

SECTION 13300
PROCESS INSTRUMENTATION AND CONTROL SYSTEM
GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01. SCOPE OF WORK

- A. The overall system general requirements are given in this section. These requirements apply to each additional section of these specifications as noted herein and as specified in the associated sections.

- B. Work includes engineering, furnishing, installing, testing, documenting and placing in operation upgrades for the existing Process Instrumentation and Control System (PICS) at the Sun-N-Lake, Sebring, Florida's Water Treatment Plant (WTP). Training of the OWNER's personnel is also included. The work is specified in this Section and as further specified in the following sections:
 - 1. Specification Section 13310: Field Instruments.
 - 2. Specification Section 13315: Control Panels.
 - 3. Specification Section 13320: Human Machine Interface (HMI) System.
 - 4. Specification Section 13321: Human Machine Interface (HMI) Programming.
 - 5. Specification Section 13325: Process Control Panel Modifications.
 - 6. Specification Section 13326: Programmable Logic Controller (PLC) Programming.
 - 7. Specification Section 13360: Fiber Optic System.
 - 8. Specification Section 16370: Variable Frequency Drives.

- C. The improvements require the replacement of an existing Programmable Logic Controller (PLC) within an existing control panel (henceforth referred to as PCP-1). All work covered by this specification shall be performed by one of the following firms henceforth referred to as the SYSTEM SUPPLIER:
 - 1. KW Controls.
 - 2. Sanders and Company.

- D. The SYSTEM SUPPLIER shall furnish all labor, materials, equipment, programming, services and incidentals required to install and place into operation a digital computer-based PICS configured as shown on the Contract Drawings, and as specified herein.
- E. The SYSTEM SUPPLIER shall provide all equipment, materials, programming, software, modifications to existing equipment, calibrations and services that are required to successfully interface and interconnect the PICS and any other control systems and associated equipment that are specified or designated in any drawings or provisions of these specifications for the purpose of providing a fully integrated and functional control system.
- F. The SYSTEM SUPPLIER may duplicate software logic code and database and graphics applications, as required, while still meeting the functional specifications. The ENGINEER may require modifications to the submitted graphics, reports and control logic without change to the contract price. All engineering development required by the SYSTEM SUPPLIER will be in accordance with the Conditions of this Contract.
- G. It is the intent of these Contract Documents that the SYSTEM SUPPLIER be retained by the CONTRACTOR to have overall responsibility for designing, furnishing, interfacing, adjusting, testing, documenting, and starting-up the various PICS equipment described in the Contract Documents. The specified intent is that the SYSTEM SUPPLIER will have overall responsibility for making sure the various systems, trades, suppliers, vendors, subcontractors, etc. come together as a complete coordinated system which will reliably perform the specified functions.
- H. The CONTRACTOR shall ensure that the SYSTEM SUPPLIER coordinates closely with suppliers of other specialty equipment to ensure the required inputs and outputs for the PICS are available.
- I. Instrumentation and control systems for this project are intended to be supplied completely under this section. All control panels shall be supplied through the SYSTEM SUPPLIER; however, some special control panels and devices specifically called out in other specification sections are to be part of those sections, furnished with that equipment. The instruments and controls shall, however, be furnished in conformance to and in coordination with, this section. This includes the following local control panels:
- J. Division of Work. It is the ultimate responsibility of the CONTRACTOR to furnish a complete and fully operable PICS that reliably performs the specified functions. The CONTRACTOR is to assume full responsibility for additional costs which may result from unauthorized deviations from the specifications. The CONTRACTOR is to establish the actual division of work with the minimum requirements as specified herein

- K. The SYSTEM SUPPLIER shall be responsible for:
1. The integration of the system including the PLC networking, computer system network, panel layouts and wiring, PLC programming, VFD programming and configuration, network communications programming, and computer system application software setup.
 2. All application software configuration including all operator interface screens, reports, and database(s).
 3. All hardware and software submittals. The SYSTEM SUPPLIER shall develop the panel shop drawings, wiring diagrams, plumbing diagrams, PLC and computer hardware configuration drawings and layouts, software documentation, and all other submittals defined herein and in the specification sections identified in paragraph 1.01B hereof. Coordination with the CONTRACTOR and other subcontractors shall be the responsibility of the SYSTEM SUPPLIER.
 4. The final system operation and reliability. All required tests and training shall be under the on-site supervision of the SYSTEM SUPPLIER.
 5. Ordering, fabrication, assembly, delivery and start-up of the PICS. All panel fabrication defined in Specification Section 13315 shall be performed at the SYSTEM SUPPLIER's shop.
 6. Obtaining from the CONTRACTOR the required information on those field elements, equipment starters, valve actuators, chemical feed equipment, local control panels, and other control equipment or devices that are required to be interfaced with, but that are not provided with the PICS in order to provide full system coordination regarding interface, function, testing, and adjustment requirements.
 7. Providing accessory devices including furnishing and installation of networking interface cards, interposing relays, control switches and signal converters necessary to perform the intent as described by the control strategies and services necessary to achieve a fully integrated and operational system as shown on the Contract Drawings and defined in the Specifications.
 8. Coordinating all interface requirements with mechanical and electrical system suppliers and furnishing any signal isolation devices that might be required In order to insure compatibility between all equipment.

9. Providing any special manufacturer's cables required.
 10. Defining the final installation and connection requirements of the PICS at the jobsite through development of interconnection diagrams.
 11. Termination and final test of fiber optic cabling, installed by others but terminating within control panels supplied hereunder.
 12. Verifying correctness of all final power and signal connections to the PICS. The SYSTEM SUPPLIER shall make final adjustments to and calibrate all field elements provided with the PICS.
 13. Ensuring that:
 - a. All components provided under this section are properly installed.
 - b. The proper type, size and number of control wires with their conduits and junction boxes are provided and installed.
 - c. Proper electric power circuits are provided for all components and systems.
- L. The CONTRACTOR shall be responsible for:
1. Including within the electrical subcontractor's scope:
 - a. Installation of fiber optic cabling furnished by the SYSTEM SUPPLIER. Termination within SYSTEM SUPPLIER provided control panels and enclosures shall be performed by the SYSTEM SUPPLIER. The electrical contractor shall make all other necessary fiber terminations.
 - b. Provision, installation and termination of field and power wiring to PICS supplied control panels and field elements. Termination shall be made in accordance with final accepted interconnection diagrams developed by the SYSTEM SUPPLIER. The electrical subcontractor shall mark on the interconnect diagram the field wire numbers used for each termination point. The SYSTEM SUPPLIER shall finalize the interconnect diagrams by including these field wire numbers in the final as built version.
 - c. Installation and termination of all specialty cables furnished by the SYSTEM SUPPLIER.

2. Including within the mechanical subcontractor's scope installation of any in-line instrumentation. Installation shall be made in accordance with the manufacturer's recommendations and under the direction of the SYSTEM SUPPLIER.
 3. Equipment storage and protection until installed following the storage and handling instructions recommended by the SYSTEM SUPPLIER. Anti-static and winterization requirements shall be per the SYSTEM SUPPLIER's instructions and the SYSTEM SUPPLIER shall periodically verify that these instructions are followed.
 4. Incorporating all necessary components into the system. Schedules included in the referenced specification sections do not necessarily indicate the complete component requirements of the PICS.
 5. Ensuring that the SYSTEM SUPPLIER coordinates work with other Divisions and Sections of the Specifications.
 6. Requiring the SYSTEM SUPPLIER to observe and advise on the installation of equipment furnished by SYSTEM SUPPLIER and installed by CONTRACTOR to the extent required to certify, with the operational check-out tests, that the equipment will perform as required.
 7. Ensuring that information on equipment provided under other Divisions and needed by the SYSTEM SUPPLIER to coordinate the PICS is provided in a timely manner.
- M. Equipment found to be defective prior to system acceptance shall be replaced and installed at no additional cost to the OWNER.
- N. In the bid price, the SYSTEM SUPPLIER shall provide for obtaining the services of authorized field personnel from the manufacturer's of specialty instruments and from the suppliers of application software packages as necessary. Should these personnel be required during installation, start-up and checkout of the respective portions of the PICS, such services shall be provided at no additional cost to the OWNER.

1.02. RELATED WORK

- A. Division 15 – Mechanical. Installation of all mechanical piping and fittings, as well as in-line instruments supplied with and/or supplied for the PICS.
- B. Division 16 - Electrical. All conduits are provided and installed under Division 16, Electrical. With the exception of certain specified special manufacturer's cables, all wiring and cables are provided and installed under Division 16, Electrical.

- C. Field devices such as motorized valves, pump motors, solenoid valves, etc. and local control panels for specialized subsystems such as chemical feed systems, etc. are supplied and installed under other Divisions of these Specifications.

1.03. SUBMITTALS

- A. Furnish, as prescribed under the General Requirements, all required submittals covering the items included under this section and its associated sections of the work.
- B. Submit complete, neat, orderly, and indexed submittal packages. Handwritten diagrams are not acceptable and all documentation submittals shall be made using CADD generated utilities.
- C. Partial submittals or submittals that do not contain sufficient information for complete review or are unclear will not be reviewed and will be returned by the Engineer as not approved.
- D. Provide all shop drawing submittals on thumb drive in PDF format.
- E. In addition to the shop drawing submittals required in the related specification sections, submit the submittals defined below covering the complete system.
 - 1. System Performance. This submittal shall be a written description of how the operator will control the system and the system's subsequent response. Every piece of controllable equipment shall be separately described and the following information included:
 - a. Use of local manual controls.
 - b. Use of OIT/HMI software controls.
 - c. Use of automatic controls.
 - 2. Each functional description shall specifically identify any interlocks (hardware and software) and OIT/HMI alarms generated.
 - 3. Operator Screens. This submittal shall include color copies of all proposed new and modified OIT/HMI operator screens. Modified graphics shall specifically indicate the revised portions.
 - 4. Field Acceptance Test Plan. This submittal shall define the steps to be conducted during the required witnessed acceptance testing. The test shall be conducted in accordance with the general requirements set forth in Part 3 hereof. The submitted plan shall meet the following requirements:

- a. Each of the equipment covered in the system performance submittal shall be tested.
 - b. For each equipment test, the required operator control actions and system response shall be demonstrated on the complete system, including each operator action, the response and appropriate HMI display/alarm updates.
- F. The Contractor and System Supplier are hereby specifically advised that the above submittals shall be Approved or Approved As Noted prior to any witnessed performance testing.
- G. Test Procedures: Submit the procedures proposed to be followed during all required testing. Procedures shall include test descriptions, forms, and check lists to be used to control and document the required tests.
- H. Test Reports: Upon completion of each required test, document the test by submitting a copy of the signed off test procedures to the Engineer.

1.04. FINAL DOCUMENTATION

- A. After the demonstration tests have been completed and as a part of the final acceptance requirements, submit the PICS record drawings. Record drawings shall include, corrected for any changes that may have been made up through Substantial Completion:
- 1. System block diagram.
 - 2. Network architecture diagram.
 - 3. Panel wiring diagrams.
 - 4. Panel elevations.
 - 5. Interconnection diagrams showing terminal numbers at each wiring termination.
- B. Record drawings shall be developed or converted to the latest version of AutoCAD. Provide two copies of all AutoCAD files on USB Flash Drives.
- C. Operating and Maintenance (O&M) Manuals: Provide the specified number of complete sets of three-ring bound O&M manuals in accordance with Division 1. Provide separate manuals for each Specification Section, clearly marked. Include descriptive material, drawings, and figures bound in appropriate places. Include:
- 1. Cross references to 3rd party O&M manuals.

2. Additional operating and maintenance instructions in sufficient detail to facilitate the operation, removal, installation, adjustment, calibration and maintenance of each component provided with the PICS.
 3. Internal wiring diagrams (not already shown on the panel wiring diagram record drawings) for all components provided in the PICS that clearly show all terminal block number designations and wire numbers.
 4. Bill of Materials identifying the manufacturer and complete part number of all components.
 5. All the submittal data for each component from the approved shop drawing submittals with corrections made on approved as noted items.
 6. A Compact Disk containing the shop drawing data in PDF format in the binder sleeve.
- D. Refer to the individual specification sections of the PICS for final documentation requirements that are in addition to the above.

1.05. QUALITY CONTROL

- A. Base bids for the SYSTEM SUPPLIER shall be as listed in the Contract Proposal. SYSTEM SUPPLIERs seeking ENGINEER approval shall have extensive experience in systems of similar size and complexity. Panel fabrication shop shall be a UL listed panel shop. Acceptance of alternates shall be made based on price, location of the fabrication shop, accessibility of personnel, PLC programming knowledge, and OWNER confidence. The SYSTEM SUPPLIER shall be subcontracted by and paid by the CONTRACTOR.
- B. The SYSTEM SUPPLIER shall meet all of the requirements of these specifications, and, unless specifically stated otherwise, no prior acceptance of any subsystem, equipment, or materials has been made.
- C. All equipment furnished by the SYSTEM SUPPLIER shall be of the latest and most recent design and shall have overall accuracy as guaranteed by the manufacturer.
- D. Materials and equipment used shall be U.L. approved wherever such approved equipment and materials are available.
- E. Component equipment shall be as supplied by one of the manufacturers named in the individual specification sections or approved equal. The

design of the PICS is based on the first-named manufacturer's equipment if there is a difference.

- F. To facilitate the OWNER's operation and maintenance, products shall be of the same major manufacturer, with panel mounted devices of the same type and model as far as possible.
- G. In order to insure the interchangeability of parts, the maintenance of quality, the ease of interfacing between the various subsystems, and the establishment of minimums with regard to ranges and accuracy, strict compliance with the above requirements shall be maintained.
- H. The SYSTEM SUPPLIER shall designate a single point of contact for interface with the ENGINEER on this project. The ENGINEER reserves the sole right to approve or reject this point of contact.
- I. The SYSTEM SUPPLIER's selected project personnel shall meet the following requirements:
 - 1. Project engineer shall have at least 10 years' experience in installing similar systems and shall have a minimum of secondary education in the field of electronics or similar technical discipline.
 - 2. Project technician assisting the project engineer for field element calibration and check out shall have at least five years experience in installing similar systems.
 - 3. Key staff resumes shall be submitted for ENGINEER's approval with the Project Plan as further detailed under submittals.
- J. Service Facility: The SYSTEM SUPPLIER shall have an established service facility from which qualified technical service personnel and parts may be dispatched upon call. Such a service facility shall be no more than six (6) hours travel time from the jobsite.
- K. The SYSTEM SUPPLIER shall provide experienced personnel on-site to coordinate and/or perform installation, termination, and adjustment; on-site testing; OWNER training; and startup assistance for the PICS.
- L. The SYSTEM SUPPLIER shall provide, on-site, an experienced project engineer to supervise and coordinate all of the on-site PICS activities. An experienced technician may be provided to assist the project engineer in field element installation, field calibration, and checkout tests. The SYSTEM SUPPLIER's project engineer shall be on-site during the period required to effect all of the critical on-site activities related to the PICS, particularly the software debugging, PICS training, and witnessed testing activities.

1.06. STANDARDS

- A. The design, testing, assembly, and methods of installation of the wiring materials, electrical equipment and accessories proposed under this Contract shall conform to the National Electrical Code and to applicable state and local requirements. UL listing and labeling shall be adhered to under this Contract.
- B. Any equipment that does not have a UL, FM CSA, or other approved testing laboratory label shall be furnished with a notarized letter signed by the supplier stating that the equipment furnished has been manufactured in accordance with the National Electric Code and OSHA requirements.
- C. Any additional work needed resulting from any deviation from codes or local requirements shall be at no additional cost to the OWNER.
- D. International Society of Automation (ISA) and National Electrical Manufacturers Association (NEMA) standards shall be used where applicable in the design of the PICS.
- E. All equipment used on this project to test and calibrate the installed equipment shall be in calibration at the time of use. Calibration shall be traceable to National Institute of Standards (NIS - formally NBS) calibration standards.
- F. For the purposes of uniformity and conformance to industry standard, provide analog signal transmission modes of electronic 4-20 ma DC. No other signal characteristics are acceptable.
- G. Discrete signals are two-state logic signals. Use 120V ac sources on all discrete signals unless otherwise noted or shown.
- H. Provide appropriately sized electrical transient protection devices for all electrical elements of the system as further defined in the individual specification sections. For field mounted devices, provide protector enclosures to the electrical Subcontractor for mounting and installation.

1.07. WARRANTY AND GUARANTEES

- A. In accordance with Division 1, the SYSTEM SUPPLIER shall furnish to the OWNER a written two year guarantee commencing with final acceptance, that all equipment and parts thereof, material and/or workmanship for the field elements, instruments, and control panels are of top quality and free from defects.
- B. The SYSTEM SUPPLIER shall guarantee all equipment whether or not of his own manufacture.

1.08. SPARES AND EXPENDABLES

- A. Obtain from the manufacturer(s) and provide the recommended critical spare parts as part of the work. Refer to the individual requirements listed in the associated specification sections for the PICS for specific parts to be provided as a minimum. The spare parts are the property of the OWNER.
- B. Obtain from the manufacturer(s) and furnish any special tools, calibration equipment and testing apparatus required for the proper adjustment and maintenance of the material provided.

PART 2 - PRODUCTS

THIS PART NOT USED

PART 3 - EXECUTION

3.01. SEQUENCE OF WORK

- A. Coordination Meetings: In order to ensure timely performance of the Contract and the system's conformance with these specifications, coordination meetings shall be held at the Engineers office located at 10620 Griffin Road, Suite 202, Cooper City, Florida 33328. The first meeting will be held 30 days after award of the Contract to the CONTRACTOR. The CONTRACTOR and SYSTEM SUPPLIER shall provide for their attendance at this meeting in their quotation. A schedule for additional coordination meetings (approximately one each month) will be derived at this initial meeting for periodic update, coordination, and conflict resolution during the project duration.
- B. Prerequisite Activities and Lead Times: Do not start the following key project activities until the listed prerequisite activities have been completed and lead times have been satisfied:
 - 1. Hardware Purchasing, Fabrication, and Assembly: Associated design related submittals completed (no exceptions, or approved as noted).
 - 2. Shipment: Completion and approval of all design related submittals.
 - 3. Startup: Operational Checkout Tests.
 - 4. OWNER Training: Owner training completed and O&M manuals delivered.

5. Demonstration Tests: Operational Check-out Tests, Startup, OWNER Training, and Demonstration Test Procedures must be complete. Give 4 weeks' notice prior to the planned test start date.
- C. Consoles, Panels, and Panel Mounted Equipment: Consoles, panels, and panel mounted equipment shall be assembled as far as possible at the SYSTEM SUPPLIER's shop. No work, other than correction of minor defects or minor transit damage, shall be done on the panels at the jobsite.

