C, relative humidity up to 95% (non-condensing).

B. Provide complete factory assembled power transfer equipment with field programmable digital electronic controls designed for fully automatic operation and including: surge voltage isolation, voltage sensors on all phases of both sources, linear operator, permanently attached manual handles, positive mechanical and electrical interlocking, and mechanically held contacts for both sources.

C. Transfer switch equipment shall have withstand and closing ratings (WCR) in RMS symmetrical amperes greater than the available fault currents. Contractor to verify available fault currents. The transfer switch and its upstream protection shall be coordinated. The transfer switch shall be third party listed and labeled for use with the specific protective device(s) installed in the application.

D. Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in the source 1 and source 2 positions. The transfer switch shall be specifically designed to transfer to the best available source if it inadvertently stops in a neutral position. Transfer switches shall be equipped with permanently attached manual operating handles and quick-break, quick-make over-center contact mechanisms. Transfer switches over 1000 amperes shall be equipped with manual operators for service use only under de-energized conditions. The transfer switch shall be configurable to control the operation time from source to source (program transition; delayed transition operation). Sync checked two position transfer switches without delayed transition are not acceptable

E. The transfer switch shall be capable of transferring successfully in either direction with 90% of rated voltage applied to the switch terminals. Transfer switches that are designated on the drawings as 3-pole shall be provided with a neutral bus and lugs. The neutral bus shall be sized to carry 100% of the current designated on the switch rating. Transfer switch shall be provided with copper long barrel Hi-Press lugs sized to accept the full output rating of the switch. Lugs shall be suitable for the number and size of conductors shown on the drawings.

F. Operator Panel. Each transfer switch shall be provided with a control panel to

allow the operator to view the status and control operation of the transfer switch. The operator panel shall be provided with the following features and capabilities.

1. High intensity LED lamps to indicate the source that the load is connected to (source 1 or source 2); and which source(s) are available. Source available LED indicators shall operate from the control microprocessor to indicate the true condition of the sources as sensed by the control. High intensity LED lamps to indicate that the transfer switch is "not in auto" (due to control being disabled or due to bypass switch (when used) enabled or in operation) and "Test/Exercise Active" to indicate that the control system is testing or exercising the generator set.
2. "OVERRIDE" pushbutton to cause the transfer switch to bypass any active time delays for start, transfer, and retransfer and immediately proceed with its next logical operation. "TEST" pushbutton to initiate a preprogrammed test sequence for the generator set and transfer switch. The transfer switch shall be programmable for test with load or test without load. "RESET/LAMP TEST" pushbutton that will clear any faults present in the control, or simultaneously test all lamps on the panel by lighting them.
3. The control system shall continuously log information on the number of hours each source has been connected to the load, the number of times transferred, and the total number of times each source has failed. This information shall be available via the operator display panel.
4. Analog AC meter display panel, to display 3-phase AC Amps, 3-phase AC Volts, Hz, KW load level, and load power factor. The display shall be color-coded, with green scale indicating normal or acceptable operating level, yellow indicating conditions nearing a fault, and red indicating operation in excess of rated conditions for the transfer switch.

G. Engine starting contacts shall be provided in transfer switch to start the generating plant if **any** phase of the normal source drops below 85% of rated voltage, after an adjustable time delay period of 1-120 seconds. Provide loss of normal source circuit with phase sequence sensing capability that verifies phase angle relationship of source voltage.

H. The transfer switch shall transfer to emergency as soon as the generator source voltage and frequency have reached 90% of rated. After restoration of normal power on all phases to 95% of rated voltage, adjustable time delay period of 2-25 minutes shall delay transfer to normal power until it has had time to stabilize. If the emergency power source should fail during the time delay period, the time delay shall be by-passed, and the switch shall return immediately to the normal source. Whenever the switch has retransferred to normal, the engine-generator shall be allowed to operate at no load for an adjustable period of time (10 minutes initially) to allow it to cool before shut-down. Transfer switch voltage sensors shall be close differential type, providing source availability information to the control system based on the following functions:

1. Monitoring all phases of the normal service (source 1) for under voltage conditions (adjustable for pickup in a range of 85 to 98% of the normal voltage level and dropout in a range of 75 to 98% of normal voltage level).
2. Monitoring all phases of the emergency service (source 2) for under voltage conditions (adjustable for pickup in a range of 85 to 98% of the normal voltage level and dropout in a range of 75 to 98% of pickup

voltage level).

3. Monitoring all phases of the normal service (source 1) and emergency service (source 2) for voltage imbalance, loss of single phase, phase rotation, over voltage conditions (adjustable for dropout over a range of 105 to 135% of normal voltage, and pickup at 95-99% of dropout voltage level), over or under frequency conditions.
4. Monitoring the neutral current flow in the load side of the transfer switch. The control shall initiate an alarm when the neutral current exceeds a preset adjustable value in the range of 100-150% of rated phase current for more than an adjustable time period of 10 to 60 seconds.

I. The transfer switch shall include a test switch to simulate normal power failure with actual load transfer. A remote contact from the plant control system shall be accepted by the ATS to provide generator start and load control testing. Pilot lights shall be included on the cabinet door to indicate the main switch closed on normal (green) or emergency (Red); a yellow pilot light shall indicate the emergency power source running.

J. The transfer switch shall include two auxiliary contacts on the main operating shaft indicating closed on normal and two auxiliary contacts indicating closed on emergency. In addition, two sets of relay contacts shall be provided to operate upon loss of the normal power supply. All relays, timers, control wiring and accessories to be front accessible. Auxiliary contacts shall be provided for remote plant control system monitoring.

K. Include an exerciser with transfer switch for exercising generator in loaded condition every 168 hours for a period adjustable to 15 minute increments from 20 minutes minimum. Include automatic return to normal should the genset fail to provide load during the exercise run, if normal power is available. Provide programmed transition controls with adjustable time delay option to limit inductive load inrush currents. Switches without adjustable programmed transition are not acceptable.

L. Provide for utility to genset ATS dry maintained contact input from the Pump Control Panel to start generator and transfer ATS on load. Provide a 20 light remote annunciator to be mounted adjacent to or within the front panel of ATS. I/O List from the ATS/Standby power system and standby system annunciator to the plant controls:

<u>Contact outputs from ATS:</u>
ATS/Genset not in Auto
Utility Supplying Load
Generator Supplying Load
Utility Available
Generator Available
ATS Common Alarm

<u>Contact inputs to ATS:</u>
Remote Test

M. The transfer switch shall be provided in a NEMA 12 (interior installation locations) or NEMA 4X stainless steel (exterior installation locations) wall mounted enclosure with a continuous hinge, gasketed and a 3 point latch. HMI deadfront

mounted through enclosure door shall be fitted with a hinged window kit, Schaefer's SPHWKSS-(###)-BC or approved equal.

1.02 SUBMITTALS

A. Submit shop drawings and product data clearly indicating:
   1. Cabinet dimensions.
   2. All applicable options and accessories.
   3. Wiring diagrams.
   4. Interrupting or withstanding current rating.
   5. All electrical characteristics and data as required showing compliance with these specifications.
   6. Digital Metering device and wiring.

PART 2-PRODUCTS(NOT USED)

PART 3-EXECUTION

3.01 QUALITY ASSURANCE/TESTS

A. As a precondition for approval, transfer switch, complete with timers relays and accessories shall be listed by Underwriters' Laboratories, Inc. in their Electrical Construction Materials Catalog under Standard UL-1008 (automatic transfer switches) and approved for use on emergency systems.

B. When conducting temperature rise tests to paragraph 99 of UL-1008 the manufacturer shall include post-endurance temperature rise tests to verify the ability of the transfer switch to carry full rated current after completing the overload and endurance tests.

C. Electrical Field Tests: Field testing shall be performed prior to substantial completion.
   1. Perform insulation resistance tests phase-to-phase and phase-to-ground with switch in both source positions.
   2. Perform a contact resistance test across all main contacts.
   3. Verify settings and operation of control devices in accordance with the specifications provided by the manufacturer.
   4. Calibrate and test all relays and timers including voltage and frequency sensing relays, in phase monitor (synchronism check), engine start and cool-down timers, transfer and retransfer timers, etc.
   5. Perform automatic transfer tests: Simulate loss of normal power. Test Return to normal power. Simulate loss of emergency power. Simulate all forms of single phase conditions. Monitor and verify correct operation and timing of the following simulations: Normal voltage-sensing relays: Engine start sequence: Time delay upon transfer: Alternate voltage-sensing relays: Automatic transfer operation: Interlocks and limit switch function: Time delay and retransfer upon normal power restoration: Engine cool-down and shutdown feature.
   6. SYSTEM FUNCTION TESTS: Perform system function tests upon completion of equipment tests. It is the purpose of system function tests to prove the proper interaction of all sensing, processing, and action devices.
      a. Develop test parameters for the purpose of evaluating performance

of all integral components and their functioning as a complete unit within design requirements.

b. Test all interlock devices.

c. Record the operation of alarms and indicating devices.

3.02 SHOP DRAWINGS

A. Submit Shop Drawings and product data clearly indicating:

1. Cabinet dimensions.
2. All applicable options and accessories.
3. Wiring diagrams.
4. Interrupting or withstanding current rating.
5. All electrical characteristics and data as required showing compliance with these specifications.
6. Digital Metering device and wiring.

END OF SECTION

SECTION 26 36 13

SAFETY SWITCHES AND DISCONNECTS

PART 1 – GENERAL (NOT USED)

PART 2 – PRODUCTS

2.01 GENERAL

A. All single throw disconnect switches and double throw manual transfer switches shall be heavy-duty horsepower rated type. Safety switches shall be rated for the available fault current where installed. Provide enclosed molded case switch type disconnects where required to meet high available fault current areas (above 10kaic). Switches shall be fusible only where required to meet equipment nameplate requirements.

B. Switches shall be 240 volt rated on systems up to and including 120/208V and 600V rated on higher voltage systems. All switches for motors shall be horsepower rated. All switches shall be NEMA 4X stainless steel enclosure except switches mounted in air-conditioned spaces. As an alternate to NEMA 4X stainless steel enclosures provide polyglass enclosures for 30amp (10hp) switches in the chemical areas equal to Hubbell Circuit-Lock.

C. Provide and install lugs on disconnect switch as required to accept conductors called for on drawings.

D. Provide Switches with an externally operated handle; quick make quick break mechanism; the handle shall be interlocked with the switch cover by means of a defeatable interlock device. The switch shall be lockable in the "off" position with a padlock. Switches shall have arch suppressors, pin hinges and be horsepower rated at 600 volts.

E. Double throw non-fused safety switches may be used for manual power transfer where shown on the drawings and in areas up to 10,000A available short circuit current. In areas above 10k amps use double throw molded case manual transfer switches rated for the available fault currents.

2.02 SUBMITTALS

A. Submit product data on all major types of disconnects.

PART 3 – EXECUTION

3.01 INSTALLATION

A. All three phase motors shall be provided with field mounted disconnects if they are not mounted within site of the three phase feeder breaker or control device they are

wired from.

B. With the safety switch in the open position, both the motor heater and power circuits shall be open as well.

END OF SECTION

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM

PART 1 -GENERAL

1.01 DESCRIPTION

A. Description of Systems:

1. A Lightning Protection System shall be placed on the structures by experienced installers in compliance with provisions of Code for Lightning Protection Systems as adopted by the National Fire Protection Association and Underwriters' Laboratories. Intent of the lightning protection systems shall be to protect the structures against damage by lightning. All equipment to that result shall be included whether or not specifically called for herein. Installers shall be Underwriters Laboratories certified as Master Label installers or of equal qualifications as approved by Engineer.
2. Provide complete and upgraded lightning protection systems as noted on the drawings. Provide bonding and grounding systems and interconnection to the site lightning protection and grounding systems as shown on the drawings and as specified. All systems shall be in conformance to NFPA-780, UL-96, UL96-A and as shown on the contract drawings.
3. Materials shall comply in weight, size and composition with the requirements of Underwriters' Laboratories and the National Fire Protection Code relating to this type of installation, and shall be U.L. labeled.
4. All installations shall be performed to meet Underwriters Laboratories Master Label standards. Provide a UL Master Label or Lightning Protection Institute (LPI) certification for all protected structures to the extent the structures are eligible under the standards of UL 96A. If the structure is not eligible under the standards of UL 96A, provide a Letter of Findings for the installation at completion of work.

1.02 SUBMITTALS

A. Shop Drawings and Product Data:

1. Shop Drawings: Shop drawings shall be submitted before work is started. Drawings shall include full layout of cabling and points, and connections. The drawing shall show the type, size and location of all equipment, grounds and cable routing. The drawing shall show all grounds and air terminals that are shown on the contract drawings. See additional requirements for shop drawings in section 26 05 02.
2. Product Data: Product Data shall be submitted on all equipment to show compliance with this section of the specifications and shall include manufacturer's written recommendations for installation. Provide a sample of the air terminal to be used with the shop drawing submittal.
3. Provide the owner with 2 spare tubes of the adhesive used to affix bases, fasteners and down conductors to facilities.

1.03 SYSTEM DESIGN

A. The system shall be an effective, aesthetically acceptable streamer-delaying lightning protection system to the standards of Underwriters Laboratories UL 96 & UL96A. The purpose of the system shall be to reduce the likelihood of a direct strike to the protected structure by delaying the formation of streamers from that structure. Secondarily the system shall be designed in such a manner that it affords protection to the structure upon which it is installed in the event a direct lightning strike to the structure does occur.

B. The system components shall not require mounting in a specific configuration or impose any other mounting limitations which may interfere with utility use of structure space or otherwise preclude or limit the intended use of the structure.

C. All components shall be attached to the structure in such a manner as to reduce the possibility of corrosion between dissimilar metals. If installed on a metallic or otherwise electrically conductive structure, the system shall be electrically bonded to the structure upon which it is installed through mounting clamps and brackets, with additional bonding to grounded objects and to the structure, as required or as indicated on the drawings.

D. The system shall be composed of components that meet the requirements of Underwriters Laboratories UL 96. Aluminum and Stainless Steel components shall be employed on structures and portions of structures subject to corrosive elements, where the use of copper components could be rendered ineffective, due to the surrounding environment. No dissimilar metals shall be allowed to be in contact. In areas where chemical conditions may deteriorate the specified materials faster than the life expectancy of the material, the LP installer shall bring these conditions to the attention of the engineer prior to installation.

E. Air Terminals shall be mounted on all outside corners of each structure, around the perimeter of each structure at intervals not to exceed twenty (20) feet, and on the interior of each structure in such a manner that no two Air Terminals are separated by a distance of more than fifty (50) feet. In the event this is not practical, such as on a large open tank, Air Terminal spacing around the perimeter shall be decreased to not more than fifteen (15) feet, with a total number around the perimeter not less than the total of the normally required perimeter Air Terminals, plus the additional number of Air Terminals if Air Terminals had been installed on the interior at intervals not greater than fifty (50) feet.

F. Each Air Terminal shall be provided with two (2) contiguous paths to ground. On structures with handrails, exposed structural members, or other conductors, provide a bond to structural conductors from the lightning protection system. Handrails shall not be used as a main lightning protection conductor. Provide a continuous lightning protection conductor parallel with handrails and bond from it to each handrail section and a minimum of 10’ on center. In the case of a structure or a portion of the structure where the structure itself is electrically conductive, such as a light pole, tower, etc, that structure or portion of the structure itself may be employed as part of the lightning protection system, provided it meets the minimum requirements of UL 96 or UL 96A, and down conductors are specifically not required on such structures.

PART 2 - PRODUCTS AND INSTALLATION

2.01 AIR TERMINALS

A. Air Terminals shall be of the streamer delaying type. Each air terminal shall have a minimum of five hundred dissipater electrode wires, none of which exceed ten thousands of an inch diameter. Electrode material shall be high quality 316 series stainless steel and shall have proper base support for surface on which they are attached, and shall be securely anchored to this surface. Terminals shall project a minimum of 18" above top of object to which attached. Air terminal point must be 3/16 or greater to meet current UL standards.

B. Streamer-delaying Air Terminals shall be manufactured by Altec Global or Thompson.

2.02 CONDUCTORS

A. Roof conductors shall consist of rope lay aluminum conductor complying with the weight and construction requirements for Class II lightning protection systems (192,000 CM). Conductors shall be coursed to interconnect with air terminals, and in general, provide a two-way minimum path to ground. The angle of any turn shall not exceed 90 degrees, and shall provide an approximately horizontal or downward course. Down conductors shall be Aluminum and transition to copper 18” minimum above grade. Down conductors shall be installed in PVC conduit and hidden within the structure. Approved bi-metal transitions from aluminum conductors for bonding of aluminum roof structures (exhaust fans, etc.) to copper down conductors shall be provided. Radius of bends shall not be less than 8 inches.

B. Counterpoise loop ground conductors shall be tinned copper and be a minimum size equal to the main roof conductor size (192,000cm) or 4/0.

2.03 FASTENER

A. Conductor fasteners shall be of the same material as the conductor, having ample strength to support conductor. Where fasteners are to be mounted in masonry or structural work, they shall be furnished to the Masonry or Structural Contractor so they may be installed during construction of the project.

B. All fasteners shall be of a heavy-duty double bolted type typically used for Class II lightning protection systems. Conductor to conductor connections shall be through heavy-duty pressure type bolted fasteners. Splice and bimetal connections shall be through four bolt pressure type heavy-duty connectors. Crimp fasteners shall not be used.

C. Dissimilar metals shall not be allowed to be in contact. Aluminum fittings shall be mounted on aluminum where necessary, and bonded to the main system using bi-metal connectors. Lead coating shall not be acceptable as a bi-metal transition.

D. All mechanical termination points and lugs shall have an anti-corrosive coating applied. In areas subject to chemical corrosion (odor control, degasifiers, chem. Rooms, etc.) apply Glyptal 1201 red enamel coating after termination is made. In

other less corrosive areas apply Permatex battery protector sealer (SA-9) or Glyptal 1201 or equal.

E. Lugs for copper cable shall be high copper alloy terminals or stainless steel equal to Burndy type QDA Qiklug. Lugs of aluminum alloy are not acceptable.

2.04 GROUND CONNECTIONS

A. Ground rods shall be installed in the quantities as indicated on the drawings and as required by NFPA-780. Ground rods shall be placed a minimum of two (2) feet from building foundations. In addition to above artificial grounds, one down conductor of each two-path system shall be connected to water piping system with approved water pipe type strap connector. All ground rods shall be 5/8" X 20' copperweld type. All connections made below grade shall be exothermically welded (cadweld) connection and placed in a ground rod inspection well as detailed.