3.02. PAYMENTS

- A. General: All work provided under this Section and its associated Sections for the PICS shall be paid for in accordance with the approved payment Schedule of Values submitted by the CONTRACTOR. The approved Schedule of Values will be the basis for partial payment for work provided for the PICS.
- B. Partial Payment for Work Completed: The breakdown in the Schedule of Values allows for the partial payment of work completed for the PICS. Before partial payment is considered for approval, each specific activity must be completed.
- C. Substantial Completion: Substantial Completion for the project is as defined in the General Conditions. However, the following requirements must be fulfilled before consideration will be given for Substantial Completion of the PICS:
1. All PICS submittals have been completed.
 2. The PICS has successfully completed the Demonstration Tests.
 3. The required Owner training has been implemented.
 4. All spares, expendables, and test equipment have been received by OWNER.
- D. Final Acceptance: PICS final acceptance is defined as the date when the ENGINEER issues a written notice of final acceptance. For this Section, the following must have been completed before consideration will be given to the issuance of notice of final acceptance:
1. All punch-list items have been checked off.
 2. Revisions to the PICS O&M Manuals have been made (that may have resulted from the Demonstration Tests).

- E. Partial Payment Limits: The partial payments for work provided for the PICS shall satisfy the following limiting maximum criteria (percentages of the lump sum pay item for the PICS):
 - 1. Submittals (not including O&M Manuals) 15%
 - 2. Training 5%
 - 3. O&M Manuals 5%
 - 4. Demonstration Tests 10%

3.03. PRODUCT HANDLING

- A. Store and protect equipment until installation following the storage and handling instructions recommended by the equipment manufacturers. Place special emphasis on proper anti-static protection of sensitive equipment.
- B. Protection During Construction: Throughout this Contract, provide protection for materials and equipment against loss or damage and from the effects of weather. Prior to installation, store items in indoor, dry locations. Provide heating in storage areas for items subject to corrosion under damp conditions. Provide covers for panels and other elements that may be exposed to dusty construction environments. Specific storage requirements shall be in accordance with the SYSTEM SUPPLIER's recommendations.
- C. Corrosion Protection: Protect all consoles, panels, enclosures, and other equipment containing electrical or instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules. Prior to shipment, include capsules in the shipping containers, and equipment as recommended by the capsule manufacturer. During the construction period, periodically replace the capsules in accordance with the capsule manufacturer's recommendations. Replace all capsules just prior to Final Acceptance.
- D. ESD Protection: Provide for the proper handling, storage, and environmental conditions required for the PICS components deemed static sensitive by the equipment manufacturer. Utilize anti-stat wrist straps and matting during installation of these items to prevent component degradation. Flooring used in control areas shall be reviewed and approved by the SYSTEM SUPPLIER.
- E. Adequately pack manufactured material to prevent damage during shipping, handling, storage and erection. Pack all material shipped to the

project site in a container properly marked for identification. Use blocks and padding to prevent movement.

- F. Ship materials that must be handled with the aid of mechanical tools in wood-framed crates.
- G. Ship all materials to the project site with at least one layer of plastic wrapping or other approved means to make it weatherproof. Anti-stat protection shall be provided for all sensitive equipment.
- H. Inspect the material prior to removing it from the carrier. Do not unwrap equipment until it is ready to be installed. If any damage is observed, immediately notify the carrier so that a claim can be made. If no such notice is given, the material shall be assumed to be in undamaged condition, and any subsequent damage that is discovered shall be repaired and replaced at no additional expense to the OWNER.
- I. The CONTRACTOR shall be responsible for any damage charges resulting from the handling of the materials.

3.04. INSTALLATION

- A. Material and Equipment Installation: Install the PICS in locations indicated on the Drawings and follow manufacturers' installation instructions explicitly, unless otherwise indicated. Wherever any conflict arises between manufacturers' instruction and these Contract Documents, follow ENGINEER's decision, at no additional cost. Keep copy of manufacturers' instructions on the jobsite available for review at all times.
- B. Install materials and equipment in a workmanlike manner utilizing craftsmen skilled in the particular trade. Provide work which has a neat and finished appearance. Coordinate instrumentation and control work with the OWNER and work of other trades to avoid conflicts, errors, delays, and unnecessary interference with operation of the existing plant during construction.
- C. Provide finish on instruments and accessories that protects against corrosion by the elements in the environment in which they are to be installed. Finish both the interior and exterior of enclosures. Provide extra paint of each color used in the material from the manufacturer for touch-up purposes.
- D. Equipment Finish: Provide materials and equipment with manufacturer's standard finish system. Provide manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment with light gray color.

- E. Cleaning and Touch-up Painting: Keep the premises free from accumulation of waste material or rubbish. Upon completion of work, remove materials, scraps, and debris from premises and from interior and exterior of all devices and equipment. Touch-up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish. Clean and polish the exterior of all panels and enclosures upon the completion of the demonstration tests.
- F. Control Valves: Verify correctness of installation. Verify calibration and adjustment of all positioners and I/P transducers and verify correct control action. Verify position switch settings. Verify opening and closing speeds and travel stops.

3.05. 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. The SYSTEM SUPPLIER shall provide detailed manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.
- C. The SYSTEM SUPPLIER shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to OWNER.
- D. The training program shall represent a comprehensive program covering all aspects of the operation and maintenance of the system.
- E. 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.
- F. Specific details of the nature and duration of training to be provided are defined in the individual specification sections.

3.06. TESTING – GENERAL

- A. All elements of the PICS, both hardware and software, shall be tested to demonstrate that the total system satisfies all of the requirements of the Contract Documents
- B. As a minimum, the testing shall include shop tests, operational check-out tests, and Demonstration Tests.

- C. Each test shall be in the cause and effect format. The person conducting the test shall initiate an input (cause) and, upon the system producing the correct result (effect), the specific test requirements will have been satisfied.
- D. All tests shall be conducted in accordance with, and documented on, prior approved procedures, forms, and checklists. Each specific test to be performed shall be described and a space provided after it for signoff by the appropriate party after its satisfactory completion. Copies of these signoff test procedures, forms, and checklists will constitute the required test documentation.
- E. Provide all special testing materials and equipment. Wherever possible, perform tests using actual process variables, equipment, and data. Where it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation. Define these simulation techniques in the test procedures.
- F. The SYSTEM SUPPLIER shall coordinate all of their testing with the CONTRACTOR, the ENGINEER, all affected suppliers, and the OWNER.
- G. The ENGINEER reserves the right to test or retest any and all specified functions whether or not explicitly stated in the approved test procedures. The ENGINEER's decision shall be final regarding the acceptability and completeness of all testing.

3.07. OPERATIONAL READINESS TEST (ORT)

- A. Prior to startup and demonstration testing, certify that the entire installed PICS (inspected, tested and documented) is ready for operation. These inspections and tests shall include Loop/Component inspections and tests. Toward the end of these checkout tests, download the HMI software and test the system loop by loop to complete the PICS checkout tests. The SYSTEM SUPPLIER shall fully debug problems in the system as a whole. Final approval of control software will not be based on written descriptions of software functions alone, but on actual performance in the field.
- B. Check the entire PICS for proper installation, calibration and adjustment on a loop-by-loop and component-by-component basis to ensure that it is in conformance with related submittals and the PICS Specifications.
- C. The Loop/Component Inspections and Tests shall be implemented using approved forms and checklists. Example sheets are provided at the end of this Specification Section. These shall be developed by the SYSTEM SUPPLIER and submitted for approval.
- D. Maintain the Loop Status Reports and Component Calibration Sheets at the jobsite and make them available to the ENGINEER at any time.

- E. Witnessing: These inspections and tests do not require witnessing. However, the ENGINEER will review the Loop Status Sheets and Component Calibration Sheets and spot-check their entries periodically and upon completion of the Operational Check-out Tests. Correct any deficiencies found.
- F. Final Documentation: The completed reports and sheets shall be assembled in one document and submitted together with a completed Manufacturer's Check-Out Certification.

3.08. FIELD ACCEPTANCE TEST (FAT)

- A. Once the PICS has passed the ORT, the SYSTEM SUPPLIER shall perform a witnessed Field Acceptance Test (FAT) on the complete PICS. The FAT shall demonstrate that the PICS is operating and in compliance with the Contract requirements. Each specified function shall be demonstrated on a paragraph-by-paragraph, and site-by-site basis.
- B. Prior to the FAT, the entire installed PICS shall be certified in writing by the CONTRACTOR that it is ready for operation.
- C. The system shall operate for a continuous 100 hours without failure before this test will be considered successful.
- D. The FAT shall cover the entire PICS, including control functions, alarms, and status monitoring. Test procedures used for factory tests may be adopted for these tests if modified as required.

Loop Check-out Sheet

Project Name:	Owner's Project No. (if applicable):	Page of
Project Owner:	Regulatory Agency Project No. (if applicable):	
HDR Project No.:	Date:	

LEAK AND TERMINATION/CONTINUITY CHECKS

DESCRIPTION	FIELD					CONTROL CAB		
	LEAK CHECK ₍₁₎			TERM/CONT CHECK ₍₂₎		TERM/CONT CHECK ₍₂₎		
	Device Tag No.	Process Conn.	Signal Tube	Device Tag No.	Termination Ident.	Device Tag No.	Tag	Termination Ident.

1. Leak check for pneumatic signal tubing to be per ISA-PR7.1.
2. Termination/continuity check includes check at terminated equipment for: (a) correct polarity, (b) appropriate signal generation, transmission and reception, and (c) correct shield & ground terminations.

OPERATOR INTERFACE CHECK-OUT

MONITORING POINTS OBSERVED

PARAMETER TYPE	TAG NO.	TAG NO.	TAG NO.	TAG NO.	TAG NO.	TAG NO.
PROCESS VAR						
EQUIP STATUS						
ALARM POINT						

OPERATOR CONTROL FUNCTIONS CHECKED

FUNCTION TYPE	TAG NO.	LOCATION	TAG NO.	LOCATION	TAG NO.	LOCATION

AS LEFT SETTINGS

TAG NO.	SWITCH & ALARM SP	CONTROLLERS			
		Gain	Reset, rpm	Deriv. (rate), min	PV Set Point

Describe all interlocks checked, equipment started/stopped, valves/operators stroked. Describe modes of operation checked, and location of operator interface (local/remote).

I certify that the control loop referenced on this page has been completely checked and functions in accordance with applicable drawings and specifications.

Certified by: _____ Date: _____

Instrument Calibration Sheet

Project Name:	Owner's Project No. (if applicable):
Project Owner:	Regulatory Agency Project No. (if applicable):
HDR Project No.:	Date:
Control Loop No.:	

Instrument Tag No.	Transmitter/gauge span:
Manufacturer:	Switch set-point:
Model No.	Switch dead band:
Serial No.	Switch range:

TRANSMITTERS AND INDICATORS

% OF SPAN	INCREASING INPUT			DECREASING INPUT		
	INPUT	OUTPUT	ERROR (% of span)	INPUT	OUTPUT	ERROR (% of span)
0%						
25%						
50%						
75%						
100%						
Other (if applicable)						
Other (if applicable)						

SWITCHES

ACTUATION POINT	INCREASING INPUT			DECREASING INPUT		
	INPUT	OUTPUT	ERROR (% of range)	INPUT	OUTPUT	ERROR (% of range)
High (Increasing input)						
Low (Decreasing input)						

Maximum allowable error (per Contract Documents):

Remarks:

CALIBRATION EQUIPMENT UTILIZED

DEVICE TYPE	MFR/MODEL NO.	ACCURACY	NIST TRACEABILITY?

Certified by: _____

Date Certified: _____

END OF SECTION

SECTION 13310
PROCESS INSTRUMENTATION AND CONTROL SYSTEM
FIELD INSTRUMENTS

PART 1 - GENERAL

1.01. SCOPE OF WORK

- A. This Specification Section covers work related to the various field instruments to be supplied with the Process Instrumentation and Control System (PICS).
- B. Field instrumentation, as specified herein, shall be furnished by the same SYSTEM SUPPLIER furnishing services and equipment as outlined in 13300.

1.02. RELATED WORK

- A. Specification Section 13300 defines work associated with the overall PICS.
- B. Specification Section 13315 defines work associated with control panels and enclosures housing the various elements of the PICS.
- C. Specification Section 13325 defines work associated with the Programmable Logic Controllers (PLCs) that will interface the system with the field instruments defined hereunder.
- D. Physical Installation of field instruments is performed under Division 15, Mechanical.
- E. Provision of all field and power wiring except manufacturer-supplied cables and installation of all such wiring is performed under Division 16, Electrical.

1.03. SUBMITTALS

- A. Submit the following Field Instrumentation Shop Drawings in a single package:
 - 1. Catalog information, descriptive literature, wiring diagrams, and shop drawings on all components of the field instruments, including all miscellaneous electrical and mechanical devices furnished under this section.
 - 2. Individual data sheets for all components of the field instruments to supplement the above information by citing all specific features for

each specific component (e.g. scale range, materials of construction, special options included, etc.). Each component data sheet shall bear the component name and instrument tag number designation shown in the Drawings and Specifications.

3. Installation details for all field mounted devices to show conformance with the Contract Documents.
4. Configuration documentation for all programmable devices to indicate actual settings used to set the device scale, range, trip points, and other control parameters.
5. Proposed tag numbers for each specific instrument.

PART 2 - PRODUCTS

2.01. GENERAL REQUIREMENTS

- A. Equipment to be installed in a hazardous area shall meet Class, Group, and Division classification as shown on the Contract Electrical Drawings, or comply with the local or National Electrical Code, whichever is the most stringent requirement.
- B. All instruments requiring plumbing shall utilize stainless steel components as follows:
 1. Test Tap: Shall consist of Crawford Fitting Co. Swagelock quick connects Series QC4-DE, or equal.
 2. Tubing, Stainless Steel: Shall be ASTM A 312, TP 316, seamless, soft annealed with 0.065 inch wall. Fittings shall be ASTM A 276, TP 316 compression or socket weld type.
 3. Valve, Ball: Shall be stainless steel ball valves, Whitey Series 40, Hoke Flamite Series 7100, or equal.
- C. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks.
- D. All transmitters shall be provided with either integral indicators or conduit mounted indicators in process units, accurate to two percent. Indicator readouts shall be linear in process units.
- E. Electronic equipment shall utilize printed circuitry suitably coated to prevent contamination by dust, moisture and fungus. Solid-state components shall

be conservatively rated for their purpose, to assure optimum long-term performance and dependability over ambient atmosphere fluctuations and 0 to 100 percent relative humidity. The field mounted equipment and system components shall be designed for installation in dusty, humid, and slightly corrosive service conditions.

2.02. LIGHTNING/SURGE PROTECTION

- A. Surge suppressors and arrestors meeting the requirements of IEEE/ANSI Standard C-62.41 (latest revision) shall be provided on all electronic field instruments.
- B. AC Powered Instruments. Lightning and surge protection shall be provided on both the AC power supply and signal lines. The instrument, a breaker and the surge suppressor shall be mounted on a ½-inch aluminum plate equipped with 1/8 inch sun shields on top and both sides with front panel facing north wherever practical. The mounting plate shall be connected to a ground rod via a #10 gauge wire. The protectors shall meet the following criteria:
 - 1. NEMA 4X small case.
 - 2. Response time of less than five nanoseconds.
 - 3. AC Power protection: IEEE/ANSI Std. C-62.41 rated C3 at 330 Volts clamping level.
 - 4. Signal line protection: 10,000 Amp 8 x 20 microsecond surge, clamped at 36 Volts clamping level.
 - 5. Test jacks for low level signal monitoring.
 - 6. Manufacturer/model: EDCO SLAC series or approved equal.
- C. Loop Powered Instruments. Lightning and surge protection shall be provided on the 4-20 mA DC signal line. The protectors shall meet the following criteria:
 - 1. Encapsulated in Stainless Steel Pipe nipples for in-line conduit mounting.
 - 2. Response time of less than one nanosecond.
 - 3. Capable of withstanding up to 400 occurrences of 500 Amps at 10 x 1 millisecond.

4. Series resistance of 5 ohms per line.
5. Protection of both lines plus shield
6. Manufacturer/model: EDCO SS65 or approved equal

2.03. FIELD INSTRUMENTS

A. Pressure Switch. The pressure switch shall sense pressure variations by means of a 316 stainless steel bourdon tube and operate a hermetically sealed mercury switch when the pressure reaches an adjustable level. Pressure switches shall be equipped with diaphragm seals where shown on the drawings.

1. Performance:
 - a. Adjustable deadband (40 psig minimum) over 0-100 psig measurement range.
 - b. Automatic reset.
 - c. SPDT contacts.
 - d. Setpoint and deadband adjustments visible from outside the enclosure.
2. Materials:
 - a. Pressure Chamber Wetted parts – 316 Stainless Steel.
 - b. Housing – Flanged steel.
3. Ratings:
 - a. NEMA 4X.
4. Electrical:
 - a. Contacts rated 4 Amps at 120 V AC.
5. Manufacturer, Model series:
 - a. Mercoid, DAW-43-153-6E.
 - b. Approved equal.

- B. Pressure Transducer. The pressure transducer shall sense variations in pressure and produce a standard current output signal linear with gage pressure (Pressure Indicating Transmitter, PIT), differential pressure (Differential Pressure Indicating Transmitter, DPIT), flow via square root extraction of differential (Flow Indicating Transmitter, FIT) or, via inference, level (Level Indicating Transmitter, LIT). The transducer shall use a diaphragm activated cell method to monitor process pressure via impulse piping connected through a valve manifold and, where noted, diaphragm seals.
1. Performance:
 - a. Total accuracy of less than or equal to 0.2% of span for +/- 50 degree temperature changes from 1:1 to 10:1 range down.
 - b. Adjustable zero and span values anywhere within the nominal range.
 - c. Differential transducers shall provide direct reading or integral square-root extraction.
 2. Materials:
 - a. Metallic Wetted parts – 316 Stainless Steel.
 - b. Wetted O-rings – Glass filled TFE.
 - c. Fill liquid - NSF approved for use in drinking water applications.
 - d. Electronics Housing – Low copper aluminum with polyurethane paint.
 - e. Mounting hardware – 316 Stainless Steel.
 3. Ratings:
 - a. Enclosure – NEMA 4X
 4. Electrical:
 - a. Transmitter excitation: 10.5 to 32 Volts DC at up to 18 mA.
 5. Options:

- a. Provide surge/lightning protection within the transmitter.
 - b. Provide 3-way SS valve manifold.
 - c. Provide integral LCD indicator with displayed value in process units.
 - d. Provide minimum half inch process connection.
6. Manufacturer, Model series:
- a. Rosemount, 3051 series.
 - b. Endress & Hauser, CerebarS series.
 - c. Siemens, Sitrans P series.
 - d. Approved equal.

2.04. PRESSURE MONITORING PANEL

- A. The panel shall meet the general panel requirements defined in Specification Section 13315 and furnished complete such that, following installation, it is only necessary to connect it to the sensing taps.
- B. The plant discharge pressure transducer specified in paragraph 2.03 shall be plumbed within the enclosure to a manifold with a 3-1/2" pressure gauge, shutoff and bleed needle valves having 1/4" female external bulkhead pressure connections in the bottom of the enclosure.
- C. The required standby pressure switches specified in paragraph 2.03 shall be installed in this enclosure and connected to a second manifold.
- D. Each instrument shall be equipped with a shut-off valve and a bleed valve.
- E. All tubing and valving within the panel shall be 304 stainless steel and meet the requirements in paragraph 2.01.

PART 3 - EXECUTION

3.01. INSTALLATION

- A. Install the PICS field instruments in strict accordance with the respective manufacturer's instructions and recommendations, in locations as shown on the Drawings, and as indicated on the installation details of the Drawings.

- B. Fully calibrate each instrument.
- C. Provide surge protection enclosures to the electrical sub-contractor for mounting and installation. The enclosures shall be fully wired internally. Coordinate grounding requirements with Division 16, Electrical.

3.02. TRAINING

- A. On-site (field) training shall be conducted at the OWNER's plant site and shall provide detailed hands-on instruction to OWNER's personnel covering all supplied field instruments.
- B. Training shall include:
 - 1. calibration procedures.
 - 2. preventive maintenance methods and timing.
 - 3. fault-finding techniques.

END OF SECTION

SECTION 13315
PROCESS INSTRUMENTATION AND CONTROL SYSTEM
CONTROL PANELS

PART 1 - GENERAL

1.01. SCOPE OF WORK

- A. This Specification Section covers work related to the control panels and enclosures to be supplied with the Process Instrumentation and Control System (PICS).
- B. The control panels, as specified herein, shall be furnished by the same SYSTEM SUPPLIER furnishing services and equipment as defined under Specification Section 13300.
- C. The SYSTEM SUPPLIER shall design, furnish and install all interior wiring within the control panels and furnish complete wiring diagrams showing the electrical circuits inside the panel and interconnections between the panel and the external instruments and components.
- D. Size control panel(s) to adequately dissipate heat generated by equipment mounted inside or on the panel front face.

1.02. RELATED WORK

- A. Specification Section 13300 defines work associated with the overall PICS,
- B. Programmable Logic Controllers (PLC) are to be mounted in control panels hereunder. PLC are defined in Specification Section 13325.
- C. The panels defined hereunder are installed under Division 15, Mechanical.

1.03. SUBMITTALS

- A. Submit the following control panel shop drawings in a single package:
 - 1. Layout diagrams for all control panels and enclosures. Include panel elevations (front, side, interior), and sizing. Panel front elevations shall be of sufficient scale to allow all engraved nameplates and inscriptions to be legible without the use of schedules.
 - 2. A complete Bill of Materials for each panel cross-referenced to the panel layout drawings and identifying the manufacturer and complete part number of all components.

3. Wiring diagrams for all control panels. Diagrams shall be complete electrical wiring diagrams showing all components and all auxiliary devices such as relays, alarms, fuses, lights, fans, heaters, etc. All wires and terminals shall be numbered on the diagrams, and line cross-references shall be labeled. Include wiring interface to the PLCs where applicable. Include on these drawings a tag number to identify each component and referenced to a component identification list.
4. Data sheets for all components. The data sheets shall be marked to indicate those portions applicable to the components to be furnished.
5. Power requirements and heat dissipation summary for all control panels. Power requirements shall state required voltages, currents, and phase(s). Heat dissipations shall be maximums and shall be given in Btu/hr. The summary shall be supplemented with calculations.

PART 2 - PRODUCTS

2.01. GENERAL REQUIREMENTS

- A. Equipment to be installed in a hazardous area shall meet Class, Group, and Division classification as shown on the Contract Electrical Drawings, or comply with the local or National Electrical Code, whichever is the most stringent requirement.
- B. Electronic equipment shall utilize printed circuitry suitably coated to prevent contamination by dust, moisture and fungus. Solid-state components shall be conservatively rated for their purpose, to assure optimum long-term performance and dependability over ambient atmosphere fluctuations and 0 to 100 percent relative humidity. The field mounted equipment and system components shall be designed for installation in dusty, humid, and slightly corrosive service conditions.
- C. All equipment shall be designed to operate on a 60-Hertz alternating current power source at a normal 120 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.
- D. All equipment, cabinets and devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system

shall contain products of a single MANUFACTURER, insofar as possible, and shall consist of equipment models which are currently in production.

- E. The equipment furnished shall be designed to operate satisfactorily between 0 degrees C and 40 degrees C at up to 95 percent Relative Humidity (non condensing).
- F. All outdoor panels and enclosures containing electronic or electrical components shall be equipped with sunshields on both sides, the back and the top with a minimum separation of one inch and a maximum separation of one and one-half inches. Sun shields shall be 14 gauge Stainless Steel or 12 gauge Anodized Aluminum or thicker. Finish with reflective white, two part epoxy coating or reflective, white, polyester powder deposited coating.
- G. All outdoor control panels and enclosures shall be equipped with 3 ½" stainless steel mounting uni-struts across the width of the back. For free-standing panels the struts shall be located half-way up the panel and six inches from the top. For other panels they shall be located 3" from the top and 3" from the bottom.
- H. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 volts-amperes (VA), unless specifically noted otherwise.
- I. All equipment shall be designed and constructed so that in the event of a power interruption, the equipment specified hereunder shall resume normal operation without manual resetting when power is restored.
- J. All discrete inputs entering the panel shall be wetted by 120 VAC. Provide isolation relays if necessary to accommodate this requirement.
- K. All discrete output signals shall be equipped with interposing relays to electrically isolate them from the control system I/O.

2.02. LIGHTNING/SURGE SUPPRESSION

- A. Surge suppressors and arrestors meeting the requirements of ANSI Standard C-62.41 (latest revision) shall be provided as further detailed below.
- B. DC Signals. Lightning and surge protection shall be provided on all discrete and 4-20 mA signal wires entering or leaving the panel. The protectors shall meet the following criteria:
 - 1. 35 mm DIN rail mounted with spring terminals.
 - 2. Response time of less than one nanosecond.

3. Operating signal current: up to 0.5 A
 4. Capable of withstanding 5,000 Amps at IEEE/ANSI C-62.41 8 x 20 microseconds combination wave.
 5. Nominal series resistance of less than 2 ohms each leg
 6. Manufacturer/model:
 - a. Dehn DCO RK ME
 - b. Approved equal.
- C. AC Signals. Lightning and surge protectors for all incoming discrete signals and single phase AC power supply lines up to 15 Amps service shall meet the following criteria:
1. Serial protection.
 2. Failure indicator
 3. Response time of less than five nanoseconds.
 4. Capable of withstanding up to 10,000 Amps at IEEE/ANSI C-62.41 8 x 20 microseconds combination wave.
 5. Manufacturer/model:
 - a. Dehn DG S 150
 - b. Approved equal.
- D. Single phase AC Power (over 15Amps). Lightning and surge protectors for AC power supply lines over 15 Amps service shall meet the following criteria:
1. Parallel protection using MOVs and thermal fusing technology.
 2. Failure indicator
 3. Response time of less than five nanoseconds.
 4. Capable of withstanding up to 6,500 Amps at IEEE/ANSI C-62.41 8 x 20 microseconds combination wave.
 5. Manufacturer/model:

- a. EDCO FAS-120AC
- b. Approved equal.

2.03. BACKUP CONTROL PANEL (PCP-2)

- A. Provide relay logic within PCP-2 that provides for backup operation of the high service pumps as described herein and shown in the Contract Drawings. Refer to sheet E-5 for the required logic.
- B. The intent is to continue high service pumping in the event of a PLC or distribution pressure transducer failure.
- C. In the event of backup operation being called for, pressure switches located in the Pressure Monitoring Panel shall start and stop the pumps. The pumps' VFD shall also be commanded by the backup logic to run at a preset speed.
- D. Hard-wired controls shall utilize a different incoming power source and Uninterruptible Power Supply from that of the rest of the control system.
- E. Back up control shall be latched until reset through a front-panel mounted pushbutton or through an operator controlled PLC output.

2.04. CONTROL PANELS AND ENCLOSURES

- A. Finish:
 - 1. All front panel openings for panel-mounted equipment shall be cut with counter-boring and provided with trim strips as required to give a neat finished appearance.
 - 2. With the exception of stainless steel panels, all steel panel surfaces shall be treated with phosphatized treatment inside and out, and then finished on the exterior with two coats of baked enamel of the approved color. Interiors of panels shall be white, ANSI No. 51.
 - 3. Stainless steel panels shall be No. 7 polished, 316 stainless steel.
- B. Doors:
 - 1. All control panels shall have a continuous piano hinge door for ease of access. A minimum of 80% of the panel interior shall be exposed by doors.

2. NEMA 4X rated panel door openings shall be sealed and fully gasketed.
 3. The inside of each door shall be equipped with a print pocket. Provide individually laminated 11x17 sheets for all wiring diagrams.
 4. Two-door enclosures shall have a removable center post.
 5. Sealed panel doors shall be equipped with quick-release latches.
 6. NEMA 1 rated panel doors shall be equipped with a three-point latching mechanism.
 7. Where noted or shown on the drawings, doors shall be equipped with a fully gasketed glass window to allow viewing of internally mounted devices without opening the door.
- C. All components and terminals shall be accessible without removing other components except for covers.
- D. All conduit entry shall be from the top only.
- E. No components shall be mounted on the interior sides of any panel.
- F. All panels shall be provided with an isolated copper grounding bus to ground all signal shield connections.
- G. Control Panels containing PICS control system equipment shall each be equipped with an internal, hand-switch controlled, LED light and 120V, 15 amp, duplex utility receptacle.
- H. All panels shall be provided with laminated as built electrical wiring diagrams in each panel.
- I. Nameplates:
1. All front-face panel mounted controls and indicators shall be equipped with 10-year outdoor-rated adhesive laminated plastic nameplates to completely define their use. Provide Brady Type BBP31 or BBP33 as applicable or approved equal.
 2. All internal components shall be equipped with identification tags
 3. Each wire shall be uniquely identified and shall be labeled.
- J. Power Supplies.

1. Uninterruptible power supplies (UPS) shall be provided in all control panels as follows:
 - a. Size the supplies for all internal equipment plus an additional 20% spare capacity.
 - b. Provide 15 minutes battery back-up capability at full load.
 - c. Provide relay option card for indication of "On UPS Power" and "Low Battery Level".
 - d. For outdoor panels provide an UPS and battery rated for operation at up to 50 degrees C.
2. Provide two diode-auctioneered DC power supplies for analog signal use.
3. Provide individually fused DC power for field transmitters.

K. Electrical:

1. Main circuit breaker and branch circuit breaker for each branch circuit as required to distribute power from the main power feed.
2. All breakers accessible when the panel door is open.
3. No more than 20 devices on any single circuit.
4. No more than 12 amps for any branch circuit.
5. Panel (or site) lighting, receptacles, heaters, controls, telemetry and fans on separate branch circuits.

L. Wiring:

1. Power wiring shall be 300 volt, type THWN stranded copper, No. 14 AWG size, for 120V service.
2. Discrete wiring shall be 300-volt type THWN stranded copper, sized for the current carried, but not smaller than No. 16 AWG.
3. Analog signal wiring shall be 300 volt, stranded copper in twisted shield pairs, no smaller than No. 16 AWG.
4. Panel wiring shall be routed within wire troughs or panduits.

5. Hinge wiring shall be secured at each end with the bend portion protected by a plastic sleeve.
6. Analog or dc wiring shall be separated from any ac power or control wiring by at least six inches.
7. Terminal blocks shall be provided for all field wiring entering the panel. The greater of ten 10 spare terminal blocks shall be provided.
8. No more than one wire per screw and yoke termination.

M. Construction:

1. Minimum metal thickness: 14-gauge.
2. Stiffeners as required to prevent deflection under instrument loading and permit lifting without racking or distortion.
3. When required, removable lifting rings and fill plugs to replace rings after installation.

N. Miscellaneous Equipment:

1. All panels shall be protected from internal corrosion by the use of corrosion – inhibiting vapor capsules, Northern Instruments Model Zerust VC, Hoffman, model A-HCI, or equal.
2. All sealed panels shall be equipped with combination drain/breathers, Crouse-Hinds model ECD18; or equal.
3. When noted on drawings, panels shall be equipped with thermostatically controlled space heaters to maintain internal temperatures above dew point.

O. All panels shall be manufactured items, Hoffman Engineering, or equal.

2.05. FRONT PANEL DEVICES

A. Potentiometer. Units shall meet the following:

1. Three-terminal potentiometers with a total resistance of 1000 ohms and a power dissipation rating of 2 watts
2. Oil-tight construction, rated NEMA 13
3. Resolution of 1 percent, and linearity of plus or minus 5 percent.

4. Panel mounting accommodating panel thickness between 1/16 to ¼ inch.
 5. Legend plates with marking as noted.
 6. Allen-Bradley, type 800T, or equal.
- B. Selector Switch. Units shall meet the following:
1. Heavy-duty, oil-tight, industrial type selector switches rated for NEMA 4 service.
 2. Contacts rated for 120-volt ac service at 10 amperes continuous.
 3. Number of positions and contact arrangements as required.
 4. Factory-engraved legend plate indicating position definition.
 5. Panel mounting accommodating panel thickness between 1/16 to ¼ inch.
 6. Black knob type operator.
 7. Square D Class 9001, Type K; Allen-Bradley type 800T, or equal.
- C. Pushbutton. Units shall meet the following:
1. Heavy-duty, oil-tight, industrial type push buttons rated for NEMA 4 service.
 2. Contacts rated for 120-volt ac service at 10 amperes continuous.
 3. Number of positions and contact arrangements as required.
 4. Factory-engraved legend plate indicating function.
 5. Panel mounting accommodating panel thickness between 1/16 to ¼ inch.
 6. Operator: Red extended head for STOP, green flush head for START, black flush head for other functions.
 7. Square D Class 9001, Type K; Allen-Bradley type 800T, or equal.
- D. Indicating Light. Units shall meet the following:

1. Heavy-duty, oil-tight, push-to-test industrial type with integral transformer for 120V AC application.
2. Rated for NEMA 4 service.
3. Screwed on flat-faced lenses in colors shown on the drawings.
4. Factory-engraved legend plates.
5. Square D type K, Allen-Bradley Type 800T, or approved equal.

2.06. INTERNAL PANEL COMPONENTS

A. Control/Interposing Relays: All relays shall meet the following:

1. Compact, general-purpose, plug-in type.
2. Socket mounted.
3. Contacts rated for not less than 10 amperes at 120V.
4. Equipped with neon status lights and test buttons.
5. Permanent, legible identification
6. Potter & Brumfield series KRPA or approved equal.

B. Time Delay Relay. Time delay relays shall meet the following:

1. Available functions: On delay, Off delay, or one shot.
2. Socket mounted.
3. Knob adjustment.
4. Contacts rated for not less than 10 amperes at 120V.
5. Timing range as appropriate for the application.
6. Magnecraft series W211 or approved equal.

C. Terminal Blocks. Terminal blocks shall meet the following requirements:

1. Terminals capable of accepting 10-26 AWG wire.
2. DIN-rail mounting.

3. Connectors shall be either copper or steel. Use of aluminum connectors shall not be permitted without prior approval of the Engineer
4. Phoenix Contact or approved equal.

2.07. SPARES AND EXPENDABLES

- A. Provide the following spare parts:
 1. Five (5) spare relays of each type provided.
 2. Two (2) spare surge suppressors of each type provided
 3. Five (5) spare fuses of each type and rating supplied.
 4. Five (5) spare indicator light bulbs of each type and color supplied.

PART 3 - EXECUTION

3.01. INSTALLATION

- A. Control Panels shall be installed at the locations indicated on the Contract Drawings.
- B. Control panels shall be provided to the mechanical subcontractor for installation.
- C. Verify the correct installation of all panels supplied under this Specification Section.

END OF SECTION

SECTION 13320
PROCESS INSTRUMENTATION AND CONTROL SYSTEM
HUMAN-MACHINE INTERFACE (HMI) SYSTEM REQUIREMENTS

PART 1 - GENERAL

1.01. SCOPE OF WORK

- A. The overall system general requirements are given in this section. These requirements apply to each additional section of these specifications as noted herein and as specified in the associated sections.
- B. This Specification Section defines requirements associated with the HMI system.
- C. The Work defined herein shall be performed by the SYSTEM SUPPLIER defined in Specification Section 13300.

1.02. RELATED WORK

- A. Specification Section 13300 defines general requirements applicable to the Work defined herein.
- B. Specification Section 13325 defines requirements for the PLC through which the HMI interfaces with field equipment and instruments.

1.03. SUBMITTALS

- A. Submit an HMI system shop drawing package that includes the following:
 - 1. Block Diagram: A detailed system block diagram showing all major components. Identify components by model number. Show interconnecting cables diagrammatically (by type and size).
 - 2. Bill of Materials: A list of all components, including all software and grouped by type. The list shall indicate component model number and part number, component description, quantity supplied, and reference to component catalog information.
 - 3. Descriptive Information: Catalog information, descriptive literature, performance specifications, internal wiring diagrams, power and grounding requirements, power consumption, and heat dissipation of all elements. Clearly mark all options and features proposed for this project.

4. Installation Details. Equipment installation drawings showing external dimensions, enclosure material and spacing, mounting connections, and installation requirements.
5. A list of, and descriptive literature for, spares, expendables, and test equipment.

PART 2 - PRODUCTS

2.01. HMI SYSTEM HARDWARE

- A. Workstation/Server. The system workstations shall meet the following minimum requirements:
 1. Mid-Tower.
 2. Intel four core Xeon Processor at 3.5 GHz.
 3. 16GB RDIMM memory.
 4. 1 TB SATA hard drive.
 5. 1 GB NVIDIA graphics card.
 6. 24-inch Ultrasharp wide screen monitor. Dell U2415 or approved equal.
 7. Equipped with the following software:
 - a. Windows 10 Professional 64 bit operating system.
 - b. Microsoft Office Professional 2016.
 - c. Application software as defined in paragraph 2.02 herein.
 8. Dell PowerEdge T5810 or approved equal.
 9. Provide a 500VA Uninterruptible Power Supply for the Workstation.
- B. System Interface Panel (SIP). Provide a wall-mounted NEMA 12 steel enclosure powered by the workstation UPS and containing the following components:
 1. A mixed media Ethernet Switch. The switch shall interconnect the HMI system components with the rest of the PICS. It shall be

provided with a minimum of six copper and two fiber ports and meet the following requirements:

- a. Operating Temperature: Up to 80 degrees C.
 - b. Power Supply – Dual redundant 10-49 Volts DC inputs.
 - c. Surge protection on all ports and power inputs.
 - d. Manufacturer/model: N-Tron or Approved equal.
2. A fiber optic patch panel sized to accommodate the incoming cable from the Process Control Panel. The patch panel shall meet the requirements set forth in Specification Section 13360, paragraph 2.02.
 3. Miscellaneous power distribution and conversion equipment as necessary for all components within the panel.
- C. Laser Printer. Provide an Ethernet capable color laser printer that meets the following requirements:
1. 28 ppm print speed (black)
 2. 600 x 600 dpi resolution
 3. 250 sheet paper tray
 4. Memory: 256 MB NAND Flash, 128 MB DRAM
 5. HP Color LaserJet Pro M452dn or approved equal.