B. Soil type in the area is primarily sand with rock layer below. The rock layers on site will require drilling of ground rod holes. All ground rods shall be installed vertically. After drilling and installation of rod, back fill with sand and hydro compact around rod to provide low resistance to ground.

2.05 GROUND ROD & GROUND SYSTEM TESTING

A. The contractor shall utilize a clamp on ground loop tester during construction to check the system for high resistance connections. The resistance at any point below the air terminal shall be less than 5 ohms. The resistance at grade level on the down conductors should be less than 2 ohms. The contractor shall investigate and correct high resistance readings within the system. Demonstrate to the engineer's satisfaction with witness testing, provision of a low resistance installation meeting this specification.

B. Provide three point fall of potential ground testing on a minimum of one ground rod on each facility prior to connection to the counterpoise system. As an alternate provide ground rod selective method testing with appropriate ground testers. The complete ground system shall be three point fall of potential tested after completion of work. The system shall be tested at a minimum of three points spaced around the site using the "Tagg Slope" technique. Total grid system grounds should be less than one ohm.

2.06 INSTALLATION

A. Installation shall be made in an inconspicuous manner with conductors coursed to conceal equipment as much as possible. Down conductors shall be concealed within structure, and shall be run in 1" PVC conduit. Surface mount down conductors to existing structures in a neat and workmanlike manner. All metallic equipment within 6 feet of any lightning conductor shall be bonded to conductor. System shall also be tied to the main service electrical ground and other ground systems in the area.

2.07 COORDINATION

A. The installer shall coordinate the lightning protection work to insure a correct, neat,

and unobtrusive installation. In normally accessible areas, catwalks, equipment platforms, etc., provide installation without trip hazard. Provide embedded conduit sleeves across access ways for ground conductors. In retrofit projects provide flat copper strap to ground or bond across access ways.

B. Any electrical service grounding system and metallic water service piping to the structure shall be electrically bonded to the lightning protection system.

C. The contractor shall coordinate his work in such a manner as to not interfere with the normal operation of the structure upon which the installation is performed.

2.08 MATERIAL MANUFACTURERS

A. Equipment shall be as manufactured by Altec Global Lighting Protection, Thompson Lightning Protection, Inc. Independent Protection Company, Inc., Heary Brothers Lightning Protection, Harger Lightning Protection or Robbins Lightning Protection.

END OF SECTION

SECTION 26 43 00

SURGE PROTECTIVE DEVICES (SPDs)

PART 1 - GENERAL

1.01 SCOPE

A. The Contractor shall furnish and install the Surge Protective Device (SPD) equipment having the electrical characteristics, ratings, and modifications as specified herein and as shown on the contract drawings. To maximize performance and reliability and to obtain the lowest possible let-through voltages, the ac surge protection should be integrated into electrical distribution equipment such as switchgear, switchboards, panelboards, busway (integrated within bus plug), or motor control centers. Refer to related sections for surge requirements in:

1.02 RELATED SECTIONS

A. Section 26 29 13 - Control Panels

B. Section 26 24 16 – Panelboards

C. Section 40 95 13 - Instrumentation and Controls Systems

1.03 REFERENCES

A. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable UL standard (ANSI/UL 1449 3rd Edition).

B. ANSI/IEEE C62.41.1-2002 – Guide on surge environment in low-voltage (1000 V and less) AC power circuits.

C. ANSI/IEEE C62.41.2-2002 – Recommended practice on characterization of surges in low-voltage (1000 V and less) AC power circuits.

D. ANSI/IEEE C62.45-2002 – Recommended practice on surge testing for equipment connected low-voltage (1000 V and less) AC power circuits.

1.04 SUBMITTALS

A. The following information shall be submitted to the Engineer:
   1. Provide verification that the SPD complies with the required ANSI/UL 1449 3rd Edition listing by Underwriters Laboratories (UL).

2. For sidemount mounting applications (SPD mounted external to electrical assembly), electrical/mechanical drawings showing unit dimensions, weights, installation instruction details, and wiring configuration.

B. Where applicable the following additional information shall be submitted to the engineer:
1. Descriptive bulletins
2. Product sheets

C. The following information shall be submitted for record purposes:
1. Final as-built drawings and information for items listed and shall incorporate all changes made during the manufacturing process

1.05 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

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

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.06 OPERATION AND MAINTENANCE MANUALS

A. Operation and maintenance manuals shall be provided with each SPD shipped.

1.07 MANUFACTURERS

A. Eaton / Cutler-Hammer products

B. SquareD by Schneider Electric: Surgelogic

C. EDCO

D. Erico

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features, and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

PART 2 – PRODUCTS

2.01 VOLTAGE SURGE SUPPRESSION – GENERAL

A. Electrical Requirements

1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
3. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
4. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

	Protection Modes			
Configuration	L-N	L-G	L-L	N-G
Wye	●	●	●	●
Delta	N/A	●	●	N/A
Single Split Phase	●	●	●	●
High Leg Delta	●	●	●	●

5. Nominal Discharge Current (I_n) – All SPDs applied to the distribution system shall have a 20kA I_n rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an I_n less than 20kA shall be rejected.

6. SHORT CIRCUIT CURRENT RATING (SCCR): Per NEC 286.6, the short circuit current rating of the SPD shall be equal to or greater than the available short circuit current at the point where installed

7. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed the following:

Modes	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	2500

Modes	240D	480D	600D
L-L; L-G	1200	2000	2500

8. SPDs installed internal to the distribution equipment shall be of the same manufacturer as the equipment. The equipment shall be fully tested and certified to the following UL standards:

   UL 67 = Panelboards
   UL 845 = Motor Control Centers
   UL 857 = Busway
   UL 891 = Switchboards
   UL 1558 = Low Voltage Switchgear

B. SPD Design

1. Maintenance Free Design – The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
2. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance.
3. Electrical Noise Filter – Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.
4. Monitoring Diagnostics – Each SPD shall provide the following integral monitoring options:
   a. Protection Status Indicators - Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.
      i. The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.
   b. Surge Counter – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location.
   c. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed.
5. Remote Status Monitor: The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.

6. Overcurrent Protection
   a. The SPD shall be designed in a way that it will take itself off-line before any damaging external effects to the suppressor or surroundings will occur.

2.02 SYSTEM APPLICATION

A. The SPD applications covered under this section include distribution and branch panel locations, busway, motor control centers (MCC), switchgear, and switchboard assemblies.

B. Surge Current Capacity – The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

Minimum surge current capacity			
Category	Application	Per Phase	Per Mode
C	Service Entrance Locations (Switchboards, Switchgear, MCC, Main Entrance)	240kA	120 kA
B	High Exposure Roof Top Locations (Distribution Panelboards)	160 kA	80 kA
A	Branch Locations (Panelboards, MCCs, Busway)	120kA	60 kA

C. SPD Type – all SPDs installed on the line side of the service entrance disconnect shall be Type 1 SPDs. All SPDs installed on the load side of the service entrance disconnect shall be Type 1 or Type 2 SPDs.

2.03 LIGHTING AND DISTRIBUTION PANELBOARD REQUIREMENTS

A. The SPD application covered under this section includes lighting and distribution panelboards.
   1. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
   2. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
   3. The panelboard shall be capable of re-energizing upon removal of the SPD.
   4. The SPD shall be interfaced to the panelboard via a direct bus bar connection. Alternately, an SPD connected to a 30A circuit breaker for disconnecting purposes may be installed using short lengths of conductors as long as the conductors originate integrally to the SPD. The SPD shall be located directly adjacent to the 30A circuit breaker.
   5. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
   6. The SPD shall be of the same manufacturer as the panelboard.

7. The complete panelboard including the SPD shall be UL67 listed.

B. Sidemount Mounting Applications Installation (SPD mounted external to electrical assembly)
   1. Lead length between the breaker and suppressor shall be kept as short as possible to ensure optimum performance. Any excess conductor length shall be trimmed in order to minimize let-through voltage. The installer shall comply with the manufacturer's recommended installation and wiring practices.

C. Switchgear, Switchboard, MCC and Busway Requirements
   1. The SPD application covered under this section is for switchgear, switchboard, MCC, and busway locations.
   2. The SPD shall be of the same manufacturer as the switchgear, switchboard, MCC, and busway
   3. The SPD shall be factory installed inside the switchgear, switchboard, MCC, and/or bus plug at the assembly point by the original equipment manufacturer
   4. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bar.
   5. The SPD shall be connected through a disconnect (30A circuit breaker). The disconnect shall be located in immediate proximity to the SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.
   6. The SPD shall be integral to switchgear, switchboard, MCC, and/or bus plug as a factory standardized design.
   7. All monitoring and diagnostic features shall be visible from the front of the equipment.

2.04 ENCLOSURES

A. All enclosed equipment mounted for indoor application shall be NEMA 1 general purpose enclosures. Provide NEMA 4X enclosures for all outdoor applications.
   1. NEMA 1 – Constructed of a polymer (units integrated within electrical assemblies) or steel (sidemount units only), intended for indoor use to provide a degree of protection to personal access to hazardous parts and provide a degree of protection against the ingress of solid foreign objects (falling dirt).
   2. NEMA 4X – Constructed of stainless steel intended for either indoor or outdoor use to provide a degree of protection against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (dirt and windblown dust); to provide a degree of protection with respect to the harmful effects on the equipment due to the ingress of water (rain, splashing water, and hose directed water).

2.05 POWER SUPPRESSORS FOR ELECTRONIC EQUIPMENT

A. Each item of electronic equipment provided under this contract and connected by line cord or direct wired to the building electrical system shall be provided with a

three-stage single or multi-phase hybrid suppressor. Fusing shall be provided which removes the protective elements from the circuit upon failure. Visual indication or loss of output power shall be used to notify the user of device failure.

B. Suppressors shall be rated for a minimum of 125% of their continuous electrical load. Suppressors for cord connected equipment shall be equipped with standard NEMA cordsets one of which includes a molded grounding receptacle and the other, a molded grounding plug. Suppressor shall be installed in series with the power cord for the protected equipment. Where several items of equipment are grouped within the same cluster of equipment, one suppressor may be used in conjunction with properly sized grounding plugstrip to serve the equipment.

C. Suppressors for direct wired equipment shall be identical in internal design to the unit described for cord connected applications, however, protected screw terminals suitable for termination of solid copper wire shall be used for wiring terminations. One suppressor may be used to support several equipment cabinets provided all cabinets are located within the same equipment cluster and the maximum connected load shall not exceed eighty percent of the rated suppressor capacity.

D. Suppressors shall be constructed with a phenolic non-flammable exterior housing with provisions for mounting to the interior of equipment racks, cabinets, or to the exterior of free-standing equipment. Suppressors shall be constructed as three-stage devices. The first stage shall include a high-energy varistor clamp between line and neutral and from neutral to ground. The second stage shall consist of series air-core inductor installed in the line conductor(s) to properly coordinate the action of the first and third stages. The third, fast acting, hard clamping stage shall consist of a network of silicon avalanche bipolar surge suppression diodes between the neutral and line conductor(s).

E. Minimum suppressor performance characteristics shall be as follows:
1. Maximum single impulse line-to-neutral current withstand: 15,000 Amperes (8 x 20 us waveform)
2. Maximum single impulse neutral-to-ground current withstand: 10,000 Amperes (8 x 20 us waveform)
3. Pulse lifetime rating Category B worst case current waveform (8 x 20 us @ 3000 Amperes): 1200 occurrences
4. Pulse lifetime rating for 200 Ampere (8 x 20 us waveform): 10,000 occurrences
5. Worst case response time: Five Nanoseconds
6. Worst case (Maximum Single Impulse Current Conditions) clamping voltage: 400% of nominal phase-to-ground RMS voltage.
7. Initial breakdown voltage: 200% of nominal phase-to-ground RMS voltage.

2.06 SUPPRESSORS FOR CONDUCTOR PAIR PROTECTION

A. Suppression devices for conductor pair protection shall be provided in single-

circuit pluggable packages suitable for the circuitry to be protected. Units for protection of data circuits which utilize standard connector configurations shall be equipped with connectors which install in series with the data cable to the protected equipment. Units intended for use with multiple wiring pairs shall be equipped with accessory terminal blocks or strips suitable for the type of wiring being used. Single pair units shall be configured as encapsulated units with wire leads or screw-terminal wiring terminations. Suppressors installed outside of terminal or equipment cabinets (except at designated terminal boards) shall be provided with a housing to afford physical protection for the surge suppression modules.

B. Suppression for each pair shall consist of a three-element gas tube first stage, an isolating element in series with each conductor of the pair, and a silicon avalanche second stage. Second stage clamping shall be provided across the pair for differential mode protection and from each side of the pair to ground for common mode protection. Resistive limiting elements may be used on low current circuits where the effect of voltage drop across the series resistance has no effect on circuit operation. Inductive series elements shall be used on higher current circuits to effectively pass direct or low frequency alternating currents while limiting passage of fast risetime surge waveforms. Silicon avalanche devices shall be designed for surge suppressor applications and shall be polarized or bipolar as appropriate for each circuit.

C. Minimum performance criteria (each circuit) shall be as follows:
   1. Maximum single impulse conductor-to-ground or conductor to conductor current withstand: 10,000 Amperes (8 x 20 us waveform)
   2. Pulse lifetime rating Category B worst case current waveform (8 x 20 us @ 3000 Amperes): 10 occurrences
   3. Pulse lifetime rating for 100 Ampere (10 x 1000 us waveform): 1,000 occurrences
   4. Worst case response time: Five Nanoseconds
   5. Worst case (Maximum Single Impulse Current) clamping voltage: 200% of normal operating voltage amplitude and polarized or bipolar as appropriate for each circuit type.
   6. Initial breakdown voltage: 150 percent of normal operating voltage peak amplitude plus or minus five percent.
   7. Capacitance: Capacitance for DC or low frequency lines shall not exceed 2000 picofarads measured line to line or line to ground at the rated diode breakdown voltage. Suppressors intended for use on high frequency or high baud rate circuits shall be designed for use on such lines. Capacitance of such units shall be equated to equivalent cable feet based on the type of cabling used for the particular circuit. The sum of equivalent cable feet for suppressors and actual cable footage shall not exceed manufacturers recommended maximum values for the system on which these devices are installed.
   8. Circuit compensation: Any additional circuit compensation (gain or equalization) required to compensate for the insertion of surge suppression devices shall be provided as part of this contract.

PART 3 - EXECUTION

3.01 BONDING AND GROUNDING CONDUCTORS AND MATERIALS

A. Conductors utilized for surge suppressor bonding shall be a minimum of #6 AWG solid insulated copper unless otherwise specified.

B. Ground bus or strip material shall be copper, a minimum of 26 gauge in thickness and three inches wide unless otherwise specified. Bus materials may be secured to surfaces with an appropriate mastic material or mechanical fasteners. Bus connections shall be bolted or brazed and reinforced as necessary on thin bus material to provide a permanent and secure connection.

C. Unless otherwise specified, all surge suppression grounding electrodes shall be 5/8" diameter copperweld rods, twenty feet in length.

D. Connectors, splices, and other fittings used to interconnect grounding conductors, bond to equipment or ground bars, shall comply with requirements of the National Electric Code and be approved by Underwriters Laboratories for the purpose.

E. Connectors and fittings for grounding and bonding conductors shall be of the compression or set-screw type in above grade locations. Connections below grade shall be exothermically welded or brazed.

F. Bonding connections between electrically dissimilar metals shall be made using exothermic welds or using bi-metal connectors designed to prevent galvanic corrosion.

3.02 SEGREGATION OF WIRING

A. All system wiring shall be classified into protected and non-protected categories. Wiring on the exposed side of suppression devices shall be considered unprotected. Surge suppressor grounding and bonding conductors shall also fall into this category.

B. All wiring between surge suppressors and protected equipment shall be considered protected. Isolated circuitry exempted from surge suppression requirements in part one of this section shall also be considered protected.

C. A minimum of three inches of separation shall be provided between parallel runs of protected and unprotected wiring in control panels, terminal cabinets, terminal boards and other locations. In no case shall protected and unprotected wiring be bundled together or routed through the same conduit. Where bundles of protected and unprotected wiring cross, such crossings shall be made at right angles.

3.03 INSTALLATION OF SUPPRESSORS

A. Suppressors shall be installed as close as practical to the equipment to be protected consistent with available space. Where space permits and no code

restrictions apply, suppressors may be installed within the same cabinet as the protected equipment. Suppressors installed in this manner shall utilize the equipment chassis as a medium for bonding of their ground terminals. Bonding jumpers not exceeding two inches in length shall be installed between the chassis and suppressor ground terminals. Bolted connections with star washers shall be used to insure electrical and mechanical integrity of connections to the equipment chassis.

B. Suppressors shall be installed in a neat, workmanlike manner. Lead dress shall be consistent with recommended industry practices for the system on which these devices are installed.

C. Bonding between ground terminals for power and signal line suppressors serving a particular item or cluster of equipment shall be kept as short as possible. Where practical, suppressors shall be installed in a common location for the cluster with their ground terminals bonded closely together. For installations requiring separation between the various suppressor grounds and equipment chassis within an equipment cluster, the following table shall be used to determine bonding conductor requirements (distances are measured between most distant suppressor or chassis grounds):

BONDING DISTANCE	MATERIAL
0 - 10 feet	#6 AWG Bare Copper (Solid)
10- 25 feet	1-1/2" Copper Strip 26ga. Min.
25- 50 feet	3" Copper Strip 26ga. Min.
Over 50 feet	6" Copper Strip 26ga. Min.

Care shall be exercised to avoid connection of incidental grounds to the bonding bus system.

D. Where terminal cabinets are used to house surge suppressors, painted steel backboards shall be used to serve as a low impedance ground plane for bonding surge suppressor leads together. Terminal boards used for the same purpose shall be laminated with a single sheet of 14 ga. galvanized steel to serve as a ground plane for suppressors. Suppressors with ground terminals not inherently bonded to the ground plane through their mounting shall be bonded to this plane using a two-inch maximum length of #12AWG copper wire and suitable lug. Ground planes and backboards shall be drilled to accept self tapping screws, any paint in the area of the bond shall be removed and star washers shall be used.

E. Supplementary grounding and bonding connections required between the bonding bus or ground plane for each equipment cluster and other locations as indicated herein shall be accomplished using #6 AWG bare copper conductors and approved connections unless otherwise noted.