2.02. HMI SYSTEM APPLICATION SOFTWARE

- A. SCADA software shall be commercially available off-the shelf and shall be non-proprietary.
- B. Software shall be a Client/Server architecture. No Microsoft Client Access Licenses (CAL) shall be required for full installation (thick) or browser-based (thin) clients. Terminal Services shall not be required.
- C. Software shall be compatible with commercially available, off-the shelf PC hardware running 32 and 64 bit Microsoft Windows client and server operating systems currently available at the time of installation.

- D. Software shall not require dedicated server-level PC hardware for any individual system components.
- E. Software shall support any computer running a thick copy of the software performing as both an application server and a user interface. Software shall support automatic server failover to an unlimited number of servers.
- F. Software shall include the following integrated components. These components shall not require separate software to be installed.
- G. I/O drivers for common industry-standard protocols
- H. Alarms management and alarms history
- I. Historian
- J. Real-time and historical data trend creation
- K. Report generation
- L. Application backup and version control
- M. Security management
- N. Support for networked applications
- O. Support for server redundancy
- P. An object oriented scripting language with debugging tools
- Q. The software manufacturer shall offer, at a minimum, the following optional components.
 - 1. Browser-based thin clients for PCs and Mobile devices
 - 2. Alarm notification (email, text message and voice.)
 - 3. Interfaces for 3rd party software programs to access data (real-time and historical) and alarms. Such interfaces may include OPC, ODBC and SNMP.
- R. Software shall compensate for deploying the same application simultaneously on a variety of monitor resolutions, while maintaining the aspect ratios of all displays.
- S. Software shall support an automatic, orderly shutdown when switching to UPS backup power and power levels drop to a predefined setpoint.

Software shall support automatically restart to full operation without user intervention.

- T. Software shall provide a mechanism to backup and restore the entire application configuration.
- U. Software shall include an integrated security system supporting an unlimited number of user accounts, roles and privileges. System users with appropriate account privileges shall be capable of changing the application configuration without requiring the software supplier's assistance. No lockout mechanisms or passwords shall be withheld from the final customer.
- V. Integrated software help manuals shall be provided to assist operators and maintenance personnel with operational and configuration tasks.
- W. Provide VTScada or functionally equivalent suite Factory Talk software.

PART 3 - EXECUTION

3.01. INSTALLATION

- A. Install the HMI system at the locations shown on the Contract Drawings.

END OF SECTION

SECTION 13321
PROCESS INSTRUMENTATION AND CONTROL SYSTEM
HMI PROGRAMMING

PART 1 - GENERAL

1.01. SCOPE OF WORK

- A. This section defines requirements associated with programming the HMI application software.
- B. The Work specified herein shall be performed by the SYSTEM SUPPLIER defined in Specification Section 13300.

1.02. RELATED WORK

- A. Specification Section 13300: General Requirements.
- B. Specification Section 13320: HMI Subsystem Hardware and Software.

1.03. SUBMITTALS

- A. Submit an HMI programming package. The submittal shall include the following:
 - 1. A listing of all process graphic screens to be provided. Graphics shall be 3D and represent actual field layout of equipment.
 - 2. A written description of how the operator will interface with the process graphic screens to effect control actions or process parameter modifications. Support the description with samples of the graphics or pop-up windows to be used.
 - 3. An example screen illustrating the proposed operator interface with the historical database.
 - 4. An example screen illustrating the proposed operator interface with the alarm/event database.
 - 5. An example screen illustrating the proposed trending displays.
 - 6. A list of proposed trends and associated parameters.
 - 7. Examples of proposed reports and associated parameters.

8. A list of proposed alarm call-out messages.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01. GRAPHIC STANDARDS

- A. All operator graphic screens shall include an alarm list at the bottom indicating the most recent alarms colored as defined below under color standards and, at the top, tabs to allow the user to switch to key graphics including the process overview and the alarm list.
- B. All graphic screens shall, as closely as possible, depict the actual process equipment in three dimensional symbols with fill color depicting current status in accordance with the graphic standards defined below.
- C. For detailed process graphics where the process is continued on or continued from another graphic, software pushbuttons shall be provided to lead to the appropriate other graphic.
- D. The following colors shall be used:
 1. Light Grey – Screen background.
 2. Dark Blue – Piping.
 3. Light Magenta - Chemical injection points.
 4. Bright Green – Running equipment or open valve. Modulating valves shall have the current percentage open in text adjacent to the symbol.
 5. Bright Green Flashing – Equipment starting or valve opening.
 6. Red– Stopped equipment or closed valve.
 7. Red Flashing – Equipment stopping or valve closing.
 8. Yellow – Equipment with an acknowledged, but not yet cleared alarm.
 9. Yellow Flashing – Equipment with an unacknowledged alarm.
- E. Operator Actions. Operator control of equipment (e.g. start, stop, change of HMI H/O/A switch, set point adjustment, etc.) shall be accomplished by

right-clicking on the appropriate graphic symbol which shall cause a pop-up window to appear providing the operator with the available options.

- F. All adjustable values shall be changeable by the operator via the graphic screens.
- G. Provide the following general monitoring functions for analog inputs:
 - 1. For all analog inputs:
 - a. Indicate in black text the current value adjacent to the symbol on the graphic.
 - b. Provide individually adjustable emergency high and low alarms when the value goes outside the allowable process range.
 - c. Provide individually adjustable high and low alarms when the value goes outside the normal process operating range.
 - d. Provide a dead-band on all alarm settings.
 - 2. For all level signals:
 - a. Color fill the symbol for the tank or vessel proportionally to indicate the amount contained.
 - b. Indicate in text the volume contained.
- H. Equipment Status. Color the symbol for each piece of equipment to reflect its current status (e.g. running, stopped, failed, etc.) in accordance with the graphic standards.
- I. Equipment Control Status. Adjacent to each piece of equipment indicate its control status, where such is available, as follows:
 - 1. Local Hardware Hand/Off/Auto switch position in context sensitive text: Hand red, Off – black, Auto – green.
 - 2. HMI software Hand/Off/Auto switch position in context sensitive text labeled “HMI”: Hand red, Off – black, Auto – green.
- J. Set points. Indicate the current value of all set points adjacent to the associated process value. All set points shall be operator adjustable via the process graphics.

3.02. GRAPHICS

- A. Provide the following graphic screens, as further detailed below:
1. Plant Overview. No control shall be provided directly from this screen unless through pop-up windows. The screen shall indicate the following:
 - a. Raw water well status.
 - b. GST tank level through fill color and text.
 - c. Current GST volume in text.
 - d. Current GST levels for well calls.
 - e. HS pump status and speed.
 - f. Discharge pressure and HSP set point.
 - g. HSP back-up control status (Normal or Back-up),
 - h. Discharge flow.
 - i. Discharge chlorine residual and pH.
 - j. Chemical feed points (active or off) through, respectively, filled or non-filled feed lines.
- B. Raw Water Wells. Provide operator control of strategy parameters from this screen. Indicate the following:
1. Raw water well status.
 2. Accumulated run times for each well.
 3. Current well sequence.
 4. GST level.
 5. GST well control level set points.
- C. High Service Pumping. Provide operator control of strategy parameters from this screen. Indicate the following:
1. High service pump status.
 2. Accumulated run times for each pump.
 3. Discharge flow and current daily total.

4. Current pump sequences.
 5. GST level.
 6. Discharge pressure.
 7. Discharge pressure control set points.
- D. Chemical Systems. Provide operator control of strategy parameters from this screen. Indicate the following:
1. Status of each Cl₂ feed water supply valve.
 2. Current raw and effluent flow rates.
 3. Current effluent chlorine residual.
 4. Calculated current dosage in lbs./day for each chlorinator based on control set-point and current flow used for control.
 5. Status of Aquamag feed pump.
- E. Power System. Indicate current status for all monitored signals.
- F. Control System. Provide a single system block diagram for the system. Indicate the status of each communication link and, via a separate screen or pop-up window, the status of each PLC module.

3.03. OTHER HMI PROGRAMMING

- A. Alarm Log. Provide a log of all alarms issued by the system. The log shall include the date and time of detection. Provide the operator with the ability to sort the displayed log by any combination of the following:
1. Specific equipment.
 2. Alarm description
 3. Date and time.
- B. Event Log. Provide a log of all events issued by the system. The log shall include all alarms, operator control commands and set point changes, alarm acknowledgements and return to normal occurrences following an alarm condition. The date and time of occurrences shall be included together with, where applicable, the identity of the operator. Provide the operator with the ability to sort the displayed log by any combination of the following:
1. Operator.

2. Specific equipment.
 3. Event description.
 4. Date and time.
- C. Historical Database. Provide a historical database that includes, as a minimum, the following information:
1. For all flows:
 - a. Maximum daily value with time of occurrence.
 - b. Daily accumulated value.
 - c. Average daily value.
 - d. Monthly maximum daily value, date and time of occurrence, updated each time the previous value is exceeded.
 - e. Monthly average updated daily.
 2. For all pressures:
 - a. Maximum and minimum daily values with time of occurrences.
 - b. Monthly maximum and minimum daily value, date and time of occurrence, updated each time the previous value is replaced.
 3. For all analysis parameters:
 - a. Maximum and minimum daily values with time of occurrences.
 - b. Average daily value.
 - c. Monthly maximum and minimum daily value, date and time of occurrence, updated each time the previous value is replaced.
- D. Trends. Provide trending of all process parameters for each WTP including all wells. Provide the following additional trends:
1. Up to eight comparative trends, each with up to four parameters. The parameters in each shall be as OWNER selected.
- E. Reports. Provide the following reports:
1. Daily Operations Report updated hourly.

2. Monthly Operations Report updated daily after midnight.
 3. Monthly Maintenance Report containing accumulated pump run times for all equipment and date and time of last reset. Update this report daily after midnight.
 4. Up to three additional reports as selected by OWNER.
- F. Text Message Alarming. Program Win911 on the servers as follows:
1. All text messages shall include the tag number, current status or value, textual description of the equipment (e.g. "High Service Pump No. 1", "Plant Discharge Chlorine Residual", etc.) and condition (e.g. "High", "Fault", etc.)
 2. Configure connectivity for alarming-out for E-mail, Pager, and 2way SMS.
 3. Configure up to 8 OWNER provided cell phone or pager numbers.
 4. Configure up to 24 analog and discrete tag alarms for Win911 alarm group as designated by OWNER.
 5. Configure an On-Screen TEST button graphic on an HMI screen for periodic testing of the text message system.

3.04. PROGRAMMING ACCEPTANCE

- A. Regardless of any submittal approvals, final acceptance of the system programming will occur during the final Demonstration Test.
- B. The ENGINEER/OWNER reserves the right to require minor changes in the graphics and programming during the test.

END OF SECTION

SECTION 13325
PROCESS INSTRUMENTATION AND CONTROL SYSTEM
PROCESS CONTROL PANEL MODIFICATIONS

PART 1 - GENERAL

1.01. SCOPE OF WORK

- A. This Specification Section covers work related to hardware modifications of the existing Programmable Logic Controller (PLC) based Process Control Panel (PCP-1). The Work comprises the following major elements as further defined herein:
1. Replace the existing Allen Bradley model 584 PLC with a new Allen Bradley CompactLogix PLC.
 2. Replace the existing Operator Interface Terminal with a new Allen Bradley Panelview 7.
 3. Interconnection of the new PLC with the new HMI defined in Specification Section 13320 via Ethernet over fiber.
 4. Removal of the existing manual control switches on the front panel. The PCP-1 shall be provided with a new cover plate covering the empty spaces associated with the removed component.
 5. Additional inputs/outputs with associated components for interface with the Backup Control Panel (PCP-2) defined in Specification Section 13315.
- B. The work specified herein shall be furnished by the same SYSTEM SUPPLIER furnishing services and equipment as defined in 13300.

1.02. RELATED WORK

- A. Related work specified elsewhere includes:
1. Specification Section 13300 defines work associated with the overall PICS.
 2. Specification Section 13315 defines control panels.
 3. Specification Section 13320 defines work associated with the PICS that interconnects the PLC and Human Machine Interface (HMI) subsystem.

1.03. SUBMITTALS

- A. Provide the following submittals specific to the work defined herein:
- B. A PLC hardware shop drawing package that includes the following:
 - 1. Block Diagram: A detailed system block diagram showing all major components. Identify components by model number. Show interconnecting cables diagrammatically (by type and size).
 - 2. Revised PCP-1 drawings indicating all new components.
 - 3. Bill of Materials: A list of all components, including all software. Group components by type and include component model number and part number, component description, quantity supplied, and reference to component catalog information.
 - 4. Descriptive Information: Catalog information, descriptive literature, performance specifications, internal wiring diagrams, power and grounding requirements, power consumption, and heat dissipation of all elements. Clearly mark all options and features proposed for this project.

PART 2 - PRODUCTS

2.01. GENERAL REQUIREMENTS

- A. All equipment, cabinets and devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single MANUFACTURER, insofar as possible, and shall consist of equipment models which are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion through the installation of plug-in circuit cards or additional cabinets.
- B. The equipment furnished shall be designed to operate satisfactorily between 0 degrees C and 40 degrees C at up to 95 percent Relative Humidity (non condensing).
- C. All equipment furnished shall be designed and constructed so that in the event of power interruption, or temperatures outside the operational range, the equipment specified hereunder shall go through an orderly shutdown with no loss of memory, and resume normal operation without manual resetting when power is restored.

2.02. PROGRAMMABLE LOGIC CONTROLLER

- A. Control and data acquisition associated with site equipment shall be performed by Programmable Logic Controllers (PLC). The PLC modules shall be Allen Bradley CompactLogix series, no equal, DIN-rail mounted within the Process Control Panel. Modules shall be selected from the following list:
1. CPU Module. Module shall meet the following requirements:
 - a. Built-in dual Ethernet/IP ports and USB port for programming.
 - b. Support for up to 16 local I/O modules
 - c. 1 GB memory card.
 - d. 2 MB user memory.
 - e. Provide Allen Bradley 1769-L33ER.
 2. Power Supply Module. Module shall meet the following requirements:
 - a. Power requirement: 85-265 VAC.
 - b. Provide Allen Bradley 1769-PA2 or 1769-PA4 as necessary based on load requirements.
 3. Input/Output Modules. Furnish input/output modules sufficient to accommodate the inputs/outputs defined in Part 3 herein plus an additional 15% spares of each type. The spares shall be supplied fully wired such that it is only necessary to add field wiring and update the PLC database in order to activate them.
 4. Discrete Input Module. Module shall meet the following requirements:
 - a. Sixteen 120 VAC inputs.
 - b. Provide Allen Bradley 1769-IA16.
 5. Discrete Output Module. Module shall meet the following requirements:
 - a. Eight individually isolated contact outputs.

- b. Operating AC voltage: 5-265 VAC.
 - c. Operating DC voltage: 5-125 VDC.
 - d. Provide Allen Bradley 1769-OA8I.
 - 6. Analog Input Module. Module shall meet the following requirements:
 - a. Eight single-ended or differential 4-20 mA inputs.
 - b. Provide Allen Bradley 1769-IF8.
 - 7. Analog Output Module. Module shall meet the following requirements:
 - a. Four individually isolated differential 4-20 mA outputs.
 - b. Provide Allen Bradley 1769-OF4CI.
- B. PLC Software. The latest revision of the programming software shall be installed as of substantial completion. Provide Rockwell Automation RSLogix 5000 Full Edition. Catalog No. 9342-RLD600ENE.
- C. Ethernet Switch. The switch shall be an industrialized, hardened metal DIN-rail mountable enclosure meeting the following requirements:
 - 1. Sufficient RJ-45 10/100 Base TX copper and fiber optic ports to support all necessary connections together with at least one spare copper port.
 - 2. Operating Temperature: Up to 80 degrees C.
 - 3. Power Supply – Dual redundant 10-49 Volts DC inputs.
 - 4. Surge protection on all copper ports and power inputs.
 - 5. Manufacturer/model:
 - a. N-Tron.
 - b. Approved equal.
- D. Operator Interface Terminal. (OIT). The OIT shall be front panel mounted and meet the following requirements:
 - 1. 15 inch, full color touch screen graphical display.

2. Power Requirement: 120 VAC.
 3. Ethernet and RS-232 communications ports.
 4. Windows CE operating system.
 5. FactoryTalk View Machine Edition Station application software.
 6. Provide Allen Bradley Panelview 7 model.
- E. Media Converter. Provide an Ethernet copper to fiber converter. Red Lion, Phoenix or approved equal.

2.03. SPARES AND EXPENDABLES

- A. Provide the following spare parts:
1. One of each PLC module.

PART 3 - EXECUTION

3.01. TRAINING

- A. Hardware Maintenance: Provide a minimum of one day of hardware training for up to three of the OWNER's personnel in the maintenance of the PLC hardware which shall include:
1. Training in standard hardware maintenance for the equipment provided.
 2. Specific training for the actual hardware configuration to provide a detailed understanding of how the equipment and components are arranged, connected, and set up.
 3. Test, adjustment, and calibration procedures.
 4. Troubleshooting and diagnosis.
 5. Component removal and replacement.
 6. Periodic maintenance.
- B. Software Maintenance: Provide a minimum of two days of software training for up to four of the OWNER's personnel in the maintenance and use of the PLC software.

3.02. INPUT/OUTPUT (I/O) LISTING

- A. Existing I/O are identified in Table 13325-1 below. The SYSTEM SUPPLIER shall field confirm all existing I/O, particularly those marked NOT IN USE or with a question mark, and correct the Table as necessary. In the Table, the right hand column indicates the point in the PCP to which the field wiring connects. Existing signals to be deleted are indicated by strikethrough text.
- B. Additional, new I/O are identified in Table 13325-2. These may be connected to existing spare terminal blocks provided that the required spare I/O requirement is still met.