3.04 WARRANTY

A. The manufacturer shall provide a full ten (10) year replacement warranty from the date of shipment against any SPD part failure in material or workmanship when installed in compliance with manufacturer's written instructions and any applicable national or local code.

END OF SECTION

SECTION 26 50 00

LIGHTING FIXTURES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Description of System
1. Light fixtures furnished under this Division shall be furnished complete with lamps and all necessary trim and mounting hardware, and installed as shown on the drawings.
2. Light fixtures shall be neatly and firmly mounted, using standard supports for outlets and fixtures. See special mounting requirements as detailed on the drawings.
3. Lamps shall be included in the system guarantee for a period of ninety (90) days after final acceptance of the building.

1.02 CODES

A. The WORK of this Section shall comply with the current editions of the following codes
1. National Electrical Code (NEC), NFPA 70
2. Florida Building Code (FBC)

1.03 SPECIFICATIONS AND STANDARDS

A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section
1. UL Underwriters Laboratories
2. CBM Certified Ballast Manufacturer's Association

1.04 SUBMITTALS

A. Shop Drawings and manufacturers data shall be submitted for the following items
1. Luminaire data shall show full-size cross sections. Indicate finished dimensions, metal thickness, U.L. Label, finish, lens/louver thickness and materials.
2. Show mounting details, including hung ceiling construction.
3. Indicate type of ballast and manufacturers and ballast quantity and location. Include information as to power factor, input watts and ballast factor.
4. Indicate lamps to be utilized and quantity.
5. Include a complete listing of all luminaries on a single sheet. This listing shall contain the luminaire type, manufacturer’s catalog number, applied voltage, lamps, ballast type and luminaire quantities.
6. The Engineer reserves the right to require submittal of a complete sample fixture for any fixture type.
7. For exterior post/pole mounted light fixtures, clearly indicate hand hole and lightning protection ground lug mounted to post/pole at hand hole inside post/pole.

8. Signed and sealed shop drawings and calculations shall be submitted for all exterior pole mounted fixtures. The seal must be of a registered professional engineer certifying that the foundation and pole/fixture assembly meets or exceeds the wind load criteria of the most current Florida Building Code. The foundation details shown on the plans are for bidding purposes only; the contractor shall provide the foundation and pole assembly necessary for compliance as submitted at no additional cost to owner.
9. Product data shall be submitted showing manufacturer's written recommendations for storage and protection, and installation instructions.

PART 2 – PRODUCTS

2.01 APPROVED MANUFACTURERS

A. Luminaires
1. Acceptable manufacturers are listed in the lighting fixture schedule shown on the Drawings.
2. The designations indicated on the lighting fixture schedule are a design series reference (not necessarily a complete catalog number) and do not necessarily represent the number, size, voltage, wattage, type of lamp, ballast, finish trim, ceiling type, mounting hardware of special requirements as specified hereinafter on as required by the particular installation(s) and code. Contractor shall verify these requirements and order fixtures as required to give proper installation per the contract documents and per codes.

B. Ballasts
1. It is preferred that all ballasts shall be of the same manufacturer. Every effort shall be made to eliminate ballasts from multiple manufacturers. Ballasts within luminaires of a given type must however be of the same manufacturer. Multiple manufacturers will not be permitted.
2. Approved Manufacturers:
    a. Motorola
    b. Advance Transformer Co.
    c. Magnetek
    d. General Electric

C. Lamps
1. All lamps shall be of the same manufacturer. Multiple manufacturers are not permitted.
2. Approved Manufacturers:
    a. General Electric
    b. Philips
    c. Osram Sylvania

2.02 MATERIALS

A. All lighting fixtures mounted outdoors subject to dampness and insects shall have gasketing material between lens door and frame to completely seal interior of fixture. Knockouts and holes in fixtures housing shall be closed and sealed. All fixtures shall be complete with lamps, shielding brackets, concrete bases, anchor

bolts, and all necessary fittings and accessories for a complete installation.

B. Plastic Lenses and diffusers:
   1. Virgin acrylic unless otherwise noted. Install and leave with no finger prints or dirt marks on the lens or diffuser. Lenses shall be provided on all recessed metal halide luminaires.
   2. Minimum unpenetrated thickness for Parabolic or conical element diffuser: 0.085 inch.
   3. Minimum nominal thickness: 0.125 inch.

C. Parabolic Luminaire Care: Parabolic luminaires to be installed with mylar cover over louvers. Cover shall be U.L. listed for temporary lighting. Upon completion of work, remove mylar cover with white gloves and blow clean reflectors.

D. Finish: Porcelain or baked enamel finish matte white on interiors with minimum tested reflectance of 90 percent matte white finish or as specified in visible exterior. Thoroughly clean base metal and painted after fabrication.

E. Sockets: Incandescent lamp sockets - porcelain housings over copper screw shells, with medium base sockets rated at 660 watts and 250 volts. Insulating joint in pull chains. Fluorescent lampholder - white, rotor lock, heat-resistant plastic rated 660 watts and 600 volts. Fluorescent industrial sockets - heavy-duty, multi-socket, metal-clad, spring-loaded. Provide heavy-duty sockets for H.I.D. luminaires where mounted less than 8'-0" AFF.

F. Luminaire Wiring: Minimum individual luminaire wiring - number 18 gauge with insulation at rated operating temperature of 105 degrees Centigrade or higher. Terminate wiring for recessed luminaires, except fluorescent units, in an external splice box.

G. Ballasts
   1. Ballasts for F32T8 lamps shall be:
      a. High frequency solid state electronic.
      b. Electronic Program start
      c. 50 F minimum starting temperature unless otherwise noted
      d. Minimum 1.15 ballast factor
      e. Maximum total harmonic distortion (THD) less than 10%
      f. High power factor, minimum 95 %
      g. Sound rated A
   2. High-power factor (over 90 percent). Certified Ballast Manufacturers' Certification, ballast case temperature not to exceed 90 degrees Centigrade during normal operation in 30 degrees Centigrade ambient temperature. Ballast voltage: 120 or 277 volts, as required by circuiting. Ballast shall be provided with the best sound rating available.
   3. Built-in self-resetting thermal actuated device will remove ballast from line when excessive ballast temperature is reached. U.L. Class P, CBM certified 100% output.
   4. The conductors between ballasts and lampholders shall have an approved insulation for 1,000 volts. This includes conductors to and from remote ballasts.
   5. High-intensity discharge ballasts shall be constant wattage

autotransformer type with built-in thermal protection, minimum power factor of 80%. 12" min. leads.

6. Provide ballasts with voltage characteristics to match that of all related circuitry indicated on the Drawings. No extra compensation will be allowed for failure to properly coordinate ballast voltage with circuitry.
7. Ballasts for control of lamps in one housing or fixture unit may control lamps of an adjoining unit, except as otherwise noted.
8. Guarantee ballast for one full year and one year prorated as per standard manufacturer's warranty against defects for a period of 2 years. Guarantee to include replacing defective ballast with new ballast.
9. Provide dimming ballasts as shown on the drawing for fixtures controlled by individual dimming or dimming systems.
10. LED drivers for interior luminaires shall employ an auto resetting thermal management system to turn off the LED array when normal operating temperatures are exceeded. Exterior drivers shall employ a step reduction circuit to reduce lumen output in order to maintain proper operating temperatures, but will not allow an “off” condition for thermal management.

H. Lamps

1. Provide a complete set of new lamps in each fixture.
2. Unless noted otherwise lamps must conform to the following:
    a. Fluorescent: T-8, 41k color. Minimum of 80 CRI and 3100 lumens.
    b. Incandescent: "A" lamps to be inside frosted rated at 130 volts.
    c. Compact Fluorescent: triple Twin tube, 4-pin
    d. HID: Metal Halide, clear, universal base, open rated.
    e. LED: Minimum of 50,000 hrs life at no less than 70% initial lumen rating. 40k color. Minimum of 80 CRI. Color variation shall not exceed a 3 step MacAdam ellipse.

I. Luminaires installed recessed in a metal pan ceiling shall have a flange type trim to overlap abutment of adjacent pans.

J. Where utilized as raceways, luminaires shall be suitable for use as raceways. Provide feed through splice boxes where necessary.

K. Where ceiling mounted fixtures are called for in the Light Fixture Schedule and on the drawings, this contractor shall provide fixture trims and supports as required to match type of ceiling system which will be furnished. No ceiling fixtures shall be ordered until the Ceiling System Installer has given written approval of the method and location of fixture hanging and fixture type. Fixtures supported by suspended ceiling systems shall be securely fastened to the ceiling framing member by mechanical means, such as bolts, screws, or rivets. Clips identified for use with the type of ceiling frame member(s) and fixture(s) shall also be permitted. Where fixtures are supported by the suspended ceiling system; the ceiling system shall have a minimum (2) opposite corners tied to structure at each fixture location; this contractor shall be responsible for doing this work or for having the ceiling contractor perform it. All supports shall meet current FBC standards.

L. All exterior post/pole mounted light fixtures shall have a hand hole at the base, lightning protection in hand hole and ground conductor connected to ground rod at base. Hand hole shall provide easy access to light fixture fusing and lightning

protection ground lug. Lightning protection ground lug shall be provided inside post/pole, electrically in contact with pole, for connection to ground rod. Provide and install ground wire from ground lug to ground rod, concealing ground wire through post/pole base. Anchor bolts to be galvanized.

M. All interior and exterior light fixtures shall not have any labels exposed to normal viewing angles. This includes manufacturer labels and U.L. labels. All labels shall be concealed within the body of the fixture and/or luminaire. No manufacturers name or logo shall appear on the exterior of any light fixtures unless approved in writing by engineer.

N. All light fixtures shall adhere to U.L. Test Standard #1571 and Section #410-65C of the National Electric Code. All manufacturers shall provide the required thermal protection as required.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install luminaires in mechanical and unfinished areas after ductwork and piping installation. Adjust fixture locations to provide the best lighting for equipment access and service locations. Locate fixtures 8 feet 6 inches above floor, or at suitable locations within space on walls but not lower than 7'-0" AFF.

B. The Contractor shall protect luminaires from damage during installation of same and up to time of final acceptance. Any broken luminaires, glassware, plastics, lamps, etc., must be replaced by the Contractor with new parts, without any additional expense to the Owner.

C. The contractor shall verify prior to ordering fixtures that each fixture scheduled has correct type trim and support arrangement for the proposed ceiling construction.

D. Install all fixtures in accordance with manufacturer's written instructions and the NEC.

E. Pendant mounted units shall comply with the following:
   1. Each stem shall have a brass or steel swivel or other self-aligning device of type approved by the Engineer. The entire luminaire mounting (hickey, aligner, swivel, stem, etc.) shall be submitted to and approved by the Engineer before installation.
   2. An insulated malleable iron bushing shall be placed at luminaire end of stem through which wire passes.
   3. A pendant support using an approved sliding clevis bracket which firmly grips an indentation in rigid sides of the wiring channel will be acceptable.
   4. Connections between outlet boxes and luminaires shall be by means of approved flexible raceways. The application of raceways directly between luminaires is unacceptable.

F. Where luminaires are mounted upon surface-mounted outlet boxes in surface mounted conduit runs, this Contractor shall furnish and install a luminaire canopy sufficiently deep to permit exposed conduits to pass through. Canopy shall have proper openings cut by luminaire manufacturer through which conduits may pass. Submit sample of canopy for approval before installation.

G. Ceiling surface mounted fluorescent fixtures installed in exposed ceiling areas are to be suspended from ceiling structure with all-thread rods and 1-1/2”x1-1/2” Kindorf channels, full length of fixture/row. Mount outlet box at structure with flexible connection to fixture.

H. Ducseal shall be installed to seal all conduits entering exterior light fixtures from underground.

I. Install exit light as indicated on the drawings but not higher than 10'0" AFF. Size and color of lettering shall comply with local codes.

J. Outdoor lighting shall be aimed in periods of darkness in front of the owner/engineer.

3.02 COORDINATION WITH AMBIENT CONDITIONS

A. The Contractor is responsible for coordinating the characteristics and the U.L. labeling of the luminaires and their components with the ambient conditions which will exist when the luminaires are installed. No extra compensation will be permitted for failure to coordinate the luminaires with their ambient conditions. These areas of coordination include but are not limited to the following:
   1. Wet location labels
   2. Damp location labels
   3. Low temperature ballasts
   4. Dimming ballasts
   5. Very low heat rise ballasts
   6. Explosion proof
   7. Plenums and air handling spaces
   8. Fire rated ceilings
   9. Low density ceilings
   10. Insulated ceilings

3.03 CLEAN-UP

A. Luminaires:
   1. Clean free from dust and dirt. Wash lens and glassware using cleaner such as “Windex” and dry with absorbent paper. Clean plastic per manufacturer’s recommendations; do not wipe. Lenses which are kept in original containers until immediately prior to final inspection may not require cleaning. Clean “Alzak” aluminum surfaces (reflectors, fixture cones and the like) per mfr’s recommendations being careful to remove finger prints and smudges.
   2. It is the contractor’s responsibility to remove any U.L. labels or

manufacturer's labels from areas of fixture exposed to view and relocate label to non-obtrusive area on fixture.

END OF SECTION

SECTION 40 95 13

INSTRUMENTATION AND CONTROL SYSTEM

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install, complete with all accessories, a programmable logic control based monitoring and control system with its associated instrumentation as described herein and shown on the contract drawings. The system shall serve as a self-contained monitoring and control system for all aspects of the pump station operation. It shall also be capable of integration with the existing Lee County fiber optic based central control network through a cellular radio or fiber optic Ethernet TCP/IP connection per site specific requirements.

B. This Specification has been developed to establish minimum requirements for a pump controller. This system shall be designed, constructed, tested and documented in strict accordance with the guidelines of this document. All system construction and programming will be the responsibility of the control system integrator. All materials and labor shall be provided for a fully functional system including any items which are required for system operation but are not specifically addressed in this document or on the contract drawings.

C. This specification is intended to be used in conjunction with all drawings supplied and is not intended to be complete without reference diagrams on system configurations, etc. All bidders must conform to all areas of the documentation. It is the intent of this specification that the monitoring and control system contractor have single source responsibility for the complete control and instrumentation package for the project; including but not limited to flow, pressure, level instrumentation and control, Variable Frequency Drives, generator, ATS and interconnecting conduit and control wiring for total system responsibility.

D. The overall requirements for the Process Instrumentation and Control System are included in this section. The following associated sections contain specific requirements for individual subsystems that are in addition to the requirements of this section.

1. 40 95 13– Appendix A MPS IO List

E. Lee County Utilities will self-perform all work required to integrate the Master pump station into the offsite central server. The instrumentation and control systems contractor will provide all local programming required for a fully functional pump control system and HMI operating panel.

1.02 CONTRACTOR QUALIFICATIONS AND ADDITIONAL RESPONSIBILITY

A. The contractor providing this system shall be an instrumentation and control systems contractor who is experienced in and regularly engaged in engineering, installation and service of systems of similar size and complexity within the water treatment industry. The panel supplier shall be a UL listed panel shop and all panels shall be UL-508 certified. All panels shall utilize components in order to achieve a minimum of 10KA AIC rating.

B. The contractor shall assume total systems responsibility for all aspects of this system including installation, commissioning and start-up of the system, training of operating personnel and coordinating interfaces between this system and equipment provided by others. This responsibility shall include mounting and wiring of relays, transformers, disconnecting means, and other control devices as required forming a complete system.

C. The installing contractor shall maintain an office with full time sales and service staff within a one hundred and fifty-mile radius of the site.

A. D. Provide the services of a qualified control system integrator that has demonstrated competence in providing controls system integration on this type of facility. Submit qualifications within 5 days of bid. Provide a list of ten (10) professional references of owners or clients of previous work. Include references from a minimum of three (3) governmental agencies that have contracted for similar type and size services, and three (3) engineering consultants whose design was incorporated or undertaken by the Contractor within the last five (5) years. The list shall include: Company name and address. Contracting officer and telephone number. Technical representative and telephone number. A written description of the project. Project value quoted for integration services work for each project. Include only projects utilizing the type and make of PLC (Allen Bradley), Scada Pack and HMI programming (Clear Scada) used on this project. Provide the services of a Lee County Utilities pre-qualified instrumentation and controls contractors for this project. The pre-approved contractors qualified through a RFQ process. This list can be found on the Procurement website. Any contractor that is not on the list will have to go through the same process as the RFQ qualified contractors.

E. The control system integrator shall insure the continued operation of the existing systems during tie-ins or interconnecting to the existing system. Provide temporary programming that may be required during construction to facilitate construction and testing as determined by the engineer.

F. The control system integrator shall assume full responsibility for all aspects of this system including components, devices, and systems not provided under this section, but that are directly interfaced by components or subsystems provided under this section such as VFDs and packaged local control panels.

1. Verify that the component, device, or system has been installed in accordance with the manufacturer's recommendations with respect to operation and control, coordinate installation, provide interfaces required.
2. Verify the calibration and adjustment of devices.
3. Verify proper control system interface and operation.
4. Start up and test to demonstrate proper control system interface and operation, in coordination with the equipment manufacturer.
5. The I&C contractor shall provide the electrical contractor with complete and coordinated VFD control drawings for manufacturer's use in the submittal approval process.
6. Provide the necessary modifications to the equipment, or other controls to properly interface and control the equipment.
7. Provide as built documentation of the existing controls and instrumentation devices and their integration into the total control and monitoring systems.

G. The control system integrator shall obtain from the contractor the required information on those primary elements, valves, valve actuators, and other control equipment or devices (both new and existing) that are required to be interfaced with, but that are not provided under, this section.

H. All conduits are provided and installed under Division 26, BASIC ELECTRICAL MATERIAL AND METHODS. With the exception of certain specified special control, fiber optic and high speed communication cables, all wiring and cables are provided and installed under Division 26, BASIC ELECTRICAL MATERIAL AND METHODS. Specific control cables and high speed communication shall be provided and installed by the control system integrator supplier.

I. Where the term "verify" and "certify" are stated in this specification, the intent is that the control system integrator shall issue formal statements in writing to the engineer that the particular activity has been accomplished.