Table 13325-1: Existing I/O	
Signal	Existing PCP-1 terminal #
Discrete Inputs	
GST #1 Emergency Low	1001
GST #1 Emergency High	1002
GST #2 Emergency Low	1003
GST #2 Emergency High	1004
Well #1 Running	1005
Well #1 In Auto	1006
Well #1 In Remote Auto	1007
Well #2 Running	1008
Well #2 In Auto	1009
Well #2 Pressure Switch Flow Confirm	1010
Well #3 Running	1011
Well #3 In Auto	1012
Well #3 Pressure Switch Flow Confirm	1013
Chlorine Leak (NOT IN USE)	1014
Chlorine #1 Low Vacuum (NOT IN USE)	1015
Chlorine #2 Low Vacuum (NOT IN USE)	1016
HS Pump #1 Running	1017
HS Pump #1 Fault	1018
HS Pump #1 In Auto	1019
HS Pump #2 Running	1020
HS Pump #2 Fault	1021
HS Pump #2 In Auto	1022
HS Pump #3 Running	1023

Table 13325-1: Existing I/O	
Signal	Existing PCP-1 terminal #
HS Pump #3 Fault	1024
HS Pump #3 In Auto	1025
HS Pump #4 Running	1026
HS Pump #4 Fault	1027
HS Pump #4 In Auto	1028
ATS In Normal	1029
ATS In Emergency	1030
Generator Running	1031
Alarm Silence	1032
Spare	1033
Spare	1034
Spare	1035
Spare	1036
Spare	1037
Spare	1038
Spare	1039
Spare	1040
Spare	1041
Spare	1042
Spare	1043
Spare	1044
Spare	1045
Spare	1046
Spare	1047
Spare	1048
Discrete Outputs	
Well #1 Control	CR1
Well #2 Control	CR2
Well #3 Control	CR3
HS Pump #1 Control	CR4
HS Pump #2 Control	CR5
HS Pump #3 Control	CR6
HS Pump #4 Control	CR7
Corrosion Inhibitor Feed Control	CR8
Hypochlorite Pump #1 Control (?)	CR9
GST #2 Chlorine Valve Control (NOT IN USE?)	CR10

Table 13325-1: Existing I/O	
Signal	Existing PCP-1 terminal #
Hypochlorite Pump #2 Control (?)	CR11
Chlorine Leak Light (NOT IN USE)	CR12
Alarm Horn	CR13
Alarm Dialer Channel #1	CR14
Spare	CR15
Spare	CR16
Analog Inputs	
Distribution Pressure #1	302
Distribution Pressure #2	303
GST #1 Level	304
GST #2 Level	305
Distribution Flow #1	307
Distribution Flow #2	308
Distribution Chlorine Residual	309
Distribution pH	310
Spare Loop Powered Input	312
Spare Loop Powered Input	313
Spare Device Powered Input	314
Spare Device Powered Input	315
Analog Outputs	
HS Pump #1 Speed Control	401
HS Pump #2 Speed Control	402
HS Pump #3 Speed Control	403
HS Pump #4 Speed Control	404
Hypochlorite Pump # Pacing Control (?)	406
Spare	407
Spare	408
Spare	409

Table 13325-2: New I/O Signals. Refer to sheet I-02.
Discrete Inputs
PLC Fail
Distribution High Pressure
Distribution Low Pressure

Table 13325-2: New I/O Signals. Refer to sheet I-02.
In Backup Mode
Backup Power Available
Discrete Outputs
Backup Reset
Analog Inputs
Distribution Pressure

END OF SECTION

SECTION 13326
PROCESS INSTRUMENTATION AND CONTROL SYSTEM
PLC PROGRAMMING

PART 1 - GENERAL

1.01. SCOPE OF WORK

- A. This Specification Section covers work related to programming the PLC furnished under Specification Section 13325.
- B. The Work specified herein shall be performed by the SYSTEM SUPPLIER defined in Specification Section 13300.

1.02. RELATED WORK

- A. Specification Section 13300: General Requirements.
- B. Specification Section 13321 defines HMI programming requirements.
- C. Specification Section 13325 defines requirements applicable to the equipment to be programmed hereunder.

1.03. SUBMITTALS

- A. Provide an application programming design package that illustrates each individual control strategy using a program flow chart or written description. The descriptions shall also include details of all formulae to be used (e.g. chemical feed, flow paced, etc.). This submittal shall be Approved or Approved As Noted prior to any PLC programming Work. Simply repeating the descriptions provided herein shall not be acceptable.
- B. Provide a final documentation package that includes:
 - 1. Licenses in the Owner's name for PLC and, where applicable, OIT programming software.
 - 2. Final copies of all programming files on a USB flash drive.
 - 3. A complete printout of all "Annotated" PLC program logic.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01. PLC PROGRAMMING – GENERAL MONITORING

- A. Provide the following general monitoring functions for analog inputs:
1. For all analog inputs (pseudo and real):
 - a. Provide out of range alarms if the input signal goes outside the instrument's range
 - b. Provide individually operator adjustable emergency high and low alarms when the value goes outside the allowable process range.
 - c. Provide individually operator adjustable high and low alarms when the value goes outside the normal process operating range.
 - d. Provide a dead-band on all alarm settings.
 - e. Issue Return-to Normal alarms whenever the signal returns to within limits.
 2. For all flow related analog inputs:
 - a. Monitor for and record minimum and maximum daily 5-minute average values. Record the date and time of occurrence for each.
 - b. Accumulate a running daily total flow. At midnight, transfer the total to yesterday's total and restart from zero.
 - c. Calculate a running daily average flow. At midnight, transfer the value to yesterday's average and restart the averaging.
 3. For all level and pressure related analog inputs:
 - a. Monitor for and record minimum and maximum daily values. Record the date and time of occurrence for each.
 4. For all analysis analog inputs:

- a. Monitor for and record minimum and maximum daily values. Record the date and time of occurrence for each.
 - b. Calculate a running daily average reading. At midnight, transfer the value to yesterday's average and restart the averaging.
- B. Provide the following general monitoring functions for discrete inputs:
1. For all discrete inputs:
 - a. Indicate but do not alarm when a discrete signal changes, as expected, as a result of a control command.
 - b. Alarm whenever an un-commanded change of state occurs
 - c. For all local control switch position feedback discrete inputs:
 - d. Issue an advisory alarm to the operator whenever a position change is detected
 - e. Exclude from any control strategy any equipment whose local switch position precludes control. If an operator attempts to control the device through the system, issue a message indicating that the control cannot be accomplished together with the reason.
 2. For all motorized equipment:
 - a. Accumulate equipment run times based on the running status feedback discrete input.
 - b. Reset the run time value to zero only on operator command via the HMI.
 3. For all device failure discrete inputs:
 - a. Issue an alarm when the input indicates a device fault
 - b. Set a software fault for the controlled device that can only be reset by operator action after the fail signal has been removed.
- C. Special Level Monitoring. Based on the level and tank dimensions, continuously calculate the volume of liquid in each storage tank and display on the associated graphic screen.

3.02. PLC PROGRAMMING – GENERAL CONTROL

- A. General Requirements applicable to the control strategies are:
1. All software fault conditions that are set can only be cleared by operator acknowledgement.
 2. Wherever in the descriptions the control strategy refers to the operator, it is intended to mean via the Operator Interface Terminal (OIT) or HMI process graphics.
 3. All control strategies shall run within the PLC. Data manipulation (calculated analog values, elapsed time functions, event determination) shall be performed by the PLC for the associated equipment it is monitoring. Any resulting values from these manipulations shall be reported as individual registers. The intent is to avoid utilizing the OIT software for this purpose.
 4. The control functions described herein are not intended to be complete comprehensive programming logic descriptions. They describe only the general intended control operation required. Provide complete program logic to completely fulfill the functional requirements indicated.
 5. Provide all programming necessary to support the functional requirements of the operator graphic screens.
 6. Provide complete debugging services to address issues identified by the OWNER or ENGINEER during and after startup until final acceptance.
- B. Common Constant Speed Motor Operator Control. For all constant speed equipment, provide an operator controllable software HAND/OFF/AUTO switch and proceed as follows:
1. While the switch is in HAND run the equipment.
 2. While the switch is in OFF, stop the equipment and prevent any start commands.
 3. While the switch is in AUTO, take start and stop signals from the appropriate automatic control strategy defined herein.
- C. Common Variable Speed Motor Operator Control. For all variable speed equipment, provide an operator controllable software HAND/OFF/AUTO switch and SPEED potentiometer and proceed as follows:

1. While the switch is in HAND run the equipment at the speed set by the potentiometer.
 2. While the switch is in OFF, stop the equipment and prevent any start commands.
 3. While the switch is in AUTO, take start, stop, and speed signals from the appropriate automatic control strategy defined herein.
- D. Common Motorized Valve Operator Control. For all valves, provide an operator controllable software OPEN/CLOSE/AUTO switch and POSITION potentiometer where applicable. Proceed as follows:
1. While the switch is in OPEN, open the valve to the position set by the potentiometer.
 2. While the switch is in CLOSE, close the valve and prevent any other commands.
 3. While the switch is in AUTO, take open, close and position signals from the appropriate automatic control strategy defined herein.
- E. Common Motorized Equipment Flow Monitoring. For all motorized equipment provided with a dedicated discharge flow meter, issue an alarm and stop the equipment if the flow fails to reach an operator controllable minimum value within an operator adjustable time of being called to start.

3.03. SPECIFIC PLC CONTROL STRATEGIES

- A. Well Sequencing/Selection Control. Provide a sequence for calling the on-site raw water wells. Allow the operator to manually exclude a specific well from the sequence. Also exclude any well that is not controllable by the system. Allow the operator to manually revise the sequence. Each time a well is stopped, place it at the end of the sequence. Should any well fail when called for or while running, automatically call for the next well in sequence to start.
- B. "Well Operations. Provide an operator controllable TANK 1/TANK 2 select switch to identify the ground storage tank to be used for control. Proceed as follows:
1. Provide the following operator adjustable parameters:
 - a. LSH – Full tank level.
 - b. LSL – Low tank level.

2. When the selected tank level falls to LSL, start the LEAD raw water well.
 3. If the level remains at or below LSL for an operator adjustable time, call for the LAG raw water well to start.
 4. When the level reaches LSH stop all raw water wells.
 5. If a raw water well fails to start or fails while running call for the next well in sequence.
- C. Well Pump Control. For each pump provide an operator controllable HAND/OFF/AUTO select switch. Proceed as follows:
1. When the select switch is in HAND, run the pump.
 2. When the select switch is in OFF, turn the pump off and prevent any further control commands.
 3. When the select switch is in AUTO, take start and stop commands from the strategy defined above.
- D. High Service Pumping Control Strategy. Establish an automatic sequence for the pumps. Omit from the sequence any pump that is not controllable. Rotate the assignments every 24 hours at midnight. Allow the operator to override these and manually assign the pumps. Issue calls for pumps as follows:
1. Provide the following operator adjustable software functions:
 - a. PSH – Upper operating limit for distribution pressure.
 - b. PS – Desired operating value for distribution pressure.
 - c. PSL – Lower operating limit for distribution pressure. Restrict this value to a minimum of 3 PSI above the emergency low pressure switch setting.
 2. Provide a PID loop that adjusts pump speed to maintain a pressure of PS.
 3. If no pump is running and the pressure falls to PSL for an operator adjustable time, start the LEAD pump and adjust its speed to maintain a pressure of PID.

4. If a pump is called and fails to start or fails while running, automatically call for the next pump in sequence.
 5. If the speed signal is at an operator adjustable maximum and the distribution pressure falls to PSL again, increase the pumping stage.
 6. When a pump is to be started, temporarily suspend the PID loop and ramp down the running pump speed. Once the starting pump reaches the speed of the running pumps, restart the PID.
 7. If the speed signal is at an operator adjustable minimum and the distribution pressure rises to PSH, reduce the pumping stage by stopping the longest running pump.
 8. Prevent a pump starting within a preset time of it being turned off.
 9. If the pressure transducer fails, force operation to the backup control mode.
- E. High Service Pump Control. Provide the operator with a software HAND/OFF/AUTO select switch and SPEED potentiometer (restricted to the range 55%-100%).
1. While the switch is in HAND, run the pump at the speed set by the potentiometer.
 2. While the switch is in OFF, stop the pump and prevent any further control commands.
 3. While the switch is in AUTO, take start, stop and speed controls from the above high service pumping control strategy.
- F. Chemical Feed Systems Control. Transfer the existing control strategies into the new PLC.

3.04. PROGRAMMING ACCEPTANCE

- A. Regardless of any submittal approvals, final acceptance of the system programming will occur during the final Demonstration Test.
- B. The ENGINEER/OWNER reserves the right to require minor changes in the graphics and programming during the test.

END OF SECTION

SECTION 13360
PROCESS INSTRUMENTATION AND CONTROL SYSTEM
FIBER OPTIC SYSTEM

PART 1 - GENERAL

1.01. SCOPE OF WORK

- A. Work includes furnishing, installing, and testing, fiber optic cable links as defined in the Contract Drawings.
- B. The SYSTEM SUPPLIER defined in Specification Section 13300 shall be responsible for coordinating all aspects of the fiber optic system.
- C. All duct bank installation work covered by this specification shall be performed by a SUB-CONTRACTOR experienced in fiber optic cable installation.
- D. It is the ultimate responsibility of the Contractor to furnish a complete and fully operable system that supports the required functions specified elsewhere. The Contractor is to assume full responsibility for additional costs which may result from unauthorized deviations from the specifications.
- E. Equipment found to be defective prior to system acceptance shall be replaced and installed at no additional cost to the OWNER.

1.02. SUBMITTALS

- A. Shop Drawings: Submit, in a single package, catalog information, descriptive literature and drawings for all components of the fiber optic system.
- B. Test Procedure: Submit the procedure proposed to be followed during duct bank cable pulls. The procedure shall include data sheets to be used to record cable pull lengths and the attenuation readings before and after installation as defined in Part 3 herein.

1.03. FINAL DOCUMENTATION

- A. Provide a complete wiring diagram of the entire fiber optic system including termination numbers at all fiber patch panels.
- B. Distances and installed attenuation of all fiber runs within the duct bank system.
- C. Provide a hard copy of all final documentation and also in electronic format on a USB Flash Drive.

PART 2 - PRODUCTS

2.01. FIBER OPTIC CABLE

- A. Provide fiber optic cable for implementing the fiber links required within the system.
- B. Duct Bank Cable. The fiber optic cable within the duct bank system shall also meet the following requirements:
 - 1. 62.5/125 micron multimode fiber.
 - 2. Number of fibers: 6.
 - 3. Indoor/outdoor rated for underground duct bank installation.
 - 4. All dielectric loose tube.
 - 5. Gel-filled.
 - 6. PE outer jacket.
 - 7. Manufacturer: Belden, Corning or approved equal.
- C. Fiber optic cable within buildings shall also meet the following requirements:
 - 1. Non-conductive, plenum rated
 - 2. Type OFNP
 - 3. PVDF outer jacket
 - 4. Manufacturer: Belden, Corning or approved equal.
- D. Fiber patch cables shall be manufacturer's pre-fabricated two fiber cables with length as required for the application.

2.02. FIBER PATCH PANELS

- A. Fiber patch panels (FPP) shall be provided at all locations where fiber optic cable enters a building.
- B. FPP located outside shall be NEMA 4X 316 Stainless Steel lockable enclosures.
- C. FPP located indoors shall be NEMA 12 steel lockable enclosures.
- D. FPP shall contain one or more housings with sufficient quantities of ST compatible adaptor panels to accommodate all fibers terminating within the FPP. This requirement includes all dark fibers.

- E. The housing shall be equipped with strain relief for the cables and shall have a lockable access door.
- F. Provide Siecor WCH housing with CCH connector panels or approved equal

PART 3 - EXECUTION

3.01. INSTALLATION

- A. Install materials and equipment in a workmanlike manner utilizing craftsmen skilled in the particular trade. Provide work which has a neat and finished appearance. Coordinate the work with the OWNER and work of other trades to avoid conflicts, errors, delays, and unnecessary interference with operation of the existing plant during construction.
- B. Install suitably sized innerduct in all duct bank conduits. Exposed innerduct shall be labeled with fiber optic warning labels where they enter the duct bank and every three feet in between.
- C. All conduit within buildings shall be labeled every six feet with fiber optic warning labels.
- D. All cables within fiber patch panels shall be clearly labeled with destination.
- E. Install all duct bank fiber cable runs in accordance with the manufacturers recommendations and including:
 - 1. Use manufacturer approved cable lubricant.
 - 2. Use a pulling winch that continuously monitors and records the pull tension.
 - 3. Note from the distance markers on the cable the exact length of each installed run and record the information.
- F. All pulling equipment and hardware that will contact the cable shall be sized to maintain the cable's minimum bend radius.
- G. Do not utilize a figure-of-eight machine for installation without prior written confirmation of compatibility from both the machine and cable manufacturer.

3.02. TESTING

- A. Measure the attenuation of the fiber optic cable prior to installation and determine the average attenuation per foot.
- B. Following installation, measure the attenuation of each run and compare the attenuation per foot readings with those taken prior to installation. Replace any runs whose attenuation per foot reading is more than 10% higher than the pre-installation value.

- C. Provide all special testing materials and equipment.
- D. Coordinate all testing with the CONTRACTOR, the ENGINEER, all affected suppliers, and the OWNER.
- E. The ENGINEER reserves the right to test or retest any and all specified functions whether or not explicitly stated in the approved test procedures. The ENGINEER's decision shall be final regarding the acceptability and completeness of all testing.

END OF SECTION

SECTION 16050

ELECTRICAL - GENERAL PROVISIONS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required for a complete electrical system for the Sun 'N' Lakes Water Treatment Plant Upgrades in the City of Sebring, Florida, hereinafter specified and shown on the Drawings.
- B. The work, apparatus and materials which shall be furnished under these Specifications and accompanying Drawings shall include all items listed hereinafter and/or shown on the Drawings. Certain equipment will be furnished as specified in other sections of these Specifications which will require wiring thereto and/or complete installation as indicated. All materials necessary for the complete installation shall be furnished and installed by the CONTRACTOR to provide complete power, lighting, communication systems, instrumentation, wiring and control systems as indicated on the Drawings and/or as specified herein.
- C. The CONTRACTOR shall furnish and install the necessary cables, transformers, switchboards, protective devices, conductors, exterior electrical system, etc., to serve motor loads, lighting loads and miscellaneous electrical loads as indicated on the Drawings and/or as specified hereinafter.
- D. The work shall include complete testing of all equipment and wiring at the completion of the work and making any minor connection changes or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; sub-standard work will be rejected.
- E. Mount and wire instruments and equipment furnished under these or other Divisions of these Specifications.
- F. Make all field connections to instruments, equipment, and control panels.
- G. For instrumentation furnish and install all conduit, wire and interconnections between primary elements, transmitters, local indicators and receivers.
- H. Install and wire all thermostats, aquastats and other devices furnished under other Divisions of this Specification directly controlling heating equipment or fan motors.

- I. Wire ventilation equipment as required and furnished under other Divisions of this Specification.
- J. Each bidder or his authorized representatives shall, before preparing his proposal, visit all areas 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 he or his representative has visited the site and noted the locations and conditions under which the work will be performed and that he takes full responsibility for a complete knowledge of all factors governing his work.
- K. All power interruptions to existing equipment shall be at the Owner's convenience. Each interruption shall have prior approval.
- L. 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.

1.02 SERVICE AND METERING

- A. The existing permanent electric service shall remain in service.
- B. It is the responsibility of the CONTRACTOR to provide all coordination efforts for the existing electrical service. The existing Water Treatment Plant service is a 300KVA, 480/277V, 3 phase, 4 wire wye service at 5306 Sun N Lakes Blvd., Sebring, FL 33872. Meter Number 2814607.
- C. Contact Duke Energy Local Service Area Customer Service (877) 372-8477 for temporary outage requests or engineering Darrin Jenkins (863) 471-5856. Note: If outage standby time is required for DEF personnel, the Contractor shall pay all service charges.
- B. Furnish and install the new secondary service lateral conduit and wire as shown on the electrical drawings.