1.03 SUBMITTALS-shall be submitted in accordance with Section 26 05 02 BASIC ELECTRICAL MATERIALS AND METHODS.

A. SHOP DRAWINGS shall include:

1. A cover sheet consisting of a Bill of Material, purchase order number, manufacturer's job number, Owner's name, location, application and shipping address.
2. Mechanical layouts detailing the overall external dimensions of all enclosures. Include all pertinent information such as location of door handles, windows, lifting lugs and enclosure mounted items such as pump controller chassis and I/O modules (show cable connections on modules), relays, cooling fans, etc.
3. Details for mounting of the processor, I/O racks, relays, motor starters, disconnect switch, fuse blocks, wireways, etc. All materials shall be labeled to provide easy cross-reference to the Bill of Material listing.
4. Electrical drawings detailing all hardwiring, done by the supplier, to devices such as relays, pump controller modules, disconnect switches, fuse blocks, etc. Provide individual wire numbers and relay contact cross-reference designations.
5. A description of all input and output modules by name, rack, module and terminal location.
6. Complete master wiring diagrams, elementary schematics and control schematics shall be submitted for approval before proceeding with manufacture. Suitable outline drawings shall be furnished as part of this submittal. Standard or typical pre-printed sheets or drawings simply marked to indicate applicability to this contract will not be acceptable. Shop drawings shall be on standard 24" X 36" or 11" X 17" media; drawn with a computer aided design package. The computer aided design package shall be AUTOCAD version 2014 or converted to Autocad version 2014. Engineering plan backgrounds of the facility shown on the contract documents will be available to the contractor on request. Submittals shall include reproducible plots of the drawings on paper translucent bond and CD-ROM electronic copies.
7. A complete drawing indicating each point of interface with the process control system and the type of signal provided or accepted at each point. This drawing shall depict the actual interface terminal block including all circuit designations.

8. A complete sequence of operation describing the control strategy in response to external signals and the signals which will be provided to the process control system during operation of the plant. All interlocks and limits which are internal to the operation of the controls shall be included in this description.
9. A drawing showing the layout of the control panels indicating every device with complete identification.
10. Analog and digital loop diagrams showing all I/O from the point of origin in the field device through the wiring systems to the PLC and HMI systems. Include all terminal block points and identification, color codes, tag names and numbers, etc. Include device range and calibration data for the analog device loop diagrams.
11. The last sheet(s) in the set shall describe all terminal block designations and individual terminal numbers.

B. SOFTWARE SUBMITTALS shall include:
1. Provide logic submittal diagrams in ISA format of all loops that are implemented in software and include a description of the control function and its control strategy, a listing of the scanned inputs and the outputs of the control function, operator inputs or outputs to and from the function and displays related to the function; failure contingencies and cross reference to other loop diagrams.
2. Generate a complete listing of all virtual discrete and analog points that are used to link modules. The virtual tag lists shall be developed and submitted to the engineer to facilitate operator interface programming.
3. Critical Path Software Development: The control system integrator shall submit a system software functional design submittal and shall meet with the Engineer at his office prior to software code development. The functional design submittal shall provide a description of the system on a functional level organized into functional subsystems. The submittal shall describe the individual programs that support these functions and include a subsystem summary; technical description from the user's standpoint; subsystem structure indicating data structures; interface structure; operator interface considerations and related operator interface display formats; initialization considerations and impacts of power failure or operator interface failure or shut down.
4. A written overview description of each ladder logic program. These descriptions shall lead the user through the major subsections of the programs. They shall generally describe the programming methods and techniques that were used to implement the functional requirements of this specification.
5. Each element (input, output, or function block) shall be fully described in a 15 character minimum description. Ladder rungs shall have comments that describe the function of the rungs. Provide an average of one 120 character comment line per ladder rung.
6. Discrete and analog input/output lists and cross reference. Each input and output shall be capable of being given up to a 27-character alpha-numeric functional identification that is printed above the respective input or output in the program listing. The cross reference shall indicate each rung number where the input or output is used.
7. Internal coils list and cross-reference. Each coil shall be capable of being given a 27-character alphanumeric function identification that is printed above the respective coil and all of its contacts in the program listing.

The cross-reference shall indicate each rung number where the respective coil or contact is used.

8. Data register list and cross-reference. This listing provides a listing of the data registers used and their locations(s) in the program.
9. A listing of all programmed special functions, including memory locations used and location in the program where the special functions can be found. Function descriptions shall also be shown in the special function printout for all pertinent memory locations used in each special function. Programmed values of all memory locations used shall also be shown.
10. Timers, counters, integer add and subtract, move, master control relay, and jump functions shall show all memory locations used and their programmed values.
11. Variable data memory storage record, indicating the memory location and description of the variable data; i.e., tag number, timer number, counter number. Function listing; all identified DCS functions indicated on the drawings and specifications shall be listed and fully described.
12. These submittals shall be returned reviewed prior to software code development. This is a critical path item and should be given appropriate consideration by the controls contractor.

C. O&M MANUALS

1. Submittal Requirements
   a. CONTRACTOR shall provide the OWNER and engineer with a single hard copy each of the preliminary O&M manual for review.
   b. Upon approval of the preliminary O&M the CONTRACTOR shall provide the OWNER with three hard copies of the final O&M manual. Award of final completion is contingent on the receipt of final O&M manuals.
   c. CONTRACTOR shall provide the OWNER with six electronic copies of the final O&M manual on CD. Award of final completion is contingent on the receipt of these CD's.
2. O&M manual shall include the approved shop drawing information as well as the following:
   a. As-Built drawings of the Control Panels
   b. Bill of Material listing for all components provided within the PLC panel (and any other panels provided) as well as provided external instrumentation devices, with cut sheets and operator's manual/user's reference books. Provide hard copy manuals and CD-Rom copy where available.
   c. Description of Operation, Local. Describe the control that takes place locally -- through the use of the local control panels and operator interface. The written description should be supported with pictorial representations such as the operator interface screens or portion of an electrical drawing.
   d. Description of Operation, SCADA. Describe the control that takes place at the Water Treatment Plant SCADA Server, similar to the local Operation Description listed above. Support the written description with pictorial representations -- screens from the Clear Scada, or pictures/images.
   e. Description of Operation Procedures. Describe Power up procedures, shut down procedures, troubleshooting procedures

f. Complete documentation for the PLC and its programming. Include the RS Logix Report with: Processor Information listing, I/O configuration, channel configuration, program file list, data file list, complete ladder-logic printout, address assignment listings for all Data Files/Bits.
g. Complete documentation concerning the Operator Interface and its database/address assignment.
h. Complete documentation of the Clear Scada Screens and its database/address assignment, similar to that above for the operator interface. Include configuration/setup listings that were used for the SCADA programming. Manual shall contain a copy of the most current SCADA system project back up. It will also include a back up of any include projects and the “Clear Scada.ini” file for all the automation computers.
i. Complete electronic copy (disk or CD-ROM) of the PLC ladder logic program. The licensed copy of the programming software as specified. The electronic copy shall contain the actual PLC program and not a PDF version of the program.
j. Complete electronic copy (disk or CD-ROM) of the operator interface program. The licensed copy of the programming software for the operator interface where required.
k. Complete electronic copy (disk or CD-ROM) of the Clear Scada Screen files and any other configuration files that are specific to the configuration/setup for the facility. Include a copy of the most current 3D model files used for the SCADA screens in the native format of the software.
l. Instrumentation Calibration Sheets and Settings Reports for all instruments as specified herein.
m. Alarms listings with clear descriptive messages. Alarm messages shall have the instruction address included in it.
n. A copy of the memory maps from PLC to PLC and all other devices such as power monitoring equipment. The electronic copy of the O&M manual shall contain the actual Excel file for the IO map and not a PDF version of the actual file.
o. Provide complete electronic file document library including AuotCAD files for all of the drawings, word processing files for all of the training and the sequence of operation.
p. System specifications.
q. Electrical power requirements.
r. Explanation of internal fault diagnostics.
s. Recommended spare parts list.

D. RECORD DRAWINGS
1. Record Drawings shall accurately show the installed condition of the following items:
   a. Underground raceway and duct bank routing.
   b. Field locate all in ground or above ground pullboxes.
   c. Field locate all in ground or above ground splice boxes.
2. Legibly record all existing conditions to scale on a set of Project Contract Drawings, (the "Record Drawings") or hand sketched drawings. Engineer and or LCU may be able to assist with providing scaled aerials or site plans to mark-up.

3. Submit a schedule of new fiber optic raceways, colors and numbers. Including the following information: Circuit origin, destination fiber color, and buffer tube color. Field wiring terminal strip names and numbers.
4. Submit a Control Network Rack schedule and label all cables to match schedule.

PART 2 - PRODUCTS

2.01 GENERAL

A. The Master pump station(MPS) electrical control equipment shall be wall mounted NEMA 3R enclosures of approximately 48”High x 36" wide x 12” in depth. The cabinet shall be arranged to separate the incoming field terminal interface blocks and surge suppression from the PLC I/O signals in the cabinet. See drawing for arrangement details. Additional enclosures shall house the motor monitor units and the Backup Pump Controller.

B. PLC enclosures shall include the following features:
1. Internal Light with toggle-Switch
2. Internal Service Power Outlets
3. Uninterruptible Power Supply (UPS)
4. UPS Bypass-Switch
5. Door Activated Switch for Intrusion Alarm
6. Drawing Pockets in the back side of the door
7. Laptop Ethernet Connection

C. The software written for this application shall be in ladder logic and provide a flexible, configurable and expandable control system for the pump station. The vendor shall provide a licensed copy of all software used in this project and registered to Lee County. All ladder code provided with this contract shall be documented so that an experienced programmer can easily make modifications to the software without having to go back to the original vendor for information. Documentation shall be approved by the engineer before final acceptance of the software. Lee County Utilities shall be the owner of the ladder logic program integration and shall have its unlimited use.

D. Components: All motor branch circuit breakers; motor starters and control relays shall be of highest industrial quality, securely fastened to the removable back panels with screws and lock washers. Back panels shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any component. A circuit breaker shall be provided on each control panel as a means of disconnecting power to the control panel. Control transformers shall be installed where shown to provide 120VAC and 24VAC for control circuits. Transformers shall be fused on the primary and secondary circuits. The transformer secondary shall be grounded on one leg.

E. All internal control panel wiring shall be identified at both ends with type written heat shrinkable wire markers with the numbering system shown on the control submittal drawings.
1. Control wiring shall be stranded copper, minimum size #1 AWG (except for shielded instrumentation cable may be #18 AWG), with 600 volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation. Each control wiring conductor shall have heat shrink identification labels on each end of termination. Terminations shall be made to screw terminal strips. All points

of terminal strips are to be labeled to match conductor labeling. Control wiring shall be SIS or XHHW insulated; PVC insulated wire is not acceptable.

F. The control panel shall be provided with nameplates identifying each component, selector switches, pilot lights, etc. Nameplates shall be permanently affixed using an epoxy process. Nameplates shall be laminated plastic, engraved white letters with a black background.

G. Corrosion Inhibitor Emitter: Provide an industrial corrosion inhibitor emitter, on all exterior mounted control panels that will protect internal components of the control panel from corrosion. Provide 1 year supply of spare corrosion inhibitors for each control panel.

H. Fused terminal blocks shall be provided for analog inputs and outputs. Blocks shall be permanently marked to indicate the appropriate I/O address of each circuit on the pump controller. Terminal strips shall be switch type with integral fuses equal to Allen Bradley 1492-H6. Wiring from the control panel to the terminal strips shall be factory installed. All spare conductors shall be terminated and identified.

I. The assembled system shall include circuit breakers, fuse blocks and other electrical components as required by the application and in accordance with the standard requirements of the National Electric Code as well as all State and Local electrical code requirements.

J. All I/O racks, processor racks and power supplies shall be grounded in accordance with the manufacturer's specifications.

K. All push-buttons, switches and other operator devices shall be UL listed and/or CSA approved and sufficiently large and durable to provide dependable, long life operation. Provide 30mm devices.

L. All cables, plugs, connectors and receptacles requiring user field installation shall be designed to withstand an industrial environment.

M. Surge suppressors shall be provided for all analog inputs and outputs and digital inputs that leave or enter the PLC and local control cabinets. Provide EDCO type HSP-121 surge suppressors for 120VAC power supply to all control panels. Provide Erico type UTB series for all digital circuits entering the PLC and local control cabinets. Provide Erico UTB series for all analog signals entering or leaving the PLC control panels.

N. RELAYS

1. Control circuit switching shall be accomplished with relays. These relays, for interfacing and control applications, shall be the compact general purpose plug-in type having low coil inrush and holding current characteristics. An LED status-indicating light shall be provided with each relay. Contact arrangements shall be as noted or shown, and shall be rated for not less than 10 amperes at 120V ac or 28V dc. Coil voltage shall be as noted or shown. Non-latching relays shall have a single coil. Latching relays are not acceptable. Relays shall have plain plastic dust covers, test buttons, and mounting sockets with screw terminals and holddown springs.

Relays shall be UL recognized. Relays shall be Square D or Allen Bradley, Omron or approved equal.

2. Time on delay functions shall be accomplished with Square D 9050JCK60V20 time relays. Provide RK electronics CFB24D-7-2M relay for time off delay applications. Units shall be adjustable time delay relays with the number of contacts and contact arrangements as shown. A neon status-indicating light shall be provided with each relay. Contacts shall be rated for 10 amperes at 120V ac. Integral knob with calibrated scale shall be provided for adjustment of time delay. Initial setting shall be as shown with time delay range approximately three times the initial setting. Time delay rangeability shall be at least 10:1. Operating voltage shall be 120V ac, plus 10 percent, -15 percent at 60-Hz. Operating temperature shall be -20 degrees F to 165 degrees F. Repeat timing accuracy shall be plus or minus 10 percent over the operating range. Units shall be Socket-mounted relays, octal plug-in, adjustable range as shown on drawings, equal to Amerace Corp., Control Products Division, Agastat Series 7000, Cutler-Hammer Series D87, Square D, Allen Bradley or Omron
3. All relays shall have a screw terminal interface with the wiring. Terminals shall have a permanent, legible identification. Relays shall be mounted such that the terminal identifications are clearly visible and the terminals are readily accessible.

O. PANEL OPERATING CONTROLS AND INSTRUMENTS

1. All operating controls and instruments shall be securely mounted on the interior deadfront as detailed on panel enclosure drawings. All controls and instruments shall be clearly labeled to indicate function.
2. Indicator lamps shall be LED full voltage push to test type and mounted in NEMA 4X (800H) 30mm modules, as manufactured by Allen Bradley or SKPI as manufactured by Square D. Lamp modules shall be equipped to operate at 24 or 120 volt input. Lamps shall be easily replaceable from the front of the control compartment door without removing lamp module from its mounted position. Units shall be heavy-duty, oiltight, industrial type with screwed on prismatic glass lenses in colors as shown, and shall have factory engraved legend plates. LED's shall be high illumination type (5ma at 130V ac).
3. Selector switches shall be 30mm heavy-duty, oiltight, industrial type selector switches with contacts rated for 120V ac service at 10 amperes continuous. Units shall have standard size, black field, legend plates with white markings, as indicated. Operators shall be black knob type. Units shall have the number of positions and contact arrangements and spring return function (if any) as shown. Units shall be single-hole mounting, accommodating panel thickness from 1/16-inch minimum to 1/4-inch maximum. Units with up to four selection positions shall be Allen Bradley 800H, Square D Type K, Cutler-Hammer Type T, or equal.

2.02 PROGRAMMABLE LOGIC CONTROL SYSTEM

A. The control system integrator shall furnish programmable controllers (PLC's) as specified herein and as shown on the Drawings. PLC's shall be provided complete with rack, power supply, I/O cards, special function cards, instructions, memory,

input/output capacity, and appurtenances to provide all features and functions as described herein.

B. The programmable controller shall be designed to operate in an industrial environment. The PLC shall operate in an ambient temperature range of 0^{o} - 60^{o} Celsius and a relative humidity of 5-95 percent, non-condensing. The PLC shall operate on supply voltages of 90-132 VAC at 47-63 Hz and be provided with a battery backup system. An integral fuse shall be provided on the power supply for short circuit protection and shall be front panel accessible. Integral overcurrent and undervoltage protection shall be provided on the power supply.

C. System configuration shall be as shown on the drawings. PLC's shall be Allen-Bradley Compact Logix 1769-L32E or better with Ethernet Network module as manufactured by Rockwell Automation. The PLC shall include provisions for automatically updating time for changes in daylight savings time. Time shall be automatically synchronized with the plant SCADA system every twenty-four hours. Time changes shall be automatically sent from the plant SCADA system to the remote PLCs.

D. The processor and its associated memory shall be enclosed in a modular enclosure. LED-type indicating lights shall be provided to indicate processor, memory, and battery status. Errors in memory shall be recognized and shall activate the memory error indicating lights. The PLC processor shall monitor the internal operation of the PLC for failure and provide an alarm output.

E. All discrete and analog data acquisition, pre-processing, storage and process control functions shall be performed at the PLC level.

F. Create a master memory map that shall document every tag that is passed from one PLC to another. Tags that pass directly from the SCADA to a PLC do not need to be placed on this memory map. Memory map shall document which devices or PLC’s originate messages, and which devices or PLC’s receive messages, and what tags/address are passed back and forth.

G. Provide a user interface for operations and configuration. Provide an C-MORE HMI 12” touchscreen display. The display shall provide status of the pump station, control of pumps, resetting of faults, and configuration of parameters. The following parameters shall be displayed on the main screen: Level, Setpoints for alarms and pump start/stop, Pumps running/stopped, Pump available, Pump fault. The screen will also have buttons to allow the user to access Faults, and Settings. The following parameters shall be available via a user key press from the main screen: Status of all I/O. All parameter settings shall be password protected.

H. The main screen shall include a Fault button which takes the user to a Fault screen and allows them to check all current and unacknowledged alarms. The fault screen will detail the fault (e.g. VFD fault, seal fault, motor overtemp, over-current, etc) along with date/time each fault occurred and cleared. A reset option for a fault will be presented to the user when faults can be acknowledged and reset.

I. The user interface should allow password protected intuitive configuration of the system, including as a minimum:
   1. Set-points, including alarm and pump setpoints.

2. Level alarms setpoints
3. Start, stop and alarm delays
4. Alternation/ fixed sequence of pumps
6. Assign pre-defined (or user-defined) faults, e.g. thermal overload, contactor fail, to any digital input
7. Zero and span analog inputs

J. Provide eight spare digital inputs and four spare digital output; two spare analog input and analog output for future designation.

2.03 INPUT/OUTPUT SUBSYSTEMS

A. Input/output hardware shall be Allen Bradley 1769 series point I/O (as appropriate for the CPU) plug-in modules in associated I/O rack assemblies. Each unit shall handle the required number of process inputs and outputs plus a minimum of 10 percent active prewired spares for each I/O type furnished, plus a minimum of 20 percent spare I/O rack space for the addition of future circuit cards or modules.