1.03 CODES, INSPECTION AND FEES

- A. All material and installation shall be in accordance with the latest edition of the National Electrical Code and all applicable national, local and state codes.
- B. Pay all fees required for permits and inspections including any charges associated with the service modifications.

1.04 TESTS

- A. Test all systems and repair or replace all defective work. Make all necessary adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.

- B. The following minimum tests and checks shall be made prior to the energizing of electrical equipment. Test shall be by an independent NETA certified testing firm, and a certified test report shall be submitted stating that the equipment meets and operates in accordance with the Manufacturer's and job specifications, and that equipment and installation conforms to all applicable Standards and Specifications:
 - 1. Testing and setting of protective relays for calibration and proper operation.
 - 2. Mechanical inspection of all circuit breakers 1200 amps and larger to assure proper operation.
 - 3. Motors: Megger to ground each motor winding. Record date, motor temperature, terminal, reading and operator and have Owner representative sign off on each reading.
 - 4. Conductors: Megger to ground prior to termination all 600 volt conductors not used for service conductors. Record the date, conductor, reading and operator and have Owner representative sign off on each reading.
 - 5. Service Conductors: Megger to ground prior to termination in the presence of the Engineer or his representative all 600 volt service conductors. Record date, conductor, reading, operator, and have the Owner representative sign off on each reading.
 - 7. Connections & Terminations:
 - a. Torque to Manufacturer's values in the presence of the Engineer or his representative. Record the date, conductor, torque, operator and have the Engineer sign off on each reading.
 - 8. Data Base: After equipment suppliers test, calibrations, and inspection, megger all circuits leaving all switchboards. Record the date, conductor, circuit condition (i.e. load connected or unconnected), reading and operator and have Owner representative sign off on each reading.

9. Hot Spot Testing: Perform infrared hot spot inspection of the 480 volt motor control centers and associated equipment as soon as determined by the engineer that representative loads are present. Record the date, gear conditions found, operator and have the owner's representative who must be present for the inspection sign off in each instance.
10. Repeat the above infrared hot spot inspection one more time if required by the Engineer.
11. Miscellaneous:
 - a. Meggering must be done at 1000 VDC for one minute. The ground plane used must be the one established at the main source of energy for conductors, switchboards and control centers. The motor frame may be used for the ground plane for motors.
 - b. In the course of construction, it will become necessary to temporarily energize some systems for testing. Confirm that any motor has been meggered prior to connection and testing. Do not leave any motor or system unattended and energized without written authorization.
 - c. An unsuccessful test will be one in which any one of the three megger readings differs from another by more than 25%. Engineer shall determine if cables and/or equipment bussing shall be replaced.

1.05 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.

1.06 CUTTING AND PATCHING

- A. All cutting and patching shall be done in a thoroughly workmanlike manner.

1.07 INTERPRETATION OF DRAWINGS

- A. The Drawings are not intended to show exact locations of conduit runs.
- B. All three-phase circuits shall be run in separate conduits unless otherwise shown on the Drawings.

- C. Unless otherwise approved by the Engineer conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.
- D. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation.
- E. The CONTRACTOR shall harmonize the work of the different trades so that interferences between conduits, piping, equipment, architectural and structural work will be avoided. All necessary offsets shall be furnished so as to take up a minimum space and all such offsets, fittings, etc., required to accomplish this shall be furnished and installed by the CONTRACTOR without additional expense to the Owner. In case interference develops, the Owner's authorized representative is to decide which equipment, piping, etc., must be relocated, regardless which was installed first.
- F. Verify with the Engineer the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
- G. The locations of equipment, fixtures, outlets, and similar devices shown on the Drawings are approximate only. Exact locations shall be as approved by the Engineer during construction. Obtain in the field all 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.
- H. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.
- I. Circuit layouts shown are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of the equipment.
- J. The ratings of motors and other electrically operated devices together with the size shown for their branch circuit conductors and conduits are approximate only and are indicative of the probable power requirements insofar as they can be determined in advance of the purchase of equipment.
- K. All connections to equipment shall be made as shown, specified, and directed and in accordance with the Manufacturer's approved shop drawings, regardless of the number of conductors shown on the Electrical Drawings.

1.08 SIZE OF EQUIPMENT

- A. Investigate each space in the building where equipment must pass to reach its final location. If necessary, the Manufacturer shall be required to ship his material in sections, sized to permit passing through such restricted areas in the building.
- B. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably, to insure that the tilting does not impair the functional integrity of the equipment.

1.09 RECORD DRAWINGS

- A. As the work progresses, legibly record all field changes on a set of project Contract Drawings. When the project is completed, furnish a complete set of reproducible "As-built" drawings and electronic files (Autocad) for the Project Record Documents. These documents shall be 22" x 34" in size.

1.10 COMPONENT INTERCONNECTIONS

- A. Component equipment furnished under this Specification will not be furnished as integrated systems. CONTRACTOR shall field install and wire completely all components.
- B. CONTRACTOR shall analyze all systems components and their shop drawings, identify all terminals and prepare drawings and wiring tables necessary for component interconnection. CONTRACTOR shall provide crimp on wire numbers on both ends of all control wiring installed between all panels furnished under this contract. These numbers shall directly relate to the interconnect wiring drawing furnished by the CONTRACTOR and be reflected in the As-built drawings submitted prior to final acceptance of the project.

1.11 SHOP DRAWINGS

- A. As specified under other sections shop drawings shall be submitted for approval of all materials, equipment, apparatus, and other items as required by the Engineer.
- B. Shop drawings shall be submitted for the following equipment:
 - 1. Service Entrance Rated Automatic Transfer Switch
 - 2. Generator Breaker
 - 3. Dry Type Transformers
 - 4. Panelboards
 - 5. Lighting Fixtures with Structural Engineering Certification
 - 6. Disconnect Switches

7. Motor Starters
8. Emergency Battery Units
9. Wire and Cable
10. Variable Frequency Drives
11. Solid State Starters
12. Process Control Panel (PCP-2)
13. PCP-1 modifications
14. Fiber Optic Cables, Patch panels, Fiber splice closures, Fiber Optic coupler
15. Chemical Systems
16. Grounding Systems
17. Conduit Layout Drawings
18. Service Equipment Racks with Structural Engineering Certification
19. Field Instruments
20. Remote Telemetry Units (RTU's)
21. Pressure Monitoring Panel

C. The Manufacturer name and product designation and catalog data sheet shall be submitted for the following material:

1. Conduit
2. Receptacles
3. Boxes and fittings
4. Switches
5. Lamps
6. Control Relays
7. Lightning Protection & Grounding Systems Material

D. Prior to submittal by the CONTRACTOR, all shop drawings shall be checked for accuracy and contract requirements. Shop drawings shall bear the date checked and shall be accompanied by a statement that the shop drawings have been examined for conformity to Specifications and Drawings. This statement shall also list all discrepancies with the Specifications and Drawings. Shop drawings not so checked and noted shall be returned.

E. The Engineer's check shall be only for conformance with the design concept of the project and compliance with the Specifications and Drawings. The responsibility of, or the necessity of, furnishing materials and workmanship required by the Specifications and Drawings which may not be indicated on the shop drawings is included under the work of this Section.

F. The responsibility for all dimensions to be confirmed and correlated at the job site and for coordination of this work with the work of all other trades is also included under the work of this Section.

- G. No material shall be ordered or shop work started until the Engineer's approval of shop drawings has been given.

1.12 MANUFACTURER SERVICES

- A. Provide Manufacturer services for testing and start-up of the following equipment:
 - 1. 480 Volt Panelboards
 - 2. Automatic Transfer Switch
 - 3. Other items as required by appropriate specification sections.

- B. The Manufacturer 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. The Manufacturer shall provide written approval that equipment supplied is approved for energization.

 - 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. Two (2) 4-hour training sessions on operation, and two (2) 4-hour training sessions (one for each system) on maintenance and trouble-shooting procedures shall be provided for the Owner's maintenance personnel. All training shall be conducted at a facility provided by the Owner. The maintenance and trouble-shooting sessions shall be conducted with record "As-built" electrical drawings sufficient for a class of eight personnel.

5. 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 CONTRACTOR shall forward a copy of this report to the ENGINEER for approval.

1.13 DEMOLITION

- A. Remove all electrical work associated with equipment shown to be removed (TBR) except those portions indicated to remain or be reused. Remove all unused exposed conduit and wiring back to point of concealment. Remove unused wiring in concealed conduits back to source (or nearest point of usage). Electrical work to be removed corresponds to the associated mechanical equipment to be removed.
- B. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or shall be suitably relocated and the system restored to normal operation. Coordinate outages in systems with the Owner. Where duration of proposed outage cannot be allowed by the Owner, provide temporary connections as required to maintain service.
- C. All removals and relocations of existing installations cannot be completely detailed on the Drawings. Survey the existing sites before submitting bid proposal.
- D. Continuous service is required on all circuits and outlets affected by these changes, except where the Owner will permit outage for a specific time. Obtain Owner's written consent before removing any circuit from continuous service.
- E. Where required to disconnect and/or remove any part of an existing circuit, reconnect that circuit to reestablish service in the remaining portion.
- F. Remove exposed conduits, wireways, outlet boxes, pull boxes and hangers made obsolete by the alternations, unless specifically designated to remain. Exposed conduits shall be removed back to point of concealment, where they shall be cut and threaded for a cap. A threaded cap shall then be installed. Conduits may be removed back to first coupling if within 3-inches of point of concealment. Cut back in traffic areas to the floor level and patch.
- G. Repair all walls to "Like new" condition and paint to match existing wall color.

1.14 DISPOSITION OF REMOVED MATERIALS AND EQUIPMENT

- A. In general, it is intended that all materials and equipment indicated to be removed and disposed of by the CONTRACTOR shall, upon removal, become the CONTRACTOR's property and shall be disposed of off the site by the CONTRACTOR, unless otherwise directed by the Owner.
- B. Reuse of wire will not be permitted. An exception is the reuse or relocation when wire is part of an existing lighting branch circuit and reuse or relocation is specifically designated and can be accomplished without removing and re-pulling the wire.
- C. All reusable and salvageable disconnect switches, starters, control devices, control panels and instruments, receptacles, light fixtures, etc. shall be sorted and returned to the Owner.
- D. All electrical equipment to be salvaged shall be removed and shall be moved by the CONTRACTOR to a location on the site for storage as directed by the Owner.

1.15 CONDUIT LAYOUT DRAWINGS

- A. In addition to the manufacturer's equipment shop drawings, the Contractor shall submit for approval, electrical installation working drawings for the overall site work and the existing water treatment plant high service pump building containing the following:
 - 1. Concealed and buried conduit layouts shown on floor plans drawn at not less than 1/4-inch = 1-foot-0-inch scale. The layouts shall include locations of process equipment, switchboards, transformers, panelboards, control panels and equipment, motors, switches, motor starters, large junction or pull boxes, instruments, and any other electrical devices connected to concealed or buried conduits.
 - 2. Plans shall be drawn on high quality bond size size 22-inch x 34-inch, and shall be presented in a neat, professional manner.
 - 3. Concrete floors and/or walls containing concealed conduits shall not be poured until conduit layouts are approved.
 - 4. Site plan conduit layout drawings shall be at 1"=10'-0.
Note: ACAD drawing files are available from the Engineer.

1.16 MATERIALS

- A. The materials used in all systems shall be new, unused and as hereinafter specified. All materials where not specified shall be of the very best of their respective kinds. Samples of materials or Manufacturer's specifications shall be submitted for approval as required by the Engineer.
- B. Materials and equipment used shall be Underwriters Laboratories, Inc. listed.
- C. 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 any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR at his own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such special tests as directed by the Engineer, at the expense of the CONTRACTOR, or shall be replaced by the CONTRACTOR at his own expense.

1.17 COORDINATION AND SHORT CIRCUIT STUDY

A. General:

1. The CONTRACTOR shall provide a Power System Study for the electrical power distribution and motor control equipment. The study shall be a totally independent effort to verify adequacy of all equipment as well as new additions being implemented under these Specifications. The study shall be prepared by a professional engineer, registered in the State of Florida, with demonstrated experience in the performance of industrial power system analysis. The Engineer may be an employee of an equipment manufacturer or supplier.
2. The CONTRACTOR shall provide data necessary to perform the study. This includes feeder cable sizes, approximate feeder length motor data, generator data, existing protective relay settings and any other information relevant to the study.
3. A summary of the short circuit analysis shall be provided to the CONTRACTOR at the time shop drawings for all of the new equipment is submitted for approval.
4. The CONTRACTOR shall provide complete sets of switchgear and emergency generator shop drawings for use in the study.

B. Scope:

1. The short circuit study shall be in accordance with ANSI Standard C37.010 and C37.13, shall be performed to check the adequacy, and to verify the correct application of circuit protective devices and other system components specified. The study shall address the case when the system is being powered from the normal source as well as from the on-site generating facilities. Minimum as well as maximum possible fault conditions shall be adequately covered in the study.
2. Fault contribution of all motors shall be considered. The CONTRACTOR shall be responsible for obtaining all required data of equipment. All back-up calculations shall become part of the final report. The calculations shall be in sufficient detail to allow easy review.

1.18 OPERATION AND MAINTENANCE DATA

- A. Submit complete operations and maintenance data for all equipment furnished under this Division in accordance with Section 01730. The manuals shall be prepared specifically for this installation and shall include all required cuts, Drawings, equipment lists, descriptions, complete part lists, etc. that are required to instruct operating and maintenance personnel unfamiliar with such equipment.

1.19 WARRANTY

- A. Provide a warranty for all the electrical equipment in accordance with the requirements of other sections, but in no case less than two (2) years from date of owner acceptance.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION

SECTION 16108

MISCELLANEOUS EQUIPMENT

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install all miscellaneous equipment as hereinafter specified and as shown on the Drawings.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Disconnect Switches:

1. Fusible and non-fusible disconnect switches shall be heavy-duty, NEMA type H, quick-make, quick-break, visible blades, 600 volt and 240 volt as shown on the drawings with full cover interlock. All current carrying parts shall be copper.
2. Enclosure type shall be NEMA 4X 316 stainless steel with copper lugs, unless otherwise shown on the drawings.
3. Switches shall be horsepower rated as manufactured by Square D, Cutler Hammer, or GE Energy.
4. Control wiring shall not pass through any disconnect enclosure. A junction box shall be provided, constructed of the same material as the disconnect, and utilized to separate power and control wiring prior to the disconnect enclosure.
5. Each disconnect shall be provided with a plastic nameplate, affixed to the enclosure without screws, identifying the equipment served.

- B. Solid-State Reduced Voltage Motor Starters (SSS):

1. Solid-state reduced voltage motor starters shall be a UL-listed motor starter with 3-pole, 60 Hz, 600 volt, power switching semiconductor (SCR) devices. Combination SSS shall have an additional motor circuit protector, when specified.
2. SSS shall have the following features:
 - a. Peak inverse voltage rating 1400V for units rated 480VAC.

- b. Built-in thermistor SCR protection with heatsinks.
 - c. Integral input power short circuit, phase loss, phase imbalance, phase reversal, under/over voltage, and control voltage protection.
 - d. Built-in integral by-pass contactors.
 - e. Integrated motor thermal overload, jam, and stall protection.
 - f. Adjustable current-limiting, start time, stop time, and start voltage
 - g. Adjustable auto reset or manual reset on trip conditions.
3. SSS shall have a minimum fault current interrupt RMS symmetrical rating of 18,000 amperes. Series rating with the integral combination circuit breaker or upstream breaker is acceptable. SSS motor starter output amperage ratings shall be greater than the ampere rating as shown on the electrical drawings.
 4. Each motor starter shall have internal control power to receive dry contact remote start/stop, trip, and fault reset commands. Auxiliary contacts shall be provided for run status and fault, as a minimum.
 5. Line and load lugs shall have finger-safe NEMA 1 conduit boxes. Load-side terminals with cables to motors installed outdoors shall have 600 volt MOV surge suppression installed
 6. Built-in digital LCD display Human Interface Module (HMI) with keypad. Fault log shall display the last (4) fault conditions, minimum. Display shall be front panel mounted and support status, elapsed run time, amps, KW, KWh, and power factor metering.
 7. Enclosure shall be NEMA 1, rated for operation up to 50 degrees Celsius.
 8. Solid-state reduced voltage motor starters shall be as manufactured by Eaton 811+, Square D Altistart, or Danfoss MCD500.
- B. Magnetic Motor Starters:
1. Combination Motor starters shall be a combination motor circuit protector and 3-pole, 60 Hz, 600 volt, magnetically operated, full voltage non-reversing contactor except as otherwise shown on the Drawings. NEMA sizes shall be NEMA rated for the horsepower shown on the Drawings.

2. Two speed starters shall be for single or two winding motors as shown on the Drawings.
3. Each motor starter shall have a 120 volt operating coil and control power transformer. Three phase starters shall have 3 overload relays. Auxiliary contacts shall be provided as shown on the Drawings or required.
4. Overload relays shall be non-adjustable, ambient compensated and manually reset.
5. Built-in control stations and indicating lights shall be furnished where shown on the Drawings.
6. Enclosure type shall be NEMA Type 1 painted steel.
7. Motor circuit protectors shall be molded case with adjustable magnetic trip only. They shall be specifically designed for use with magnetic motor starters. Motor circuit protectors shall be furnished with bolt-on current limiting fuses.
8. Combination magnetic motor starters shall be as manufactured by Danfoss, Square D, or Eaton.

C. Control Stations:

1. Control stations shall be NEMA 4X stainless steel heavy-duty type, with full size operators when located outdoors, in "NEMA 4" locations or in "Corrosive" areas.
2. Control stations shall be Class 9001, manufactured by the Square D Company or approved equal.
3. Pilot lights shall be complete with glass jewels and 150 volt lamps.

D. Control Relays:

1. Control relays shall be heavy duty machine tool type, with 10 ampere, 600 volt, convertible contacts. Time delay relays shall be pneumatic, adjustable 1/5 to 180 seconds.
2. Relays shall be CR2810 and CR2820 as manufactured by the General Electric Co. or approved equal.

Unless otherwise noted, all outdoor enclosures shall be NEMA 4X 316 stainless steel. NEMA 4X push buttons and pilot lights shall be provided in all weatherproof control panels.

END OF SECTION

SECTION 16110

RACEWAYS AND FITTINGS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install complete raceway systems as shown on the Drawings and as specified herein.