B. Discrete inputs shall be a 120VAC signal (integral to PLC) from dry field contacts. Discrete outputs shall be relay type output modules. The PLC shall provide momentary and latched outputs as required to interface with motor controls and external devices. Interposing relays shall be provided where required to interface with field equipment. Maximum density for discrete I/O modules shall be 16 per input module and 16 per output module.

C. Analog input circuits shall be isolated, 12-bit resolution type. Analog input hardware shall be provided as required for all types of analog inputs being transmitted to the PLC. Analog input modules shall be capable of receiving 4-20 mA signals. Analog outputs shall be coordinated with the receivers but shall be isolated 24 VDC 4-20 mA outputs powered from the PLC. Each input/output circuit shall have optical isolation to protect the equipment against high voltage transients. Optical isolation shall be rated at not less than 1500 V RMS. Maximum density for analog I/O modules shall be 8 per module.

D. The modules shall be connected to wiring arms which can be disconnected to permit removal of a module without disturbing field wiring. Covers shall be provided to prevent operator personnel from inadvertently touching the terminals.

E. External power supplies shall be provided with the PLC as required to meet 150% of the specified installed I/O power requirements plus spares under full load conditions. Power supplies shall be modular units, shall be fully redundant and shall alarm the PLC upon failure. Power supplies shall have a line regulation of 0.05% and meet the environmental and power requirements specified herein for the PLC. Power supplies shall be furnished with isolated lightning/surge protection systems.

2.04 CELLULAR ROUTER or FIBER BASED TELEMETRY SYSTEM

A. The Contractor shall furnish, test, install and place in satisfactory operation a mixed media Ethernet Industrial Protocol (IP) network. The network topology will vary by location but basically consists of a combination of unshielded twisted pair (UTP)

Cat-6 copper cable within control panels and single mode fiber optic cable from control panel to control panel or control panel to plant. Each connected device shall be equipped with its own network interface unit. The well PLCs will communicate with an existing SCADA system via single-mode fiber optic cable or cellular routers using TCP/IP protocols. A power monitoring system shall also communicate to the SCADA system via single-mode fiber optic cable using the TCP/IP protocols. Existing Human Machine Interfaces (HMIs) are located in the plant control room and will be modified by the CONTRACTOR to include the new Station.

Fiber B. Provide for an Ethernet/IP communications with the Central Telemetry SCADA system through a CAT6 UTP copper connection to the fiber optic backbone as shown on the drawings. Coordinate with the fiber optic contractor for connection to the fiber backbone switch and facilities for the IP addresses required. Provide a combination media converter/ unmanaged 100 base-T Ethernet switch in the Fiber optic conversion cabinet.

CellularB. Provide for an Ethernet/IP communications with the Central Telemetry SCADA system through a CAT6 UTP copper connection to the owner provided Vanguard 3000 cellular router. Provide an unmanaged 100 base-T Ethernet switch in the Radio conversion cabinet.

C. Bi-directional communications between the fiber ready network and network connected equipment shall be provided by 10/100 base-T unmanaged Ethernet switches.

D. Each individual PLC shall be connected to the network via a dedicated 10/100 Base-T Ethernet port on its Ethernet module. The PLC Ethernet module shall be connected to the Ethernet switch located in the media(fiber or cellular) conversion cabinet. The PLC Ethernet Communication Interface shall provide for a minimum 100 M Baud TCP/IP network. True duplex peer-to-peer, networking shall be supported.

CellularE. Install Modbus TCP/IP and Ethernet Citect drivers to allow direct communication of power monitoring media converters and control system switches through the cellular router to the existing Citect Global central server at LCU central operations facility.

2.04 PUMP STATION CONTROLLER OPERATION

A. The programmable logic controller (PLC) system shall perform all logic operations necessary to sequence and alternate the pumps to accomplish proportional level control and to ensure equal run times on all pumps. The PLC shall also automatically select one or multiple backup units in the event of a single or multiple pump failure. The PLC shall interface with the VFD's through discrete and analog module interfaces. The PLC coordinates the operation of the pump drive system; monitors status of the complete plant operation and provides the SCADA interface. In normal operation the PLC shall schedule the pumps on and off to maintain wetwell level. The level control parameters will be based on values set by the operator from the HMI graphic screen. The initial wetwell proportional values are as indicated on the drawings. The control levels set by the operator are to be checked by the PLC to be within the minimum and maximum limits established.

Initial minimum low level limits will be 48" above wetwell floor to protect pumps from running dry. Initial maximum high level control limit will be ___ feet above wetwell floor. High level alarm and start back up pump control for pump 1 is initially set to ___' above wetwell bottom. The backup pump control for the second and third pump is initially set to control at ___' above wetwell bottom. Also provide virtual high level alarms from the level transmitter signal at 3" above high level control range.

B. The following operating modes shall be required for the pump controller:

1. Maintain the wetwell level established by the proportional level control system, automatically and without regard to system flow. The turn on and turn off each pump (lead, lag and lag-2) based on high level range corresponding to 100% speed; and operator configurable with the initial values as indicated on the drawings. The pump controller shall insure speed matching of all VFD driven pumps. Speed matching shall be compared with monitored speed of each pump with a 5% pump speed deviation alarmed.

2. Allow or disallow automatic operation of each pump via telemetry or locally from the local operator interface.

3. The VFD external fault indication will provide for automatic pump shutdown on motor monitor relay system temperature high fault. Provide for operator initiated remote stop for other pump alarm conditions. Provide for SCADA password protected over ride of motor monitor system auto shutdown. A external(temperature)fault will require manual resetting and shall not be reset remotely via SCADA. VFD internal faults may be reset remotely via SCADA.

C. For each Drive in the system, the controller program shall control the RUN command and specify the operating mode (LEAD, LAG, LAG-2) of the pumps. The software internal to the controller shall coordinate the Drives to allow a lower priority pump to move up in the priority string in the event of the next higher pump is faulted. The drives will be hardwired control and monitored through an Ethernet connection. Provide start/stop, speed setpoint, speed feedback, drive fault and not-in-auto hard wired control. All other parameters will be available through an Ethernet/IP connection.

D. As the level in the wetwell increases to the 100% level range (lead pump running at full speed), a signal shall immediately activate and latch to call on the lag pump. The lag pump will come on line and quickly ramp up and match the speed of the lead pump (10 second ramp). All VFD driven pumps will operate as speed matched units. As the level continues to rise and the Lead and Lag pumps are running at full speed, the level again reaches the 100% level range, a signal shall activate and latch to call on the Lag-2 pump. After the lag pump is called on a countdown timer (initial set of 45 sec) is set before the lag-2 pump is called on.

E. As demand decreases and wetwell level decreases, the Pump controller shall stage off the lag and lag-2 pumps based on "lag pump stop" elevations. As flow decreased further the lead pump ramps down based on level to minimum speed. The minimum speed is maintained until the level drops further to a "stop lead pump" wetwell level setpoint. The lead VFD pump shall be alternated on each operation based on the VFD pump with the least hours. Provide operator initiated

rotation of lead pump unit. The operator configurable VFD minimum speed programmed into the VFD (initially 35hz) shall be set to maintain a flowrate with an initial value of ___gpm for all head conditions. The critical setpoints such as pump start stop points, time delays, alarm setpoints shall be adjustable from the central station SCADA and located within a maintenance settings screen with limited access.

F. A backup pump controller shall override the control to the VFDs on initiation of a high-high level switch operation. The VFDs shall be programmed to start and run at a pre-determined speed until a low level float activates.

H. The control signals to and from the PCP shall be as shown in the PLC I/O list in the appendix. Provide for virtual alarm and setpoint signals.

2.05 DATA ACQUISITION AND GENERAL CONTROL LOGIC

A. Not in AUTO Alarms: Before operating any field device, the PLC program shall check to see that the device has been switched to the AUTO mode. If the device is not in AUTO, the PLC shall set an error bit and suspend control of the device until it is switched to AUTO.

B. No Response Alarm: If at any time a field device fails to respond to an output command from the PLC, the PLC shall set an error bit. The SCADA shall use the error bit to log a "No Response" alarm.

C. Adjustable Timers: The preset values for all PLC timers shall be adjustable through the HMI software by the operator under security password clearance.

D. PLC Diagnostic Alarms: In addition to the alarm conditions shown on the P&IDs, each PLC shall monitor its CPU and I/O modules. When the CPU or any I/O module fails, the PLC shall generate a PLC FAIL alarm.

E. Process Variable Filtering: Each analog process variable being transmitted to the SCADA shall have adjustable digital filtering applied.

F. Totalizer Current Average Value: The current average flowrate for each totalized value shall be provided for each flowrate input.

G. Flowrate Integration: Flowrate integration shall be provided for each analog flowrate input.

H. Daily Average: Daily average calculations shall be provided as required to support displays and reports.

I. Daily Totalizer Counter: Accumulate daily total over Ethernet signal. The totalizer shall be reset daily when the daily reports are produced.

J. Monthly Totalizer Counter: Accumulate daily total flow over Ethernet signal. The totalizer shall be reset monthly when the monthly reports are produced.

K. Cumulative Totalizer Counter: Accumulate total over flow over Ethernet signal.

L. Run Time: Each piece of equipment shall have a run timer, which accumulates time.

2.06 RADAR LEVEL TRASMITTER

A. Provide non-contact level transmitters to sense the liquid level of the wetwell. The unit shall consist of a radar sensor and antenna system to provide continuous monitoring of the wetwell level. Provide IP68 plastic horn antenna. Provide connection cable with strain relief wire of Kevlar to hook mount antenna.

B. Provide transmitter with 4-20madc output, loop powered type, with output signal directly proportional to the measured level. Excitation range 9-35vdc.

C. Provide VEGAPULS WL 61 with 15m(49.21ft) max measuring range.

2.07 BALL FLOAT SWITCHES

A. Units shall be direct-acting float type level sensing device. The switch shall be chemical resistant polypropylene, normally open, type-S suspended type with built-in weight. The float cable shall be rated "continuous service" for high flexibility. All mounting hardware shall be 316 SS. All float fittings shall be flared and incorporate strain relief jacketing.

B. Cable shall be rugged and flexible with heavy neoprene or PVC jacket. The actuation/deactivation differential shall not exceed 4 inches. Units shall be pipe mounted or suspended type as noted, and provided with 40 feet of cable unless otherwise noted. Each pipe mounted type shall be provided with a clamp to secure the cable to 1-inch support pipe.

C. Each suspended type shall be provided with necessary brackets and clamps to suspend the unit from the top of a tank or vessel. The suspended type shall include an integral weight assembly for stabilization and positive operation of the unit. All mounting clamps shall be PVC or neoprene.

D. Provide Anchor Scientific suspended type Roto-Float switch.

2.08 PROCESS METERS

A. Process Meters: Provide digital programmable process meters designed for a 4-20MA current loop display and isolated retransmission of displayed output. Provide minimum 0.5" high, 4-1/2 digit LED display to indicate amplitude of current in the current loop and calibrated to engineering process units. In general, a loop current of 4ma corresponds to a display indication of 0 percent and a loop current of 20ma corresponds to a display indication of 100 percent. The meter shall be provided with programmable internal scaling adjustment. Provide units with NEMA-4X faceplate rating constructed of silicone coated Lexan and gasketed for NEMA 4 requirements; circuit boards coated for moisture resistance.

B. Provide YOKOGAWA UM33A or equal indicators.

2.09 ELECTROMAGNETIC FLOWMETER

A. Magnetic flow meter systems shall include a flanged spool piece style magnetic flow tube and a remote microprocessor based transmitter that is capable of converting and transmitting a signal from the flow tube. The magnetic flow meters shall utilize the characterized field principle of pulsed electromagnetic induction, and shall produce DC signals directly proportional to the liquid flow rate.

B. Provide meters of 304 stainless steel material with a PFA or Polyurethane liner. Liner shall have a minimum thickness of 0.125 inches. The inside diameter of the liner shall be within 0.125 of the inside diameter of the adjoining pipe. Liner protectors shall be provided on all flow tubes.

C. Provide flow tubes with flush mounted Hastelloy-C electrodes, or as recommended by the manufacturer. Size flow tube as shown on mechanical drawings.

D. Grounding rings shall be provided for all meters.

E. All materials of construction for metallic wetted parts (electrodes, grounding rings, etc.) shall be minimum 316L stainless steel or compatible with the process fluid for each meter in accordance with the manufacturer's recommendations.

F. Flow tube shall be rated for temperatures of up to 180°C and pressures up to 1.1 times the flange rating of adjacent piping. System shall be rated for ambient temperatures of 30 to +65°C. Meter shall meet IP68/NEMA-6P requirements for submersible service. Transmitter shall meet IP65/NEMA-4X requirements. When meter and transmitter are located in classified explosion hazard areas, the meter and transmitter housings shall be selected with rating to meet the requirements for use in those areas.

G. The transmitter shall provide pulsed DC coil drive current to the flow tube and shall convert the returning signal to a linear, isolated 4 20 mA DC signal. The transmitter shall utilize "smart" electronics and shall contain automatic, continuous zero correction, signal processing routines for noise rejection, and an integral LCD readout capable of displaying flow rate and totalized flow. The transmitter shall continuously run self diagnostic routines and report errors via English language messages.

H. The transmitter's preamplifier input impedance shall be a minimum of 109-1011 ohms which shall make the system suited for the amplification of low-level input signals and capable of operation with a material build up on the electrodes.

I. The transmitter shall provide an automatic low flow cutoff below a user configurable low flow condition (0-10%). The transmitter's outputs shall also be capable of being forced to zero by an external unpowered signal.

J. Accuracy shall be 0.5% of rate over the flow velocity range of 0.3 to 10.0 m/s. Repeatability shall be 0.1% of rate; minimum rangeability shall be 100:1. Minimum required liquid conductivity shall not be greater than 5 uS/cm. Maximum response time shall be adjustable between 1 and 100 seconds as a minimum. Transmitter ambient temperature operating limits shall be 10 to +50 degrees Celsius. Power supply shall be 115 VAC, 60 Hz.

K. Provide flow tubes that are factory calibrated and assigned a calibration constant or factor to be entered into the associated transmitter as part of the meter configuration parameters. Manual calibration of the flow meter shall not be required. Meter configuration parameters shall be stored in non-volatile memory in the transmitter. An output hold feature shall be provided to maintain a constant output during configuration changes. Flow Meters shall be factory calibrated to NIST traceable standards. Provide certified factory calibration records.

L. Provide flow meter system with in-situ flow calibration verification. Provide field verification system (including hardware and software) that automatically tests the flow measurement system and is capable of producing a printed certificate of calibration verification that is traceable (Endress Hauser Proline Fieldcheck with Field Tool Software or equal by flowmeter manufacturer).

M. Manufacturer’s representative shall conduct a field inspection after installation, conduct start-up of the flow meters, certify in writing the meters’ proper installation, and verify calibration of flowmeters after installation.

N. Flow metering systems shall be Endress Hauser Proline Promag 400L, Siemens or equal with integral flow indicating transmitter.

O. Manufacturer to provide a written five year extended warranty from (a) date of issuance of “Certificate of Proper Installation” and Operation.

2.10 ISOLATING TRANSMITTERS: CURRENT-TO-CURRENT ISOLATING TRANSMITTER

A. Unit shall receive 4 to 20 mA dc input signal and shall produce an isolated, proportional 4 to 20 mA dc output signal into loads in the range of 0 to 1,200 ohms minimum without load adjustments for a 24V dc supply. Input impedance shall be less than or equal to 50 ohms. Unit accuracy shall be plus or minus 0.25 percent of span, minimum. Unit shall be provided with multi-turn span and zero adjustments.

B. Unit shall be housed in a NEMA 1 rated enclosure and shall be furnished with an integral bracket for rear-of-panel mounting, unless otherwise noted. Unit shall have input/output and power isolation. Unit shall operate on 120-volt, 50/60-Hz power.

C. Provide isolating transmitters where required by system conditions. Unit shall be Moore Industries SCT/ECT/MIX or equal.

2.11 SPARE PARTS

A. Provide as part of this contract a complete compliment of replacement spare parts for all component parts of this system. It shall be the supplier's responsibility to prepare a detailed suggested replacement parts list for review and approval by the owner.

B. As a minimum, the controls system supplier shall furnish one plug-in module for each type of control module used in the system; CPU module, one analog input module; one analog output module; one digital input module; one digital output module; two of each relay; one of each type power supply; one of each type Ethernet switch; 2 each type signal surge suppressor; two sets complete of each type fuse; two of each length patch cords; two of each pilot light; 12 fiber cable connectors; one level instrument; one ball float.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The work included in this section consists of furnishing, installing and placing in operation the instruments and appurtenances, including all conduit, wiring and circuitry, necessary to provide the Owner with a fully operable system properly calibrated and installed.

B. Include the services of a factory trained, qualified service engineer of the equipment manufacturer to inspect the complete equipment installation to assure that it is installed in accordance with the manufacturer's recommendations, make all adjustments necessary to place the system in trouble-free operation and instruct the operating personnel in the proper care and operation of the equipment furnished.

C. All workmanship utilized in the manufacture and installation of this system shall be of the highest quality and performed in a manner which is consistent with all accepted practices for industrial controls.

D. Provide continuous protection of the installed instrumentation equipment from the elements, moisture, construction damage, dust, debris, paint spatter or other conditions which will adversely affect the unit operation until such time as the equipment is scheduled for start-up testing.

3.02 MOUNTING OF EQUIPMENT AND ACCESSORIES

A. Install and mount equipment in accordance with the Contract Documents, manufacturer's instructions and installation detailed shop drawings. Mount

equipment so that they are rigidly supported, level and plumb, and in such a manner as to provide accessibility; protection from damage; isolation from heat, shock and vibration; and freedom from interference with other equipment, piping, and electrical work. Do not install field enclosures, cabinets, and panels until heavy construction work adjacent to the equipment has been completed to the extent that there shall be no damage to the equipment.

B. Locate devices, including accessories, where they shall be accessible from grade, except as shown otherwise.

C. Coordinate the installation of the electrical service to components related to the system to assure a compatible and functionally correct system. All accessories shall be coordinated and installation supervised by the Contractor.

3.03 CALIBRATION

A. Calibrate each instrument in the factory before shipping and furnish with the calibration data and the certification of calibration.

B. The service technician shall calibrate all instruments and components of the instrumentation system with field adjustable ranges and/or settings after installation in conformance with the manufacturer's instructions, the Contract Documents and the reviewed shop drawings. Set each instrument and components for the specific conditions and intended application as specified for this installation. Replace defective instruments and components which cannot achieve correct calibration of stated accuracy, either individually or collectively within the system.

C. Certify in writing to the Owner that all calibrations have been completed and the instrumentation system is ready to be operated. Provide instrumentation calibration sheets in the O&M manuals for future reference for both factory and field calibration tests. Calibration certification documents shall be available on site at the time of substantial completion. Certification documents shall include the signature of the service technician performing the calibration.

3.04 GENERAL TESTING REQUIREMENTS

A. All system start-up and test activities shall follow detailed test procedures, check lists, etc., submitted and previously approved by the Engineer. The Engineer shall be notified at least 21 days in advance of factory system tests and reserves the right to have his and/or the Owner's representatives in attendance.

B. The Contractor shall provide the services of experienced factory trained technicians, tools and equipment to field calibrate, test, inspect, and adjust all equipment in accordance with manufacturer's specifications and instructions.

C. The Contractor shall maintain master log books for each phase of installation, startup and testing activities specified herein. Log book shall include signal, loop or control strategy tag number, equipment identification, description and space for sign-off dates, Contractor signature and Engineer signature. Example test documentation specific to each phase of testing shall be approved prior to initiation of that testing, as specified here.

D. All test data shall be recorded on test forms, previously approved by the Engineer. When each test has been successfully completed, a copy of all test results shall be furnished to the Engineer together with a statement that all specified test requirements have been met and that the system is operating in accordance with the Contract Documents.

3.05 START-UP SUPERVISION

A. The system supplier shall provide a qualified service technician to inspect all final connections and check the system prior to start-up of the system. The service technician shall coordinate with the owner's representative for functional check-out of the complete system.

B. A system software engineer shall be provided on site during start up of the plant to make adjustments to the Control Computer/ Operator Interface and tune the system as deemed necessary by the engineer.

C. System verification marking end of supplier’s on-site start-up obligations will be issued after system functionality can be demonstrated for a period of 168 continuous hours without interruptions due to error on the part of the supplier.

D. At least two qualified control systems technician shall be provided by the Contractor when loop checkout is being performed and at least one for all other control system startup and test activities.

E. The control system integrator's startup personnel shall be present and coordinate with all other startup and testing activities especially the pump, standby power system and variable frequency drive startups.

3.06 INITIAL FIELD TESTING

A. All system start-up and test activities shall follow detailed test procedures, test report, check lists, etc., submitted and previously approved by the Engineer.

B. Control system start-up and testing shall be performed to ensure that all plant processes shall be systematically and safely placed under digital control in the following order:
   1. Primary elements such as transmitters and switch devices shall be calibrated and tested as specified.
   2. Each final control element shall be individually tested by Contractor.
   3. Each instrument and control loop shall be tested by Contractor.
   4. Each control strategy shall be tested under automatic control as specified by Contractor.
   5. The entire control system shall be tested for overall monitoring, control, communications, and information management functions, and demonstrated for system availability as specified by Contractor and Engineer.

C. System start-up and test activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal operating conditions in terms of applied process loads, operating ranges and environmental conditions.

D. Verify that each instrument, meter, and gage has been properly installed, connected, grounded and calibrated. Perform three-point calibration on continuous elements and systems. Provide calibration records.

E. Verify that the input/output functions of each instrument conform to the requirements of the application.

F. Exercise each system as defined by each loop description through operational tests to demonstrate that it performs as intended on a continuing basis and to demonstrate the integrity of the system.

3.07 LOOP CHECKS

A. Prior to control system startup and testing, each monitoring and control loop shall be tested by the Contractor on an individual basis from the primary element to the final element, including the RTU Controller I/O, PLC I/O module and PLC data table, for continuity and for proper operation and calibration.

B. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses. Simulated input data signals may be used subject to prior written approval by the Engineer. All modes of control shall be exercised and checked for proper operation.

C. The accuracy of all analog inputs shall be verified using field inputs or by manually applying input signals at the final controller, and then reading and recording the resulting analog input data at the PLC, RTU or work station.

D. Final control elements and ancillary equipment shall be tested to verify that proper and stable control is achieved using local area control panels, motor control center circuits, and local field mounted control circuits. All hardwired control circuit interlocks and alarms shall be operational. The control to final control elements and ancillary equipment shall be tested using both manual and local automatic (where provided) control circuits.

E. Each loop tested shall be witnessed, dated and signed off by both the Contractor and the Engineer/owner upon satisfactory completion.

3.08 INITIAL START-UP TESTING

A. Perform satisfactory Contractor's initial start-up and functional test prior to demonstration for Owner and Engineer.

B. After the field testing has been successfully demonstrated, a date for system start up involving the Owner's operating personnel will be scheduled as agreed to by the Owner. Notify Engineer fourteen (14) days prior to initial start-up of each item of equipment.

C. Have Contract Documents, shop drawings, product data, and operation and maintenance data at hand during entire start-up process.

D. Provide control diagrams that show actual control components and wiring.

E. Coordinate sequence for initial start-up of various items of equipment

F. Verify control systems are fully operational in automatic and alternate modes of operation.

G. Start up and test the instrumentation equipment with the entire system operational. Conduct start-up and initial functional testing.

3.09 STARTUP AND FUNCTIONAL TESTING, DEMONSTRATION FOR OWNER AND ENGINEER

A. Perform pre-startup inspection of installation. Perform startup under no-load conditions, if possible. Observe noise, vibration and operation. If all operating characteristics are normal, proceed with startup. Operate equipment and systems under all load conditions and confirm all operating characteristics are normal. If normal operation is observed, proceed with witnessed functional test and performance test as required.

B. Perform functional and performance tests under supervision of responsible manufacturer's representatives, control system integrator, and Contractor personnel. Representatives of Owner and Engineer shall witness functional test. Perform functional and performance tests on each piece of equipment and operational system as specified in the individual product sections.

C. Demonstrate that equipment operates and complies with specified performance requirements. Demonstrate that control panel functions, including failures and alarms operate and comply with specified performance requirements.

D. Functionally test failures and alarm conditions; or if approved by engineer simulate by jumping failure input terminals. Provide signal generators that simulate control conditions if it is not feasible to create actual conditions. Testing activities shall include the simulation of both normal and abnormal operating conditions.

E. Use Operation and Maintenance manuals, loop descriptions, submittals, graphic screens, etc., to demonstrate operation of equipment. Use actual as-built control diagrams in demonstration of functions.

F. Each control strategy shall be tested by the Engineer to verify the proper operation of all required functions. The control system start-up and test activities shall include procedures for tuning all control loops incorporating PID control modules, and for adjusting and testing all control loops as required to verify specified performance.

3.10 WARRANTY

A. All products mentioned herein must be warranted by the supplier for a period of Two (2) years from the date of system turnover; final acceptance.

B. An unconditional warranty shall be provided for all equipment supplied for Two years from date of final acceptance of system by the owner. THIS WARRANTY SHALL INCLUDE ANY DAMAGES CAUSED BY LIGHTNING INDUCED ELECTRICAL SURGES; ONLY DAMAGES CAUSED BY DIRECT LIGHTNING STRIKES TO THE BUILDING STRUCTURE (AS DETERMINED BY THE ENGINEER) SHALL BE EXCLUDED FROM THE WARRANTY. Theft, fire,

vandalism and floods shall be excluded from the warranty except for fire damage which originates at equipment which is provided as part of this work.

D. CONTRACTOR shall issue two copies of a written warranty to the OWNER.
   1. The warranty shall be a legal and binding document.
   2. Warranty shall include the start and end date of the warranty period.
   3. Warranty shall include the OWNER'S and CONTRACTORS name.

E. Warranty calls shall be broken into two categories, emergency and non-emergency. Whether the warranty call is emergency or non-emergency shall be dictated by the OWNER.
   1. An emergency warranty call shall be responded to within 8 hours of the call, whether during business hours or not.
   2. A non-emergency warranty call shall be responded to within 48 hours of the call, whether during business hours or not.

F. Telephone support for operating procedures and non-hardware problems shall be provided on an unlimited basis during the warranty period.

3.11 TRAINING

A. The system supplier shall provide a minimum of three (3) days of training instruction to the owner's personnel to include; one day operator training; and two days PCP and Controls system maintenance training including software maintenance training.

B. Training shall not occur until after completion of successful functional testing and performance testing. Provide training while equipment is fully operational

C. Training shall not occur until after review and approval of system O&M manuals. Use accepted Operation and Maintenance manuals as the basis of instruction.

D. Submit to OWNER not less than 14 days prior to each training session an outline of the training program and the qualifications of the trainer(s).

E. Coordinate services with the OWNER, with a minimum of two week's notice.
   1. Training shall be held to accommodate OWNER'S schedule.

F. Training services are exclusive of travel time to and from the facility. The times specified shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to insure equipment is in satisfactory and continuous operation.

G. Trainings should be geared to not only impart knowledge of the control functionality of the new control system but also some background understanding of how and why things work.

H. Onsite Operations Staff Training Sessions shall be held over two full days. A full day training session shall cover all necessary material. Between the two different days all operations staff should be able to attend at least one training session.

I. Training Manual

1. The operations staff training shall be based on the training manual created by the CONTRACTOR.
2. All training manuals shall be provided with color graphics.
3. The training manual shall provide DETAILED working knowledge of the control of the plant and how to use the SCADA interface.
4. Each SCADA control object, whether it be a display field, push button, or set point field shall be specifically called out and its purpose explained.
5. The underlying theory of why something is controlled shall be explicitly explained.
6. All faults and permissives that affect the operation of equipment shall be explicitly called out.
7. All set points shall be recorded under a separate section titled “Set Points.” An explanation of how the set point value was determined shall also be included next to the set point value.
8. EACH section of the training manual shall include a 10 question quiz. Answer key for each quiz shall also be provided, but not as part of the training manual.
9. The training manual will be used as the basis for the INITIAL Operations Staff Training Sessions. At the end of EACH section covered in the training manual the CONTRACTOR shall administer the 10 question quiz. At the end of the quiz the CONTRACTOR shall review the quiz with the operations staff and discuss what the correct answer was for each quiz question. Operations staff shall be allowed to keep their quizzes for further study.
10. The training manual will be used as the basis for the FINAL Operations Staff Training Sessions. At the end of EACH section covered in the training manual the CONTRACTOR shall administer the 10 question quiz. At the end of the quiz the CONTRACTOR shall collect all quizzes, seal them in an envelope and give them to OWNER Process Control Engineer for grading.
11. The course shall cover the following subjects, as a minimum:
    a. SCADA overview in which the basic systems design, configuration, and purpose is covered.
    b. DCS hardware in which the specific hardware elements and specific configurations provided are covered.
    c. How the actual PLC programs operate.
    d. Programmer equipment orientation in which the student becomes familiar with the operation and operational maintenance procedures.
    e. Specific application program instruction covering the overall design and philosophy of the applications as provided under this contract. The intent shall be to make the student fully knowledgeable in all aspect of the system provided, along with methods for making additions, modifications, and deletions to the SCADA.
    f. Complete systems backup and reload procedures.
    g. Diagnostic software details including capabilities, usage, and interpretation of results.

END OF SECTION

SECTION 40 95 13

INSTRUMENTATION AND CONTROL SYSTEM

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install, complete with all accessories, a programmable logic control based monitoring and control system with its associated instrumentation as described herein and shown on the contract drawings. The system shall serve as a self-contained monitoring and control system for all aspects of the pump station operation. It shall also be capable of integration with the existing Lee County fiber optic based central control network through cellular radio connection per site specific requirements.

B. This Specification has been developed to establish minimum requirements for a pump controller. This system shall be designed, constructed, tested and documented in strict accordance with the guidelines of this document. All system construction and programming will be the responsibility of the control system integrator. All materials and labor shall be provided for a fully functional system including any items which are required for system operation but are not specifically addressed in this document or on the contract drawings.

C. This specification is intended to be used in conjunction with all drawings supplied and is not intended to be complete without reference diagrams on system configurations, etc. All bidders must conform to all areas of the documentation. It is the intent of this specification that the monitoring and control system contractor have single source responsibility for the complete control and instrumentation package for the project; including but not limited to flow, pressure, level instrumentation and control, Variable Frequency Drives, Solid State Soft Starters, generator, ATS and interconnecting conduit and control wiring for total system responsibility.

D. The overall requirements for the Process Instrumentation and Control System are included in this section. The following associated sections contain specific requirements for individual subsystems that are in addition to the requirements of this section.

1. 40 95 13– Appendix B Duplex & Triplex IO List

E. Lee County Utilities will self-perform all work required to integrate the pump station into the offsite central server. The instrumentation and control systems contractor will provide all local programming required for a fully functional pump control system and HMI operating panel.

1.02 CONTRACTOR QUALIFICATIONS AND ADDITIONAL RESPONSIBILITY

A. The panel supplier shall be a UL listed panel shop and all panels shall be UL-508 certified. All panels shall utilize components in order to achieve a minimum of 10KA AIC rating.

B. The contractor shall assume total systems responsibility for all aspects of this system including installation, commissioning and start-up of the system, training of operating personnel and coordinating interfaces between this system and equipment provided by others. This responsibility shall include mounting and wiring of relays, transformers, disconnecting means, and other control devices as required forming a complete system.

C. The installing contractor shall maintain an office with full time sales and service staff within a one hundred and fifty-mile radius of the site.

H. All conduits are provided and installed under Division 26, BASIC ELECTRICAL MATERIAL AND METHODS. With the exception of certain specified special control, fiber optic and high speed communication cables, all wiring and cables are provided and installed under Division 26, BASIC ELECTRICAL MATERIAL AND METHODS. Specific control cables and high speed communication shall be provided and installed by the contractor.

I. Where the term "verify" and "certify" are stated in this specification, the intent is that the control system integrator shall issue formal statements in writing to the engineer that the particular activity has been accomplished.

1.03 SUBMITTALS-shall be submitted in accordance with Section 26 05 02 BASIC ELECTRICAL MATERIALS AND METHODS.

A. SHOP DRAWINGS shall include:

1. A cover sheet consisting of a Bill of Material, purchase order number, manufacturer's job number, Owner's name, location, application and shipping address.
2. Mechanical layouts detailing the overall external dimensions of all enclosures. Include all pertinent information such as location of door handles, windows, lifting lugs and enclosure mounted items such as pump controller chassis and I/O modules (show cable connections on modules), relays, cooling fans, etc.
3. Details for mounting of the processor, I/O racks, relays, motor starters, disconnect switch, fuse blocks, wireways, etc. All materials shall be labeled to provide easy cross-reference to the Bill of Material listing.
4. Electrical drawings detailing all hardwiring, done by the supplier, to devices such as relays, pump controller modules, disconnect switches, fuse blocks, etc. Provide individual wire numbers and relay contact cross-reference designations.
5. A description of all input and output modules by name, rack, module and terminal location.
6. Complete master wiring diagrams, elementary schematics and control schematics shall be submitted for approval before proceeding with manufacture. Suitable outline drawings shall be furnished as part of this submittal. Standard or typical pre-printed sheets or drawings simply marked to indicate applicability to this contract will not be acceptable. Shop drawings shall be on standard 24" X 36" or 11" X 17" media; drawn with a computer aided design package. The computer aided design package shall be AUTOCAD version 2014 or converted to Autocad version 2014. Engineering plan backgrounds of the facility shown on the contract documents will be available to the contractor on request. Submittals shall include reproducible plots of the drawings on paper translucent bond.

7. A complete drawing indicating each point of interface with the process control system and the type of signal provided or accepted at each point. This drawing shall depict the actual interface terminal block including all circuit designations.
8. A complete sequence of operation describing the control strategy in response to external signals and the signals which will be provided to the process control system during operation of the plant. All interlocks and limits which are internal to the operation of the controls shall be included in this description.
9. A drawing showing the layout of the control panels indicating every device with complete identification.
10. Analog and digital loop diagrams showing all I/O from the point of origin in the field device through the wiring systems to the RTU controller and HMI systems. Include all terminal block points and identification, color codes, tag names and numbers, etc. Include device range and calibration data for the analog device loop diagrams.
11. The last sheet(s) in the set shall describe all terminal block designations and individual terminal numbers.

B. RECORD DRAWINGS
1. Record Drawings shall accurately show the installed condition of the following items:
   a. Underground raceway and duct bank routing.
   b. Field locate all in ground or above ground pullboxes.
   c. Field locate all in ground or above ground splice boxes.
2. Legibly record all existing conditions to scale on a set of Project Contract Drawings, (the "Record Drawings") or hand sketched drawings. Engineer and or LCU may be able to assist with providing scaled aerials or site plans to mark-up.

PART 2 - PRODUCTS

2.01 GENERAL

A. The pump station electrical control equipment shall be wall mounted NEMA 4X enclosures of approximately 48”High x 48" wide x 16” in depth. The cabinet shall be arranged to separate the incoming field terminal interface blocks and surge suppression from the SCADA Pack I/O signals in the cabinet. See drawing for arrangement details.

B. Control panel enclosures shall include the following features:
1. Internal Light with toggle-Switch
2. Internal Service Power Outlets
3. Uninterruptible Power Supply (UPS)
6. Drawing Pockets in the back side of the door
7. Laptop Ethernet Connection

C. The software written for this application shall be in ladder logic and provide a flexible, configurable and expandable control system for the pump station. The vendor shall provide a licensed copy of all software used in this project and registered to Lee County. All ladder code provided with this contract shall be documented so that an experienced programmer can easily make modifications to the software without having to go back to the original vendor for information. Documentation shall be approved by the engineer before final acceptance of the

software. Lee County Utilities shall be the owner of the ladder logic program integration and shall have its unlimited use. LEE county shall provide the Ladder Logic programming for use with the pump stations.

D. Components: All motor branch circuit breakers; motor starters and control relays shall be of highest industrial quality, securely fastened to the removable back panels with screws and lock washers. Back panels shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any component. A circuit breaker shall be provided on each control panel as a means of disconnecting power to the control panel. Control transformers shall be installed where shown to provide 120VAC and 24VAC for control circuits. Transformers shall be fused on the primary and secondary circuits. The transformer secondary shall be grounded on one leg.

E. All internal control panel wiring shall be identified at both ends with type written heat shrinkable wire markers with the numbering system shown on the control submittal drawings.

1. Control wiring shall be stranded copper, minimum size #1 AWG (except for shielded instrumentation cable may be #18 AWG), with 600 volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation. Each control wiring conductor shall have heat shrink identification labels on each end of termination. Terminations shall be made to screw terminal strips. All points of terminal strips are to be labeled to match conductor labeling. Control wiring shall be SIS or XHHW insulated; PVC insulated wire is not acceptable.