1.02 APPLICATIONS

- A. Except where otherwise shown on the Drawings, or hereinafter specified. The following describes the conduit requirements of the project:
 - 1. All exposed raceways shall be in aluminum conduit unless otherwise noted in 2 through 5 below.
 - 2. Underground power conductors (Non VFD motor units) shall be installed in schedule 80 PVC conduits.
 - 3. VFD cable shall be installed in schedule 80 PVC conduit.
 - 4. Instrumentation circuits shall be installed in schedule 80 PVC conduit with a #10 ground wire.
 - 5. Conduit installed in "Corrosive" areas or chemical rooms shall be PVC schedule 80.
- B. All conduit of a given type shall be the product of one manufacturer.
- C. Unless otherwise hereinafter specified or shown on the Drawings, all boxes installed outdoors shall be NEMA 4X stainless steel. All boxes installed indoors shall be PVC construction.
- D. Exposed switch, outlet and control station boxes and fittings shall be cast iron or "Feraloy" by Crouse-Hinds in NEMA 1 areas, and stainless steel where outdoors, where located in NEMA 4 areas or in "Corrosive" areas.
- E. Concealed switch, outlet and control station boxes shall be pressed steel. Terminal boxes, junction boxes, pull boxes, etc., installed outdoors shall be NEMA 4X stainless steel. All boxes installed indoors shall be PVC construction. NEMA rating for the PVC boxes shall be as shown on the drawings.

- F. All conduits entering or leaving the Chlorine Room shall have Crouse Hinds EYS conduit seals installed and filled with Chico cement.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Rigid Metal Conduit

1. Rigid metal conduit shall be for use under the provisions of NEC Article 346.
2. Rigid steel conduit interior and exterior shall be hot-dipped galvanized after threading and be as manufactured by the Allied Tube and Conduit Corp., Wheatland Tube Co., Triangle PWC Inc., or approved equal.
3. Rigid aluminum conduit shall be 6063 alloy and shall be as manufactured by New Jersey Aluminum Corp., AFC Co., VAW of America, Inc., or approved equal.
4. PVC coated rigid steel conduit shall have a 1/50-in thick, polyvinyl chloride coating permanently bonded to hot-dipped galvanized steel conduit and an internal phenolic coating, and shall be plasti-bond 2" as manufactured by Robroy Industries, Triangle PWC Inc., Perma-Cote Industries, or approved equal.

B. Rigid Nonmetallic Conduit

1. Rigid nonmetallic conduit shall be for use under the provisions of NEC Article 347.
2. PVC conduit shall be rigid polyvinyl chloride Schedule 80 as manufactured by Carlon, An Indian Head Co., Kraloy Products Co., Inc., Highland Plastics Inc., or approved equal.

C. Liquidtight Flexible Metal Conduit, Couplings and Fittings

1. Liquidtight flexible metal conduit shall be for use under the provisions of NEC Article 351A.
2. Liquidtight flexible metal conduit shall be Sealtite, Type UA, manufactured by the Anaconda Metal Hose Div., Anaconda American Brass Co., American Flexible Conduit Co., Inc., Universal Metal Hose Co., or approved equal.

3. Fittings used with liquidtight flexible metal conduit shall be of the screw-in type as manufactured by the Thomas and Betts Co., Crouse-Hinds Co., or approved equal.

D. Flexible Couplings

1. Flexible couplings shall be as manufactured by the Crouse-Hinds Co., Appleton Electric Co., Killark Electric Manufacturing co., or approved equal.

E. Boxes and Fittings:

1. Steel elbows and couplings shall be hot-dipped galvanized. An extra 40 mil PVC protective coating shall be provided when used with PVC coated steel conduit. Joints shall be tapped.
2. Conduit hubs shall be as manufactured by Meyers Electric Products, Inc., Raco Div., Appleton Electric Co., or approved equal. Conduit hubs shall be provided for all outdoor conduit terminations.
3. Conduit wall seals shall be type WSK as manufactured by the O.Z. Electrical Mfg. Co., or approved equal.
4. Conduit wall seals for cored holes shall be type CSML as manufactured by the O.Z./Gedney Co., or approved equal.
5. Conduit wall and floor seals for sleeved openings shall be type CSMI as manufactured by the O.Z./Gedney Co., or approved equal.
6. Conduit sealing bushings shall be O.Z./Gedney Type CSB or approved equal.

F. Conduit Mounting Equipment:

1. In dry indoor areas, hangers, rods, backplates, beam clamps, channel, etc. shall be galvanized rigid steel or FRP construction.
2. FRP channel, and stainless steel hardware shall be used in areas designated "WET," "CORROSIVE," or NEMA 4 on the Drawings. Fiberglass channel shall be resistant to the chemicals present in the area in which it is used.
3. Channel installed outdoors shall be stainless steel.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. No conduit smaller than 3/4-inch electrical trade size shall be used, nor shall any have more than four 90 degree bends in any one run. Pull boxes shall be provided as required or directed. Minimum size in floor slabs shall be 3/4-inch.
- B. No wire shall be pulled until the conduit system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the conduit system has been completed in every detail.
- C. The ends of all conduits shall be tightly plugged to exclude dust and moisture while the buildings are under construction.
- D. Conduit supports shall be spaced at intervals as required to obtain rigid construction, but in no case more than as required by the NEC.
- E. Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the surface. Multiple runs of conduits shall be supported on trapeze type hangers with steel horizontal members and threaded hanger rods. The rods shall be not less than 3/8-inch diameter. Material type shall be as specified in Section 2.
- F. Conduit hangers shall be attached to structural steel by means of beam or channel clamps. Where attached to concrete surfaces, concrete inserts of the spot type shall be provided.
- G. All conduits on exposed work shall be run at right angles to and parallel with the surrounding walls and shall conform to the form of the ceiling. No diagonal runs will be allowed. Bends in parallel conduit runs shall be concentric. All conduit shall be run perfectly straight and true. Conduits not installed in this fashion shall be replaced.
- H. No unbroken run shall exceed 300 feet in length. This length shall be reduced by 75 feet for each 90 degree elbow.
- I. Conduit terminating in pressed steel boxes shall have double locknuts and insulated bushings.
- J. Conduit terminating in gasketed enclosures shall be terminated with conduit hubs.

- K. Conduit wall seals shall be used for all conduits penetrating walls below grade or other locations shown on the Drawings.
- L. Liquidtight flexible PVC conduit shall be used for all motor and transformer terminations and other equipment where vibration is present.
- M. Flexible couplings shall be used in hazardous locations for all motor and transformer terminations and other equipment where vibration is present.
- N. Conduit stub outs for future construction shall be provided with threaded PVC end caps at each end.
- O. Galvanized steel conduit entering manholes and below grade pull boxes shall be terminated with grounding type bushings and connected to a 5/8" x 10" rod with a #6 bare copper wire.
- P. Underground 120 volt circuits (GRS or Schedule 80 PVC) shall be installed directly to the respective motor control centers, lighting panels, etc. Stainless steel pull boxes shall be wall mounted on structures to eliminate excessive bends. With prior approval, below grade pull boxes, equal to Brooks #2424 (minimum), with hot dip galvanized covers and frames, may be used. Splices shall not be made in above or below grade pull boxes without prior approval.
- Q. All field cut threads on galvanized steel conduit shall be cleaned and painted with zinc-rich paint before installing.
- R. A 4-inch concrete conduit housekeeping pad shall be required for all exposed conduit stub-ups. This applies to ALL exposed conduits installed indoors or outdoors.

END OF SECTION

SECTION 16120
WIRES AND CABLES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish, install and test all wire, cable, and appurtenances as shown on the Drawings and as hereinafter specified.

1.02 SUBMITTALS

- A. Samples of proposed wire and cable shall be submitted for approval. Each sample shall have the size, type of insulation and voltage stenciled on the jacket.
- B. Approved samples will be sent to the project location for comparison by the Resident Engineer with the wire actually installed.
- C. Installed, unapproved wire shall be removed and replaced at no additional cost to the Owner.

1.03 APPLICATIONS

- A. Wire for all power circuits shall be type THWN-2.
- B. Single conductor wire for control, indication and metering shall be type MTW No. 14 AWG, 19 strand or type XHHH No. 14 AWG stranded.
- C. Multi-conductor control cable shall be No. 14 AWG, 19 strand.
- D. Wire for process instrumentation or shielded control cable shall be No. 16 AWG, shielded and stranded. All shielded cables shall be provided with a #16 shielded ground.
- E. All power cables between the motor and VFD shall be VFD rated cable.

1.04 MINIMUM SIZES

- A. Except for control and signal leads, no conductor smaller than No. 12 AWG shall be used.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. All wires and cables shall be of annealed, 98 percent conductivity, soft drawn stranded copper conductors.

2.02 600 VOLT WIRE AND CABLE

- A. Type XHHW shall be cross-linked polyethylene (XLP); as manufactured by General Cable, Southwire Co., Collyer Insulated Wire Co., Rome Cable or approved equal.
- B. Type THWN shall be as manufactured by General Cable, Southwire Co., Collyer Insulated Wire Co., Rome Cable or approved equal.

2.03 INSTRUMENTATION AND CONTROL CABLE

- A. Process instrumentation wire shall be twisted pair, 600V, cross-linked polyethylene insulated, aluminum tape shielded, polyvinyl chloride jacketed, type "XLP" as manufactured by General Cable, American Insulated Wire Co., Eaton Corp. "Polyset," or approved equal. Multi-conductor cables shall be supplied with individually shielded twisted pairs.
- B. Multi-conductor control cable shall be stranded, 600V, cross-linked polyethylene insulated with PVC jacket, type "XLP" as manufactured by General Cable, American Insulated Wire Co., Eaton Corp. "Polyset," or approved equal.

2.04 TERMINATIONS AND SPLICES

- A. Power Conductors: Terminations shall be die type or set screw type pressure connectors as specified. Splices (where allowed) shall be die type compression connector and waterproof with heat shrink boot or epoxy filling.
- B. Control Conductors: Termination on saddle-type terminals shall be wired directly with a maximum of two conductors per termination. Termination on screw type terminals shall be made with a maximum of two spade connectors. Splices (where allowed) shall be made with insulated compression type connectors. Heat shrink boots shall be utilized for all outdoor splices.
- C. Instrumentation Signal Conductors (including graphic panel, alarm, low and high level signals): Terminations permitted shall be typical of control conductors. Splices are allowed at instrumentation terminal boxes only.

- D. Except where otherwise approved by the Engineer no splices will be allowed in manholes, handholes or other below grade located boxes.
- E. Splices shall not be made in push button control stations, control devices (i.e., pressure switches, flow switches, etc.), conduit bodies, etc.

2.05 VARIABLE FREQUENCY DRIVE (VFD) OUTPUT POWER CABLE:

- A. Section applies to power cables routed between the output of VFD's and motor terminals.
- B. Cable shall be rated for 2000 volts and shall meet the requirements below:
 - 1. Conductors shall be stranded Class B bare copper.
 - 2. All wire shall be brought to the job in unbroken packages and shall bear the data of manufacturing; not older than 12 months.
 - 3. Type of wire shall be XLPE RHH/RHW-2 rated 90 degrees C suitable for wet locations.
 - 4. Provide overall 5 millimeter metallic shield (copper tape shield) overlapped 50%.
 - 5. No wire smaller than No. 12 gauge shall be used unless specifically indicated.
 - 6. Cable construction shall consist of three insulated current-carrying phase conductors and three bare ground conductors, symmetrically placed between the phase conductors, and twisted beneath a continuous overall PVC polymeric jacket.
- C. Each ground conductor size (circular mil area) shall be one-third (1/3) of the NEC required size (circular mil area) for a single ground conductor. If one third of the required circular mil area does not correspond to a standard size (circular mil area) of construction, the next largest size of standard construction shall be used. All conductors shall be megger tested after installation and insulation must be in compliance with the Insulated Power Cable Engineers Association Minimum Values of Insulation Resistance.
- D. Manufacturers:
 - 1. Belden
 - 2. Flex
 - 3. Lutze

PART 3 - EXECUTION

3.01 INSTALLATION

- A. All conductors shall be carefully handled to avoid kinks or damage to insulation.

- B. Lubrications shall be used to facilitate wire pulling. Lubricants shall be U.L. listed for use with the insulation specified.
- C. Shielded instrumentation wire shall be installed from terminal to terminal with no splicing at any intermediate point.
- D. Shielded instrumentation wire shall be installed in rigid steel conduit and pull boxes that contain only shielded instrumentation wire. Instrumentation cables shall be separated from control cables in manholes.
- E. Shielding on instrumentation wire shall be grounded at one end only, as directed by supplier of the instrumentation equipment.
- F. Wire and cable connections to terminals and taps shall be made with compression connectors. Connections of insulated conductors shall be insulated and covered. All connections shall be made using materials and installation methods in accordance with instructions and recommendations of the manufacturer of the particular item of wire and cable. The conductivity of all completed connections shall be not less than that of the uncut conductor. The insulation resistance of all completed connections of insulated conductors shall be not less than that of the uncut conductor.
- G. All wire and cable shall be continuous and without splices between points of connection to equipment terminals, except a splice will be permitted by the Engineer if the length required between the points of connection exceeds the greatest standard shipping length available from the manufacturer specified or approved by the Engineer as the manufacturer of the particular item of wire and cable.
- H. Steel fish tapes and/or steel pulling cables shall not be used in PVC conduit runs.
- I. All control and instrumentation circuits and wiring shall be clearly and permanently numbered and labeled at each end so as to identify the location of the opposite end and the function of the circuit. Individual wires in a multi-wire circuit shall be identified with wire numbers. Labeling shall be in place prior to turnover of any equipment, system or sub-system to Owner.

3.02 TESTS

- A. All 600-volt wire insulation shall be tested with a meg-ohmmeter after installation. Tests shall be made at not less than 1,000 VDC. See 16050 for additional testing requirements.

- B. All service conductors shall be tested as in paragraph A above. These tests shall be witnessed by the Engineer. A written report shall be submitted to the engineer for review.

END OF SECTION

SECTION 16160

PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor materials, equipment and incidentals required and install all panelboards as hereinafter specified and as shown on the Drawings.

PART 2 - PRODUCTS

2.01 RATING

- A. Panelboard ratings shall be as shown on the Drawings. All panelboards shall be rated for the intended voltage.

2.02 STANDARDS

- A. Panelboards shall be in accordance with the Underwriter Laboratories, Inc. "Standard for Panelboards" and "Standard for Cabinets and Boxes" and shall be so labeled where procedures exist. Panelboards shall also comply with NEMA Standard for Panelboards and the National Electrical Code.

2.03 CONSTRUCTION (NEMA 1)

- A. Interiors:
 - 1. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the antiturn solderless type and all shall be suitable for copper or aluminum wire of the sizes indicated.
 - 2. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping.
 - 3. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.
 - 4. A nameplate shall be provided listing panel type, number of circuit breakers and ratings.

B. Buses:

1. Bus bars for the mains shall be of copper. Full size neutral bars shall be included. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction. Cross connectors shall be copper.
2. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
3. Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.
4. Buses for 480V panelboards shall be rated for interrupt RMS symmetrical, as shown on the drawings. Buses for 120/208V light and appliance panels shall be rated 10,000 amperes RMS symmetrical.

C. Boxes:

1. Recessed boxes shall be made from galvanized code gauge steel without multiple knockouts. Surface mounted boxes shall be painted to match the trim. Boxes shall be of sufficient size to provide a minimum gutter space of 4-inches on all sides.
2. Surface mounted boxes shall have an internal and external finish as hereinafter specified in paragraph D4.
3. At least four (4) interior mounting studs shall be provided.
4. All conduit entrances shall be field punched.
5. All indoor installed panelboards shall be NEMA 1.
6. All Outdoor installed panelboards shall be NEMA 4X stainless steel.

D. Trim:

1. Hinged doors covering all circuit breaker handles shall be included in all panel trims.
2. Doors shall have semi flush type cylinder lock and catch, except that doors over 48-inches in height shall have a vault handle and 3-point

catch, complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed. Two keys shall be supplied for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.

3. The trims shall be fabricated from code gauge sheet steel.
4. All exterior and interior steel surfaces of the panelboard shall be properly cleaned and finished with ANSI Z55.1, No. 61 light gray paint over a rust-inhibiting phosphatized coating. The finish paint shall be of a type to which field applied paint will adhere.
5. Trims for flush panels shall overlap the box by at least 3/4-inch all around. Surface trims shall have the same width and height as the box. Trims shall be fastened with quarter turn clamps.

E. Manufacturer:

1. 120/240V, single phase, 3-wire, and 120/208V 3-phase, 4-wire panelboards shall be type NLAB as manufactured by the Cutler Hammer, Square D or GE Energy.
2. 480V, 3-phase, 3-wire panelboards shall be type CCB as manufactured by the Cutler Hammer, Square D or GE Energy.

2.04 CIRCUIT BREAKERS

- A. Panelboards shall be equipped with circuit breakers with frame size and trip settings as shown on the Drawings.
- B. Circuit breakers shall be molded case, bolt-in type.
- C. Circuit breakers used in 120/240V and 120/208V panelboards shall have an interrupting capacity of not less than 10,000 - amperes, RMS symmetrical.
- D. Three pole breakers used in 480V panelboards shall have an interrupting capacity of not less than 18,000 - amperes RMS symmetrical.
- E. GFCI (ground fault circuit interrupter) shall be provided for circuits where indicated on the Drawings. GFCI units shall be 1 pole, 120 volt, molded case, bolt-on breakers, incorporating a solid state ground fault interrupter circuit insulated and isolated from the breaker mechanism. The unit shall be U.L. listed Class A Group I device (5 milliamp sensitivity, 25 millisecond trip time), and an interrupting capacity of 10,000 amperes RMS.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Boxes for surface mounted panelboards shall be mounted so there is at least 1/2-inch air space between the box and the wall.
- B. Unless otherwise noted on the Drawings, top of cabinets shall be mounted 6-feet 0-inch above the floor, properly aligned and adequately supported independently of the connecting raceways.
- C. All wiring in panelboards shall be neatly formed, grouped, laced, and identified to provide a neat and orderly appearance. A typewritten directory card identifying all circuits shall be placed in the cardholder inside the front cover.

END OF SECTION

SECTION 16217

AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to install, put into operation, and field test the Service Entrance Rated Automatic Transfer Switch (ATS) and appurtenances as shown on the Drawings and specified herein.
- B. 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.
- C. For the unit, there shall be furnished and installed all necessary and desirable accessory equipment and auxiliaries whether specifically mentioned in these Specifications or not. This installation shall incorporate the highest standards for the type of service shown on the Drawings. The CONTRACTOR 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.

1.02 DESCRIPTION OF SYSTEMS

- A. The ATS shall be rated and mounted as shown on the Drawings and shall be arranged for automatic starting and stopping, and load transfer upon failure of the normal source of power.
- B. All conduit and wire installation requirements are the responsibility of the Contractor.

PART 2 - PRODUCTS

2.01 AUTOMATIC TRANSFER SWITCH (ATS)

- A. The automatic transfer switch shall be service entrance rated and shall be a standard product of a manufacturer regularly engaged in the manufacture of automatic transfer switches for a period of at least 10 years.