F. The control panel shall be provided with nameplates identifying each component, selector switches, pilot lights, etc. Nameplates shall be permanently affixed using an epoxy process. Nameplates shall be laminated plastic, engraved white letters with a black background.

G. Corrosion Inhibitor Emitter: Provide an industrial corrosion inhibitor emitter, on all exterior mounted control panels that will protect internal components of the control panel from corrosion. Provide 1 year supply of spare corrosion inhibitors for each control panel.

H. Fused terminal blocks shall be provided for analog inputs and outputs. Blocks shall be permanently marked to indicate the appropriate I/O address of each circuit on the pump controller. Terminal strips shall be switch type with integral fuses equal to Allen Bradley 1492-H6. Wiring from the control panel to the terminal strips shall be factory installed. All spare conductors shall be terminated and identified.

I. The assembled system shall include circuit breakers, fuse blocks and other electrical components as required by the application and in accordance with the standard requirements of the National Electric Code as well as all State and Local electrical code requirements.

J. All I/O racks, processor racks and power supplies shall be grounded in accordance with the manufacturer's specifications.

K. All push-buttons, switches and other operator devices shall be UL listed and/or CSA approved and sufficiently large and durable to provide dependable, long life operation. Provide 30mm devices.

L. All cables, plugs, connectors and receptacles requiring user field installation shall be designed to withstand an industrial environment.

M. Surge suppressors shall be provided for all analog inputs and outputs and digital inputs that leave or enter the RTU and local control cabinets. Provide EDCO type HSP-121 surge suppressors for 120VAC power supply to all control panels. Provide Erico type UTB series for all digital circuits entering the RTU and local control cabinets. Provide Erico UTB series for all analog signals entering or leaving the control panels.

N. RELAYS

1. Control circuit switching shall be accomplished with relays. These relays, for interfacing and control applications, shall be the compact general purpose plug-in type having low coil inrush and holding current characteristics. An LED status-indicating light shall be provided with each relay. Contact arrangements shall be as noted or shown, and shall be rated for not less than 10 amperes at 120V ac or 28V dc. Coil voltage shall be as noted or shown. Non-latching relays shall have a single coil. Latching relays are not acceptable. Relays shall have plain plastic dust covers, test buttons, and mounting sockets with screw terminals and holddown springs. Relays shall be UL recognized. Relays shall be Square D or Allen Bradley, Omron or approved equal.
2. Time on delay functions shall be accomplished with Square D 9050JCK60V20 time relays. Provide RK electronics CFB24D-7-2M relay for time off delay applications. Units shall be adjustable time delay relays with the number of contacts and contact arrangements as shown. A neon status-indicating light shall be provided with each relay. Contacts shall be rated for 10 amperes at 120V ac. Integral knob with calibrated scale shall be provided for adjustment of time delay. Initial setting shall be as shown with time delay range approximately three times the initial setting. Time delay rangeability shall be at least 10:1. Operating voltage shall be 120V ac, plus 10 percent, -15 percent at 60-Hz. Operating temperature shall be -20 degrees F to 165 degrees F. Repeat timing accuracy shall be plus or minus 10 percent over the operating range. Units shall be Socket-mounted relays, octal plug-in, adjustable range as shown on drawings, equal to Amerace Corp., Control Products Division, Agastat Series 7000, Cutler-Hammer Series D87, Square D, Allen Bradley or Omron
3. All relays shall have a screw terminal interface with the wiring. Terminals shall have a permanent, legible identification. Relays shall be mounted such that the terminal identifications are clearly visible and the terminals are readily accessible.

O. PANEL OPERATING CONTROLS AND INSTRUMENTS

1. All operating controls and instruments shall be securely mounted on the control compartment door or interior deadfront as detailed on panel enclosure drawings. All controls and instruments shall be clearly labeled to indicate function.

2. Indicator lamps shall be LED full voltage push to test type and mounted in NEMA 4X (800H) 30mm modules, as manufactured by Allen Bradley or SKPI as manufactured by Square D. Lamp modules shall be equipped to operate at 24 or 120 volt input. Lamps shall be easily replaceable from the front of the control compartment door without removing lamp module from its mounted position. Units shall be heavy-duty, oiltight, industrial type with screwed on prismatic glass lenses in colors as shown, and shall have factory engraved legend plates. LED's shall be high illumination type (5ma at 130V ac).
3. Selector switches shall be heavy-duty, oiltight, industrial type selector switches with contacts rated for 120V ac service at 10 amperes continuous. Units shall have standard size, black field, legend plates with white markings, as indicated. Operators shall be black knob type. Units shall have the number of positions and contact arrangements and spring return function (if any) as shown. Units shall be single-hole mounting, accommodating panel thickness from 1/16-inch minimum to 1/4-inch maximum. Units with up to four selection positions shall be Allen Bradley 800H, Square D Type K, Cutler-Hammer Type T, or equal. Units with up to 12 selection positions shall be Rundel-Idec Standard Cam Switch, Electroswitch 31, or equal.

2.02 SCADA PACKS

A. The control system integrator shall furnish RTU as specified herein and as shown on the Drawings. SCADA Packs shall be provided complete with instructions, memory, input/output capacity, and appurtenances to provide all features and functions as described herein.

B. The RTU shall be designed to operate in an industrial environment. The controller shall operate over an ambient temperature range of -40°C to 70°C (-40°F to 158°F) with a relative humidity 5% to 95%, non-condensing. The controller shall operate from nominal power supplies 12-24 VDC, but shall tolerate a wider range than this. 115/240 VAC operation shall be provided through the use of an optional power supply. The controller shall include a built-in power supply with wide range input, at least 10VDC - 30VDC. The power supply must be capable of providing 24VDC output to power field transmitters. Diagnostic LEDs shall be included for the following: Controller Status, Wide area communication link activity such as transmit, receive, Local peripheral communication link activity, I/O point indication (All DI & DO points as a minimum, preferably including AI points)

C. System configuration shall be as shown on the drawings. SCADA Pack shall be Square D SCADAPack 334E or better with Ethernet Network port 10BaseT/100BaseT. The RTU shall include provisions for automatically updating time for changes in daylight savings time. Time shall be automatically synchronized with the plant SCADA system. Time changes shall be automatically sent from the plant SCADA system to the remote controller.

D. The SCADA controller shall be intelligent, modular unit, capable of both data acquisition and local data processing. It shall monitor and control local equipment in a standalone mode as well as being an intelligent node in a

distributed system. It shall be based on multiprocessor architecture, in which a co-processor is used for handling on-board input/output channels. To facilitate initial installation, maintenance and future expansion, all external input/output modules shall connect to the basic controller using a high-speed bus.

E. All discrete and analog data acquisition, pre-processing, storage and process control functions shall be performed at the controller RTU level.

F. Provide a user interface for operations and configuration. Provide an C-MORE HMI 6" touchscreen display.

G. Provide a user interface for operations and configuration. Provide an C-More 6" Gray Scale touchscreen. The display shall provide status of the pump station, control of pumps, resetting of faults, and configuration of parameters. The following parameters shall be displayed on the main screen: Level, Setpoints for alarms and pump start/stop, Pumps running/stopped, Pump available, Pump fault. The screen will also have buttons to allow the user to access Faults, and Settings. The following parameters shall be available via a user key press from the main screen: Status of all I/O. All parameter settings shall be password protected.

2.03 CELLULAR ROUTER TELEMETRY SYSTEM

A. The Contractor shall furnish, test, install and place in satisfactory operation a mixed media Ethernet Industrial Protocol (IP) network. The network topology will vary by location but basically consists of a combination of unshielded twisted pair (UTP) Cat-6 copper cable within control panels. Each connected device shall be equipped with its own network interface unit. The well RTU will communicate with an existing SCADA system via cellular routers using TCP/IP protocols. Existing Human Machine Interfaces (HMIs) are located in the plant control room and will be modified by the CONTRACTOR to include the new stations.

B. Provide for an Ethernet/IP communications with the Central Telemetry SCADA system through a CAT6 UTP copper connection to the owner provided Vanguard 3000 cellular router. Provide an unmanaged 100 base-T Ethernet switch in the Radio conversion cabinet.

C. Bi-directional communications between the fiber ready network and network connected equipment shall be provided by 10/100 base-T unmanaged Ethernet switches.

D. Each individual RTU shall be connected to the network via a dedicated 10/100 Base-T Ethernet port on its Ethernet module. The RTU Ethernet module shall be connected to the Ethernet switch located in the control panel cabinet. The RTU Ethernet Communication Interface shall provide for a minimum 100 M Baud TCP/IP network. True duplex peer-to-peer, networking shall be supported.

2.04 DATA ACQUISITION AND GENERAL CONTROL LOGIC

A. Not in AUTO Alarms: Before operating any field device, the RTU program shall

check to see that the device has been switched to the AUTO mode. If the device is not in AUTO, the RTU shall set an error bit and suspend control of the device until it is switched to AUTO.

B. No Response Alarm: If at any time a field device fails to respond to an output command from the RTU, the RTU shall set an error bit. The SCADA shall use the error bit to log a "No Response" alarm.

C. Adjustable Timers: The preset values for all RTU timers shall be adjustable through the HMI software by the operator under security password clearance.

D. RTU Diagnostic Alarms: each RTU shall monitor its CPU and I/O modules. When the CPU or any I/O module fails, the RTU shall generate a RTU FAIL alarm.

E. Process Variable Filtering: Each analog process variable being transmitted to the SCADA shall have adjustable digital filtering applied.

F. Totalizer Current Average Value: The current average flowrate for each totalized value shall be provided for each flowrate input.

G. Flowrate Integration: Flowrate integration shall be provided for each analog flowrate input.

H. Daily Average: Daily average calculations shall be provided as required to support displays and reports.

I. Daily Totalizer Counter: Accumulate daily total over Ethernet signal. The totalizer shall be reset daily when the daily reports are produced.

J. Monthly Totalizer Counter: Accumulate daily total flow over Ethernet signal. The totalizer shall be reset monthly when the monthly reports are produced.

K. Cumulative Totalizer Counter: Accumulate total over flow over Ethernet signal.

L. Run Time: Each piece of equipment shall have a run timer, which accumulates time.

2.05 SUBMERSIBLE LEVEL TRANSDUCER (intrinsically safe)

A. Provide submersible level transmitters to sense the liquid level of the wetwell. The unit shall consist of a submersible sensor and encapsulated transmitter to provide a continuous monitoring of the wetwell level. Provide transducer housing fabricated of 316 stainless steel with oil filled diaphragm. Provide transducer with 1/2” NPT male thread for pipe mounting and stainless steel standoff to protect the diaphragm.

B. Provide transmitter with 4-20madc output, loop powered type, with output signal directly proportional to the measured level. Excitation range 9-36vdc.

C. Provide a NEMA-4X lockable weatherproof enclosure for the wiring termination. The enclosure shall house a sealed breather system that relieves the internal air

pressure of the sensor assembly to atmospheric pressure and a Permanent Desiccant Filter.

D. Provide unit with 24+/- foot 0.75” 316 stainless steel pipe and chain mounting provisions as detailed.

E. Provide Contegra model SLX 130 sensors with 0-5PSI (0-11.5’) or 0-10PSI (0-23.5ft) range.

2.06 BALL FLOAT SWITCHES

A. Units shall be direct-acting float type level sensing device. The switch shall be chemical resistant polypropylene, normally open, type-S suspended type with built-in weight. The float cable shall be rated "continuous service" for high flexibility. All mounting hardware shall be 316 SS. All float fittings shall be flared and incorporate strain relief jacketing.

B. Cable shall be rugged and flexible with heavy neoprene or PVC jacket. The actuation/deactivation differential shall not exceed 4 inches. Units shall be pipe mounted or suspended type as noted, and provided with 40 feet of cable unless otherwise noted. Each pipe mounted type shall be provided with a clamp to secure the cable to 1-inch support pipe.

C. Each suspended type shall be provided with necessary brackets and clamps to suspend the unit from the top of a tank or vessel. The suspended type shall include an integral weight assembly for stabilization and positive operation of the unit. All mounting clamps shall be PVC or neoprene.

D. Provide Anchor Scientific suspended type Roto-Float switch.

2.07 PROCESS METERS

A. Process Meters: Provide digital programmable process meters designed for a 4-20MA current loop display and isolated retransmission of displayed output. Provide minimum 0.5" high, 4-1/2 digit LED display to indicate amplitude of current in the current loop and calibrated to engineering process units. In general, a loop current of 4ma corresponds to a display indication of 0 percent and a loop current of 20ma corresponds to a display indication of 100 percent. The meter shall be provided with programmable internal scaling adjustment. Provide units with NEMA-4X faceplate rating constructed of silicone coated Lexan and gasketed for NEMA 4 requirements; circuit boards coated for moisture resistance.

B. Provide YOKOGAWA UM33A or equal indicators.

2.08 ISOLATING TRANSMITTERS: CURRENT-TO-CURRENT ISOLATING TRANSMITTER

A. Unit shall receive 4 to 20 mA dc input signal and shall produce an isolated, proportional 4 to 20 mA dc output signal into loads in the range of 0 to 1,200 ohms minimum without load adjustments for a 24V dc supply. Input impedance shall be less than or equal to 50 ohms. Unit accuracy shall be plus or minus 0.25

percent of span, minimum. Unit shall be provided with multi-turn span and zero adjustments.

B. Unit shall be housed in a NEMA 1 rated enclosure and shall be furnished with an integral bracket for rear-of-panel mounting, unless otherwise noted. Unit shall have input/output and power isolation. Unit shall operate on 120-volt, 50/60-Hz power.

C. Provide isolating transmitters where required by system conditions. Unit shall be Moore Industries SCT/ECT/MIX or equal.

2.09 SPARE PARTS

A. Provide as part of this contract a complete compliment of replacement spare parts for all component parts of this system. It shall be the supplier's responsibility to prepare a detailed suggested replacement parts list for review and approval by the owner.

B. As a minimum, the controls system supplier shall furnish one plug-in module for each type of control module used in the system; CPU module, one analog input module; one analog output module; one digital input module; one digital output module; two of each relay; one of each type power supply; one of each type Ethernet switch; 2 each type signal surge suppressor; two sets complete of each type fuse; two of each length patch cords; two of each pilot light; one level instrument; one ball float.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The work included in this section consists of furnishing, installing and placing in operation the instruments and appurtenances, including all conduit, wiring and circuitry, necessary to provide the Owner with a fully operable system properly calibrated and installed.

B. Include the services of a factory trained, qualified service engineer of the equipment manufacturer to inspect the complete equipment installation to assure that it is installed in accordance with the manufacturer's recommendations, make all adjustments necessary to place the system in trouble-free operation and instruct the operating personnel in the proper care and operation of the equipment furnished.

C. All workmanship utilized in the manufacture and installation of this system shall be of the highest quality and performed in a manner which is consistent with all accepted practices for industrial controls.

D. Provide continuous protection of the installed instrumentation equipment from the elements, moisture, construction damage, dust, debris, paint spatter or other conditions which will adversely affect the unit operation until such time as the equipment is scheduled for start-up testing.

3.02 MOUNTING OF EQUIPMENT AND ACCESSORIES

A. Install and mount equipment in accordance with the Contract Documents, manufacturer's instructions and installation detailed shop drawings. Mount equipment so that they are rigidly supported, level and plumb, and in such a manner as to provide accessibility; protection from damage; isolation from heat, shock and vibration; and freedom from interference with other equipment, piping, and electrical work. Do not install field enclosures, cabinets, and panels until heavy construction work adjacent to the equipment has been completed to the extent that there shall be no damage to the equipment.

B. Locate devices, including accessories, where they shall be accessible from grade, except as shown otherwise.

C. Coordinate the installation of the electrical service to components related to the system to assure a compatible and functionally correct system. All accessories shall be coordinated and installation supervised by the Contractor.

3.03 CALIBRATION

A. Calibrate each instrument in the factory before shipping and furnish with the calibration data and the certification of calibration.

B. The service technician shall calibrate all instruments and components of the instrumentation system with field adjustable ranges and/or settings after installation in conformance with the manufacturer's instructions, the Contract Documents and the reviewed shop drawings. Set each instrument and components for the specific conditions and intended application as specified for this installation. Replace defective instruments and components which cannot achieve correct calibration of stated accuracy, either individually or collectively within the system.

C. Certify in writing to the Owner that all calibrations have been completed and the instrumentation system is ready to be operated. Provide instrumentation calibration sheets in the O&M manuals for future reference for both factory and field calibration tests. Calibration certification documents shall be available on site at the time of substantial completion. Certification documents shall include the signature of the service technician performing the calibration.

3.04 GENERAL TESTING REQUIREMENTS

A. All system start-up and test activities shall follow detailed test procedures, check lists, etc., submitted and previously approved by the Engineer. The Engineer shall be notified at least 21 days in advance of factory system tests and reserves the right to have his and/or the Owner's representatives in attendance.

B. The Contractor shall provide the services of experienced factory trained technicians, tools and equipment to field calibrate, test, inspect, and adjust all equipment in accordance with manufacturer's specifications and instructions.

C. The Contractor shall maintain master log books for each phase of installation, startup and testing activities specified herein. Log book shall include signal, loop or control strategy tag number, equipment identification, description and space for sign-off dates, Contractor signature and Engineer signature. Example test

documentation specific to each phase of testing shall be approved prior to initiation of that testing, as specified here.

D. All test data shall be recorded on test forms, previously approved by the Engineer. When each test has been successfully completed, a copy of all test results shall be furnished to the Engineer together with a statement that all specified test requirements have been met and that the system is operating in accordance with the Contract Documents.

3.05 START-UP SUPERVISION

A. The Control panel startup personnel shall be present and coordinate with all other startup and testing activities especially the pump, standby power system and variable frequency drive startups.

3.06 INITIAL FIELD TESTING

A. All system start-up and test activities shall follow detailed test procedures, test report, check lists, etc., submitted and previously approved by the Engineer.

B. Control system start-up and testing shall be performed to ensure that all plant processes shall be systematically and safely placed under digital control in the following order:
   1. Primary elements such as transmitters and switch devices shall be calibrated and tested as specified.
   2. Each final control element shall be individually tested by Contractor.
   3. Each instrument and control loop shall be tested by Contractor.
   4. Each control strategy shall be tested under automatic control as specified by Contractor.
   5. The entire control system shall be tested for overall monitoring, control, communications, and information management functions, and demonstrated for system availability as specified by Contractor and Engineer.

C. System start-up and test activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal operating conditions in terms of applied process loads, operating ranges and environmental conditions.

D. Verify that each instrument, meter, and gage has been properly installed, connected, grounded and calibrated. Perform three-point calibration on continuous elements and systems. Provide calibration records.

E. Verify that the input/output functions of each instrument conform to the requirements of the application.

F. Exercise each system as defined by each loop description through operational tests to demonstrate that it performs as intended on a continuing basis and to demonstrate the integrity of the system.

3.07 LOOP CHECKS

A. Prior to control system startup and testing, each monitoring and control loop shall be tested by the Contractor on an individual basis from the primary element to the final element, including the RTU Controller I/O and data table, for continuity and for proper operation and calibration.

B. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses. Simulated input data signals may be used subject to prior written approval by the Engineer. All modes of control shall be exercised and checked for proper operation.

C. The accuracy of all analog inputs shall be verified using field inputs or by manually applying input signals at the final controller, and then reading and recording the resulting analog input data at the RTU or work station.

D. Final control elements and ancillary equipment shall be tested to verify that proper and stable control is achieved using local area control panels, motor control center circuits, and local field mounted control circuits. All hardwired control circuit interlocks and alarms shall be operational. The control to final control elements and ancillary equipment shall be tested using both manual and local automatic (where provided) control circuits.

E. Each loop tested shall be witnessed, dated and signed off by both the Contractor and the Engineer/owner upon satisfactory completion.

3.08 INITIAL START-UP TESTING

A. Perform satisfactory Contractor's initial start-up and functional test prior to demonstration for Owner and Engineer.

B. After the field testing has been successfully demonstrated, a date for system start up involving the Owner's operating personnel will be scheduled as agreed to by the Owner. Notify Engineer fourteen (14) days prior to initial start-up of each item of equipment.

C. Have Contract Documents, shop drawings, product data, and operation and maintenance data at hand during entire start-up process.

D. Provide control diagrams that show actual control components and wiring.

E. Coordinate sequence for initial start-up of various items of equipment

F. Verify control systems are fully operational in automatic and alternate modes of operation.

G. Start up and test the instrumentation equipment with the entire system operational. Conduct start-up and initial functional testing.

3.09 STARTUP AND FUNCTIONAL TESTING, DEMONSTRATION FOR OWNER AND ENGINEER

A. Perform pre-startup inspection of installation. Perform startup under no-load conditions, if possible. Observe noise, vibration and operation. If all operating

characteristics are normal, proceed with startup. Operate equipment and systems under all load conditions and confirm all operating characteristics are normal. If normal operation is observed, proceed with witnessed functional test and performance test as required.

B. Perform functional and performance tests under supervision of responsible manufacturer's representatives, control system integrator, and Contractor personnel. Representatives of Owner and Engineer shall witness functional test. Perform functional and performance tests on each piece of equipment and operational system as specified in the individual product sections.

C. Demonstrate that equipment operates and complies with specified performance requirements. Demonstrate that control panel functions, including failures and alarms operate and comply with specified performance requirements.

D. Functionally test failures and alarm conditions; or if approved by engineer simulate by jumping failure input terminals. Provide signal generators that simulate control conditions if it is not feasible to create actual conditions. Testing activities shall include the simulation of both normal and abnormal operating conditions.

E. Use Operation and Maintenance manuals, loop descriptions, submittals, graphic screens, etc., to demonstrate operation of equipment. Use actual as-built control diagrams in demonstration of functions.

F. Each control strategy shall be tested by the Engineer to verify the proper operation of all required functions. The control system start-up and test activities shall include procedures for tuning all control loops and for adjusting and testing all control loops as required to verify specified performance.

3.10 WARRANTY

A. All products mentioned herein must be warranted by the supplier for a period of Two (2) years from the date of system turnover; final acceptance.

B. An unconditional warranty shall be provided for all equipment supplied for Two years from date of final acceptance of system by the owner. THIS WARRANTY SHALL INCLUDE ANY DAMAGES CAUSED BY LIGHTNING INDUCED ELECTRICAL SURGES; ONLY DAMAGES CAUSED BY DIRECT LIGHTNING STRIKES TO THE BUILDING STRUCTURE (AS DETERMINED BY THE ENGINEER) SHALL BE EXCLUDED FROM THE WARRANTY. Theft, fire, vandalism and floods shall be excluded from the warranty except for fire damage which originates at equipment which is provided as part of this work.

D. CONTRACTOR shall issue two copies of a written warranty to the OWNER.
1. The warranty shall be a legal and binding document.
2. Warranty shall include the start and end date of the warranty period.
3. Warranty shall include the OWNER'S and CONTRACTORS name.

E. Warranty calls shall be broken into two categories, emergency and non-emergency. Whether the warranty call is emergency or non-emergency shall be dictated by the OWNER.

1. An emergency warranty call shall be responded to within 8 hours of the call, whether during business hours or not.
2. A non-emergency warranty call shall be responded to within 48 hours of the call, whether during business hours or not.

F. Telephone support for operating procedures and non-hardware problems shall be provided on an unlimited basis during the warranty period.

3.11 TRAINING

A. The system supplier shall provide a minimum of three (3) days of training instruction to the owner's personnel to include; one day operator training; and two days PCP and Controls system maintenance training including software maintenance training.

B. Training shall not occur until after completion of successful functional testing and performance testing. Provide training while equipment is fully operational

C. Training shall not occur until after review and approval of system O&M manuals. Use accepted Operation and Maintenance manuals as the basis of instruction.

D. Submit to OWNER not less than 14 days prior to each training session an outline of the training program and the qualifications of the trainer(s).

E. Coordinate services with the OWNER, with a minimum of two week's notice.
1. Training shall be held to accommodate OWNER'S schedule.

F. Training services are exclusive of travel time to and from the facility. The times specified shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to insure equipment is in satisfactory and continuous operation.

G. Trainings should be geared to not only impart knowledge of the control functionality of the new control system but also some background understanding of how and why things work.

H. Onsite Operations Staff Training Sessions shall be held over two full days. A full day training session shall cover all necessary material. Between the two different days all operations staff should be able to attend at least one training session.

I. Training Manual
1. The operations staff training shall be based on the training manual created by the CONTRACTOR.
2. All training manuals shall be provided with color graphics.
3. The training manual shall provide DETAILED working knowledge of the control of the plant and how to use the SCADA interface.
4. Each SCADA control object, whether it be a display field, push button, or set point field shall be specifically called out and its purpose explained.
5. The underlying theory of why something is controlled shall be explicitly explained.
6. All faults and permissives that affect the operation of equipment shall be explicitly called out.

7. All set points shall be recorded under a separate section titled “Set Points.” An explanation of how the set point value was determined shall also be included next to the set point value.
8. EACH section of the training manual shall include a 10 question quiz. Answer key for each quiz shall also be provided, but not as part of the training manual.
9. The training manual will be used as the basis for the INITIAL Operations Staff Training Sessions. At the end of EACH section covered in the training manual the CONTRACTOR shall administer the 10 question quiz. At the end of the quiz the CONTRACTOR shall review the quiz with the operations staff and discuss what the correct answer was for each quiz question. Operations staff shall be allowed to keep their quizzes for further study.
10. The training manual will be used as the basis for the FINAL Operations Staff Training Sessions. At the end of EACH section covered in the training manual the CONTRACTOR shall administer the 10 question quiz. At the end of the quiz the CONTRACTOR shall collect all quizzes, seal them in an envelope and give them to OWNER Process Control Engineer for grading.
11. The course shall cover the following subjects, as a minimum:
    a. SCADA overview in which the basic systems design, configuration, and purpose is covered.
    b. DCS hardware in which the specific hardware elements and specific configurations provided are covered.
    c. How the actual RTU programs operate.
    d. Programmer equipment orientation in which the student becomes familiar with the operation and operational maintenance procedures.
    e. Specific application program instruction covering the overall design and philosophy of the applications as provided under this contract. The intent shall be to make the student fully knowledgeable in all aspect of the system provided, along with methods for making additions, modifications, and deletions to the SCADA.
    f. Complete systems backup and reload procedures.
    g. Diagnostic software details including capabilities, usage, and interpretation of results.

END OF SECTION

SECTION 40 95 33

FIBER OPTIC COMMUNICATION SYSTEM

PART 1 – GENERAL

1.01 REFERENCED STANDARDS

A. The cable and installation shall meet all requirements stated in this specification as well as the latest edition of the following:
   1. Insulated Cables Engineers Association (ICEA); S-87-640 Standard for Fiber Optic Outside Plant Communication Cable
   2. United States Department of Agriculture Rural Development Utilities Program (RDUP); PE-90
   3. ISO/IEC:
      a. 24702 Information technology -- Generic cabling -- Industrial premises OS2 Single-mode fiber type 0.4db/km attenuation
      b. 11801 Information technology — Generic cabling for customer premises OM1 Multimode fiber type 62.5 µm core; minimum modal bandwidth of 200 MHz*km at 850 nm
   4. International Electrotechnical Commission (IEC):
      a. 60793-2-50 Type B1.3 Product specifications - Sectional specification for class B single-mode fibres
      b. 60793-2-10 Type A1b Product specifications - Sectional specification for category A1 multimode fibres
   5. International Telecommunication Union (ITU); T G.652.D Characteristics of a Single Mode Optical Fibre and Cable
   6. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA) Standards:
      a. 455-78-B Measurements Methods and Test Procedures-Attenuation
      b. 492 CAAB Detail Specification for Class IVa Dispersion-Unshifted Single Mode Optical Fibers with low water peak
      c. 492 AAAA-A Detail Specification for 62.5 micrometer Core Diameter/125 micrometer cladding diameter Class IVa Graded-Index Multimode
      d. 568-C.3 Optical Fiber Cabling Component Standard
      e. 598-B Optical Fiber Cable Color Coding
   7. Restriction of Hazardous Substance (RoHS) Compliant
   8. Telcordia; GR-20-CORE

1.02 QUALITY ASSURANCE

A. Manufacturer
   1. The cable manufacturer shall be ISO 9001 or Quality Management System TL 9000 registered.

B. Installer
   1. The fiber optic cable installer shall be certified by the cable manufacturer and adhere to the engineering, installation and testing procedures and

utilize the authorized manufacturer components and distribution channels in provisioning the Project

2. The Contractor directly responsible for this work shall be a Premise Distribution contractor who is, and who has been, regularly engaged in the providing and installation of commercial and industrial telecommunications wiring systems of this type and size for at least the immediate past five years.
3. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size. The Contractor shall own and maintain tools and equipment necessary for successful installation and testing of optical and have personnel who are adequately trained in the use of such tools and equipment.

1.03 SUBMITTALS-shall be submitted in accordance with Section 26 05 02 BASIC ELECTRICAL MATERIALS AND METHODS.

A. SHOP DRAWINGS shall include:
1. Cable schedule showing cable identification, fiber counts for each cable and identification of used fiber pairs.
2. Component Data:
a. Manufacturers and model number
b. Data sheets
3. System Block Diagram
4. Detailed Test Procedure to be implemented including all tests to be conducted and list of equipment to be used.

B. OPERATION and MAINTENANCE submittal shall include:
1. All shop drawing data revised for as built conditions
2. Manufacturers user manuals and installation instructions
3. Fiber Optic Cable Test Results

1.04 SYSTEM DESCRIPTION

A. Furnish and install complete with all accessories a TIA/EIA fiber optic, Cabling System (FOCS). The FOCS system shall serve as a vehicle for transport of data and video signals connecting designated demarcation points and other locations as indicated on the contract drawings and described herein.

B. The system shall utilize a network of fiber optic cabling. Cables and terminations shall be provided and located as shown and in the quantities indicated on the drawings. Cables shall terminate on rack mounted Fiber Distribution Centers (FDC's) located as shown on the drawings. All cables, and terminations shall be identified at all locations. All terminations shall comply with, and be tested to TIA/EIA and Gigabit Ethernet fiber optic standards.

C. Major work items include but are not limited to:
1. Fiber optic cable and patch cords
2. Fusion splicing
3. Splice enclosures
4. Fiber Optic Patch Panels
5. Installation of fiber optic cable

6. Fiber optic terminations
7. Testing of the fiber optic cable including:
    a. OTDR testing on installed fiber optic cable.

D. Electrical Contractor to furnish and install conduit and pull boxes for fiber optic cable. Coordinate fiber optic cable and conduit requirements with electrical contractor.

E. Provide fiber optic cable for installation based on lengths provided by the electrical contractor.

F. Environmental Specifications:
1. Outside Plant Fiber Optic Cable operation and storage -40 degrees C to +70 degrees C.
2. Equipment Outside above ground -40 degrees C to +80 degrees C.

PART 2 – PRODUCTS

2.01 GENERAL

A. Multi-mode fiber optic cabling shall be provided between fiber racks as designated on the contract drawings. Cables placed below grade shall be certified by the manufacturer for that environment. Cables installed in vertical risers between floors shall be U.L. listed riser type cable. Cables installed in plenum spaces shall be listed for that environment.

2.02 MODE FIBER OPTIC CABLE

A. Provide 62.5/125-micron OM1 Class IVa Graded-Index Multimode Optical Fiber for use in the backbone and horizontal distribution system.

B. Fiber Characteristics:
1. Reduced Water Peak
2. Maximum Attenuation: 850/1300nm: 3.5/1.5dB/km
3. Color coded buffer tube
4. Color coded fiber
5. Loose Tube
6. Maximum Transmission: 1 Gbps Ethernet; 300m at 850nm and 600m at 1300nm
7. Minimum Bend Radius 4.1” longterm, 8.2” during installation.

C. Cable Characteristics:
1. Fiber Count-6 fibers per cable or as otherwise noted on the drawings.
2. Loose Tube Cable with diaelectric gel free water blocked buffer tubes
3. Up to 12 fibers per buffer tube
4. UV resistant Outer Jacket
5. The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrinkback requirements.
6. Buffer tubes shall be stranded around a dielectric central member using a reverse oscillating lay.
7. Top and bottom ends of cable shall be available for testing.
8. Both ends of cable shall be sealed during shipping to prevent ingress of

moisture.

9. The jacket shall be free of holes, splits and blisters. It shall also contain no metal elements and shall be of consistent thickness.
10. Maximum Tensile Loading: 2700N(600lbf) during installation and 890N(200lbf) long term.

D. Manufacturers:
   1. Superior Essex Series 11
   2. Corning
   3. Berk-Tek

2.03 FIBER OPTIC TERMINATION PANELS

A. Rack Mounted Panels: Fiber optic cabling shall be terminated in fiber distribution centers as described herein. FDC's shall include plexiglass front doors with latching mechanism. Provide blanking modules in all unused connection ports. FDC's shall be provided in quantities and configurations as required complete with SC style connectors. All FDC's shall be provided with rack mounting hardware allowing the unit to be placed in a standard EIA 19" rack.

B. Control Panel Mounted Field Panels: Fiber optic cabling shall be terminated in wall mount fiber enclosures as described herein. Enclosures shall include swinging side doors with latching mechanism and routing guides. Provide blanking modules in all unused connection ports. FDC's shall be provided in quantities and configurations as required complete with SC style connectors. All FDC's shall be provided with mounting hardware allowing the unit to be mounted to a backplane.

C. General: Provide blanking modules in all unused connection ports on the panels. All panels shall include strain relief points where fiber optic cable strength members shall be securely attached.

D. Labels: Labeling for fiber cabling shall be by the color suffix designating which fiber is terminated. Die cut acetate labels or Kroy labels shall be considered acceptable the purpose

E. Accessories: Provide (6) six duplex fiber optic patch cords with ST connectors at each termination point.

F. Manufacturers:
   1. Lightwave
   2. Blackbox
   3. Corning

2.04 FIBER OPTIC CONVERTER

A. Control Network Switch
   1. Provide 120V hardened heavy duty 10-/100-Mbps copper to 1000 Mbps Single Mode switch with SC Connectors.

B. Manufacturers:
   1. Blackbox

2. Sixnet

2.05 FIBER OPTIC CONNECTORS

A. General: Provide field installable, single mode SC type connectors. Connectors shall be Glass-in-Ceramic, with a maximum loss of .2 dB.

B. Manufacturers:
1. Blackbox
2. Corning
3. Siemon

2.06 FIBER OPTIC PATCH CORDS

A. General: All patch cords shall be of the same manufacturer as provided with the FDU units and shall comply with manufacturers approved testing and warranty statements.

2.07 UNSPECIFIED EQUIPMENT AND MATERIAL

A. Any item of equipment or material not specifically addressed on the contract drawings or in this document and required to provide a complete and functional SCS installation shall be provided in a level of quality consistent with other specified items.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Fiber Optic Cable
1. Install cable in accordance with cable manufacturer recommendations for bend radius and pulling tension. Do not exceed limits specified by the manufacturer.
2. Utilize break away swivel set at 600lbs for straight pulls greater than 100' and all pulls which are not in a straight line.
3. Identify cable on both ends, in pull boxes and at all terminations.
4. Terminate all fibers in each cable to a connector.
5. Provide slack fiber coiled neatly in cable management at all fiber termination centers, converters and switches.
6. Terminate cables using manufacturer supplied break-out kits.
7. Fan out fiber to allow direct connection with connectors. Provide strain relief with fan out collar.

3.02 TESTING

A. Fibers in fiber optic cable shall be tested for correctness of termination and overall transmission loss using an approved fiber optic transmission loss test instrument (OLTS) and optical time domain reflectometer instrument (OTDR). System loss measurements shall be provided at 1310nm and 1550 nm for single mode fiber, at 850 and 1300 nanometers for multimode fiber. A certification report shall be provided listing both the calculated and measure loss for each

fiber optic circuit and submitted with the close out documents.

B. All cabled fibers greater than 1000 meters in length shall be 100% attenuation tested. The Attenuation of each fiber shall be provided with each cable reel.

C. Perform OLTS testing in both directions of installed backbone and horizontal fiber.
   1. Submit test report which includes:
      a. Fiber Identification
      b. Length of each fiber vs calculated length
      c. Copy of the OTDR printouts
      d. Pass or fail status of length under test.

D. Provide OTDR post installation tests for each installed fiber strand
   1. Test each installed fiber optic link for continuity and loss using an OTDR with disk storage capabilities.
   2. Submit test report for each cable which includes:
      a. Cable Identification
      b. ID of reel cable was taken from
      c. Copy of the OTDR printouts
      d. Pass or fail status of each fiber on the reel.

END OF SECTION