- B. Subject to compliance with requirements, provide products by one of the following:
1. ASCO
 2. Lake Shore Electric Corporation
 3. Eaton
- C. Transfer Switch Construction and General Product Requirements
1. The automatic transfer switch shall be rated for continuous duty and suitable for use in emergency situations. Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp load not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
 2. The complete automatic transfer switch shall be listed under U.L. 1008 for use on emergency systems. The switch shall be circuit breaker type, mechanically interlocked with double actuator for center-off lockout position control, and labeled as Suitable for Use as Service Entrance Equipment.
 3. A neutral assembly shall be provided.
 4. The automatic transfer switch shall be rated for 35,000 AIC short circuit availability. The manufacturer shall provide certification of compliance to all U.L. and NEMA Standards referred to above.
 5. The automatic transfer switch shall be positively and reliably interlocked to prevent both sources from being simultaneously connected to the load unless intended.
 6. The automatic transfer switch shall be mechanically held and electrically operated, energized by the source to which it is being transferred. It shall be double throw, actuated by two stored energy operators. Connection to the transfer mechanism shall be accomplished by a simple over-center toggle mechanism, which shall mechanically lock the main contacts in place. Main contacts shall be fully rated, self-wiping, and arc quenching. Separate arcing contacts with magnetic blowouts shall be provided.
 7. The automatic transfer switch shall be provided with a permanently attached means to manually operate the switch without the use of special tools, devices or fixtures. The manual operating means shall provide safety to operators performing transfer under load. The manual operator shall transfer

8. The switch with the same contact-to-contact transfer speed as the electrical operator. The transfer switch shall be "Load Break" rated when manually operated. The inability to manually operate the transfer switch without first disconnecting loads will not be acceptable.
9. The cable entry area of the transfer switch shall be accessible from the top, bottom or front of the enclosure. All control components and wiring shall be front accessible.
10. The switch shall have a neutral position programmable time delay between opening one source and closing the other shall be provided. This shall allow residual voltages to decay before reapplying power to the load.

D. Automatic Transfer Switch Controls

1. Controls shall be microprocessor based and shall provide all necessary functions of the automatic transfer switch. The controller shall be equipped with a real time and date clock, battery backup, and non-volatile memory storage.
2. An HMI shall be provided containing a 16 character with automatic scrolling features for necessary data display, LCD display, LED indicating lights as specified herein, and a touch pads to allow access to the system.
3. The controller shall be equipped to accept power quality or condition signals from a variety of external relays or monitors connected to either the normal or emergency sources.
4. The controller shall store all timer and mode settings in non-volatile memory so that upon re-energizing the switch it will return to the previous position without loss of data.
5. The controller shall allow for five modes of operation: Off/Reset, Automatic, Load Test, Engine Start and Fault.
6. In the fault mode, the transfer switch shall be locked out and the reason for its failure shall be displayed on the HMI display.
7. The controller shall have complete diagnostic capabilities so that every input and output can be monitored for troubleshooting or maintenance purposes. Specifically, the transfer switch controller shall display 3-phase voltage and frequency values for both power

sources. It shall also display timer functions as they execute in normal operation.

8. The controller shall have an operating range of -40°C to +85°C
9. The controller shall meet IEEE C62.41 surge test.
10. The controller shall be able to withstand unlimited power interruptions.

E. Automatic Transfer Switch Features

1. The transfer switch controller shall be equipped with no less than 6 timers as follows:
 - a. Time Delay in Neutral: Adjustable time delay to provide delay between opening the contacts on one source and closing the contacts on the other source. This shall be the programmable time delay required when the automatic transfer switch is serving inductive loads. Timer shall be field adjustable from 0 to 300 seconds, in 1-second increments.
 - b. Time Delay to Engine Start: Adjustable time delay after a failure of the Normal source before initiating an Engine-Start signal to allow for temporary short-duration fluctuations in voltage. Timer shall be field adjustable from 0 to 300 seconds, in 1-second increments.
 - c. Time Delay to Emergency: Adjustable time delay after the engine has started before transferring the load from the Normal source to the Emergency source. Timer shall be field adjustable from 0 to 300 seconds, in 1-second increments.
 - d. Time Delay to Return: Adjustable time delay after the return of Normal power before retransferring the load from the Emergency source to the Normal source. Timer shall be field adjustable from 0.0 to 60.0 minutes.
 - e. Engine Cool Down Timer: Adjustable time delay after retransferring the load from the Emergency source to the Normal source before shutting down the engine. Timer shall be field adjustable from 0.0 to 60 minutes, in 0.1-minute increments.

- f. Minimum Run Timer: Adjustable time delay after starting engine before shutting it down. Timer shall be field adjustable from 0.0 to 60 minutes, in 0.1-minute increments.
2. A Digital Plant Exerciser shall be provided to provide for the regular automatic exercising of the Emergency Power System on a pre-selected schedule at field adjustable periods. The controller shall allow exercising with load or without load. In the event of an engine-generator failure, when operating in the plant exerciser mode, the automatic transfer switch shall immediately return to the normal source, if available.
3. A Close Differential Under Voltage Relay shall be provided to continuously monitor normal voltage. The under voltage relay shall be field adjustable from 70% (seventy percent) to 100% (one hundred percent) of nominal voltage. Factory set at 90% (ninety percent) pick-up and 80% (eighty percent) dropout.
4. The transfer switch controller shall incorporate A Loss of Phase protection for both sources. In the event of the loss of phase or under voltage of the normal source, the transfer switch shall immediately be disconnected from the normal source to prevent damage to connected equipment. The transfer switch shall automatically return to service when the power problem no longer exists.
5. To protect against regenerative voltages under a single-phasing condition, the transfer switch controller shall be equipped with a fault output terminal interconnected to a 24Vdc shunt trip, integral to the transfer switch and with built-in time delay that functions to disconnect the utility source from the load, should the emergency power source fail to start. The transfer switch shall automatically return to utility service when the power problem no longer exists.
6. Transfer switch controller shall include data logging feature to provide troubleshooting aid to field technicians.
7. Transfer switch assembly shall include 5 year warranty, inclusive of parts and labor.
8. A single-phase frequency and voltage-sensing relay shall be provided for protection against transferring to the Emergency source until the generator has reached both operating frequency and voltage.

9. A Customer Relay Interface Board shall be provided to allow customer interface to the transfer switch controls. All interfaces shall be voltage free contacts rated 10 amps at 120 Vac. The following interface points shall be made available.
 - a. Engine start contacts consisting of one normally open and one normally closed contact.
 - b. Switch Position contacts consisting of two normally open and two normally closed contacts.
 - c. Trouble contacts consisting of one normally open and one normally closed contacts.
10. Light Emitting Diode (LED) pilot lights shall be provided on the HMI panel to indicate the following conditions:
 - a. Normal Source Available
 - b. Normal Switch Closed
 - c. Emergency Source Available
 - d. Emergency Switch Closed
 - e. System not in Automatic (Flashing light)
11. A Maintenance Disconnect switch shall be provided to disconnect control circuitry from line for maintenance purposes.
12. A momentary Load Test Switch shall be mounted inside the enclosure for ease of servicing. This switch shall cycle the transfer switch through a complete transfer to emergency and retransfer to normal.
13. A Keypad Enable Switch shall be mounted inside the enclosure, which will inhibit use of the HMI operator interface.
14. An Override Pushbutton shall be provided, mounted on the inside of the enclosure to bypass the Time Delay to Return Timer.
15. Surge Protection Devices: Surge Protection Devices shall be provided on the Emergency source. All surge protection devices shall be integral to the ATS and rated 65ka per phase minimum.
16. Overcurrent Protection: Overcurrent protection shall be provided on the (Normal or Emergency) source with “tripped” indication on the HMI panel.

17. Auxiliary Contacts Source Available: Dry contacts consisting of two normally open and two normally closed contacts shall be provided to indicate the following:

- ATS In Normal
- ATS In Emergency
- ATS Fail

F. Enclosure

1. The automatic transfer switch shall be enclosed in a NEMA ICS 250, NEMA 3R 316 stainless steel enclosure, unless otherwise shown on the drawings.
2. The automatic transfer switch shall be front accessible only and suitable for rack mounting.

G. Source Quality Control

1. Factory test components assembled switches and associated equipment to ensure proper operation. Check transfer time and voltage, frequency and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

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 for a period of not less than two (2) days in two separate visits to inspect the installed equipment, supervise the initial test run, and to provide instructions to the plant personnel. The first visit will be for checking and inspecting the equipment after it is installed.
- B. At least one (1) of the two (2) days shall be allocated solely to the 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 during plant start-up and acceptance by the OWNER.
- C. Three final copies of operation and maintenance manuals specified must be delivered to the ENGINEER prior to scheduling the instruction period with the OWNER.

- D. A three (3) year extended warranty shall be provided to the Owner from the date of initial start up.

END OF SECTION

SECTION 16370

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to furnish and install variable frequency drives as shown on the Drawings and as specified herein.
- B. 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 furnished. They are, however, intended to cover the furnishing, the shop testing, the delivery and complete installation and field testing, of all materials, equipment and appurtenances for the variable frequency drives herein specified.

1.02 DESCRIPTION OF SYSTEM

- A. All VFDs furnished for this project shall be the responsibility of the Contractor. The CONTRACTOR shall be responsible for complete system operation and all required coordination with all disciplines. VFD's shall be furnished and installed by the CONTRACTOR.
- B. The drives furnished herein under shall be totally compatible and adequately sized with the existing motors.
- C. Installation of the VFDs shall be provided as indicated on the electrical drawings.

1.03 QUALIFICATIONS

- A. Variable speed drives shall be sized to operate the ampacity shown on the electrical drawings. To assure unit responsibility, all equipment specified in this section of the specifications shall be furnished and coordinated by the CONTRACTOR. The CONTRACTOR shall be responsible for coordinating the sizing of all VFDs.
- B. The drives covered by these Specifications are intended to be equipment of proven ability as manufactured by reputable manufacturers having long experience in the production of identical units. The equipment furnished shall be designed, constructed and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed.

- C. The variable frequency control shall operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 10% total harmonic voltage distortion and commutation notches up to 36,500 volt microseconds, or when other variable frequency drives are operated from the same bus.

Individual or simultaneous operation of the variable frequency drives shall not add more than 5% total harmonic voltage distortion to the normal bus, nor more than 10% while operating from standby generator (if applicable) per IEEE 519, latest edition. The load side of the main breaker shall be the point of common coupling (PCC). The short circuit current at point of common coupling under utility operation is approximately 50,000 Amps. A preliminary harmonic (voltage and current) analysis must be submitted by the variable frequency drive manufacturer at bid time, this must include all calculations, simply a statement of compliance is not acceptable. Compliance shall be verified by the variable frequency drive manufacturer with field measurements of the harmonic distortion difference at the point of common coupling with and without variable frequency drives operating. See testing requirements.

- D. The variable frequency drive manufacturer shall maintain and staff engineering service and repair shops through the United States, including the State of Florida, trained to do start up service, emergency service calls, repair work, service contracts and training of customer personnel.
- E. The variable frequency drives shall be as manufactured by Danfoss, Square D or Eaton.

1.04 SUBMITTALS

- A. Copies of all materials required to establish compliance with the specifications shall be submitted. Submittals shall include at least the following:
1. Certified shop and erection drawings showing all important details of construction, dimensions and anchor bolt locations.
 2. Descriptive literature, bulletins and/or catalogs of the equipment.
 3. Data on the characteristics and performance of the variable frequency drives. Data shall include certification that the variable frequency drives are warranted for use with the motors specified in Division 11 and Division 16.
 4. Complete drawings shall be furnished for approval before proceeding with manufacture and shall consist of master wiring diagrams,

elementary or control schematics including coordination with other electrical control devices operating in conjunction with the variable frequency drive, and suitable outline drawings with sufficient details for locating conduit stub-ups and field wiring. Generic schematics not specific to this project shall not be acceptable.

5. A list of the manufacturer's recommended spare parts with the manufacturer's current price for each item. Include gaskets, packing, etc. on the list. List bearings by the bearing manufacturer's numbers only.

1.05 TOOLS AND SPARE PARTS

- A. One (1) set of all special tools required for normal operation and maintenance shall be provided. If no special tools are required then a statement to this effect shall be provided.

1.06 PRODUCT HANDLING

- A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the units and equipment are ready for operation.
- B. All equipment and spare parts must be properly protected against any damage during a prolonged period at the site.
- C. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.
- D. Each box or package shall be properly marked to show its net weight in addition to its contents.

1.07 WARRANTY

- A. Five (5) - year on-site warranty shall be provided such that the owner is not responsible for any warranty costs including travel, labor, parts, or other costs for a full 5 years from the date of manufacture of the Drive. The warranty shall cover all Drive failures including line anomalies – including lightning strikes, load anomalies, accidental exposure to moisture or corrosives and accidental collision of other physical damage; product misapplications, vandalism and chronic problems due to the misapplication are not covered. The cost of the warranty shall be included in the bid.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The CONTRACTOR is responsible for the start up of all VFD drives furnished on this project.
- B. The Contractor shall be responsible for the erection and installation of all equipment defined in this section of the contract documents.
- C. The variable frequency drive shall be comply with the latest applicable standards of ANSI, NEMA, IEEE, and the National Electric Code.
- D. Variable frequency drive shall operate as specified on standby generators or normal power sources.
- E. The CONTRACTOR shall provide a listing of all programmable parameters that are different from the factory default values. For each indicate:
 - 1. The factory default and meaning
 - 2. The revised value and meaning

2.02 CONSTRUCTION

- A. Each variable frequency drive shall consist of a 460V, 3-phase rectifier, DC link and variable frequency inverter with features, functions and options as specified. The inverter shall be voltage source design using pulse width modulation (PWM) techniques.
- B. The variable frequency drives shall be rated for continuously operating at 1.15 times the full load current of the motor. The variable frequency drives shall be designed to provide continuous speed adjustment of three-phase motors. The variable frequency output voltage shall provide constant volts-per-Hertz excitation to the motor terminals up to 60 Hertz.
- C. Inverters shall be capable of converting incoming three phase, 460V (+10 to -10%) and 60 Hertz (+/-2) Hertz power to DC bus levels. The DC voltage shall be inverted to a variable frequency output.
- D. Controllers shall be rated for an ambient temperature of 0°C to 40°C and humidity of 0 to 95% non-condensing.
- E. VFDs shall have complete front accessibility. All VFD openings shall be filtered.
- F. The following standard basic control features shall be provided on the inverter:

1. Start, Stop, "Power On" indicating light and speed control potentiometer. Terminations for remote mounted operator control devices shall be furnished.
2. Unidirectional operation, coast to rest upon stop.
3. Variable linear independent timed acceleration.
4. Variable torque performance from 4 to 60 Hertz.
5. All variable frequency drives shall be furnished with 5% input and output power line reactors.
6. Frequency stability of 2% for 24 hours with voltage regulation of +2% of maximum rated output voltage.
7. LCD status indication for Power On, Run, Inverter Enable, Overcurrent, Overvoltage, Overtemperature, Low Supply, and Phase Loss.
8. 115V AC control power for operator devices.
9. Phase insensitive to input power.
10. Automatic restart upon return of power following a utility outage. Drive shall require manual reset after three (3) attempts in a 60 second period.

G. The following protective features shall be provided on the drive:

1. Electronic overcurrent trip for instantaneous overload protection.
2. Undervoltage and phase loss protection of output.
3. Over-frequency protection.
4. Over-temperature protection.
5. Surge protection from input AC line transients.
6. Electrical isolation between the power and logic circuits, as well as between the 115V AC control power and the static digital sequencing.
7. Drive to be capable of withstanding output terminal line short or open circuits without component failure.

8. di/dt and dv/dt protection for converter semiconductors.
 9. Units shall have an English language (no codes) alphanumeric diagnostic display. LED indication of over frequency, instantaneous overcurrent, DC over voltage, AC undervoltage/loss-of-phase, emergency stop, overload, over temperature, inverter pole trip and standby modes shall be provided and door mounted. Additional door mounted status indicating LEDs for self-diagnostic including run, phase loss, micro-processor fault, as well as board mounted LEDs including one for each inverter pole gating signal, each inverter pole status and each logic level VDC used. A comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions is also approved.
- H. The following standard independent adjustments shall be provided on the inverter:
1. Minimum speed (12 to 54 HZ).
 2. Maximum speed (40 to 60 HZ).
 3. Acceleration time 6 to 60 Sec. (minimum).
 4. Deceleration time 6 to 60 Sec. (minimum).
 5. Volts per Hertz.
 6. Stability adjustment, if required.
 7. Voltage boost (100 to 600 percent of nominal V/HZ ratio at 1 HZ tapering to 100 percent at 20 HZ).
- I. The following shall be furnished with each controller:
1. Isolated process instrument speed input signal of 4-20 mA DC.
 2. Isolated process instrument speed output signal 4-20 mA DC.
 3. Relay output auxiliary contacts as shown on the drawings or as required herein, in Division
 4. Door-mounted output load ammeter, voltmeter, and speed output indicating meters.
 5. Built-in self diagnostics.
 6. Relay output auxiliary contacts as shown on the drawings.
 7. All openings in the VFD shall be filtered.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the locations shown on the Drawings. Field wiring shall be in accordance with manufacturer's recommendations. Anchor bolts shall be stainless steel and set in accordance with the manufacturer's recommendations.

3.02 SHOP PAINTING

- A. Prior to shop painting, all surfaces shall be thoroughly cleaned, dry, and free from all mill/scale, rust, grease, dirt, and other foreign matter.
- B. Drives shall be shop painted.

3.03 TESTING

- A. Tests and Check
 - 1. The drive manufacturer shall test the drive controller with a motor load prior to shipment. The motor shall have equal or greater full load current than the specified motor.
 - 2. A certified copy of all tests and checks performed in the field, complete with meter readings and recordings, where applicable, shall be submitted to the Owner.
- B. The CONTRACTOR shall provide the services of a competent and experienced equipment manufacturer's factory field engineer to supervise start-up and provide training to the Owner's personnel. The factory field engineer shall be available for one (1) - eight (8) hour day to inspect the installed equipment and supervise the start-up demonstration and testing. Start-up, and additional testing and training as specified herein. The factory field engineer shall be available for two (2) additional eight (8) hour days (a total of three (3) - eight (8) hour days) to provide factory and on-site training to the Owner's personnel as specified herein. Training of the Owner's personnel will only be considered valid for approval by the Engineer if it takes place after the successful start-up and demonstration test.

3.04 TRAINING

- A. The training and instruction shall be directly related to the System being supplied.
- B. The CONTRACTOR shall provide classroom training detailed manuals to

supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

- C. The Supplier shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to Owner.
- D. The training program shall represent a comprehensive program covering all aspects of the variable frequency drive and maintenance of the system.
- E. 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.
- F. Factory Training: Factory training shall be conducted before the System is commissioned, and subsequent to final manual submittals. Two days of factory training shall be provided and consist of schooling and hands on experience for two people covering the following:
 - 1. Theory of Operation
 - 2. Use of Software
 - 3. Troubleshooting
- G. On-site Training: On-site (field) training shall be conducted at the Owner's Plant Site and shall provide detailed hands-on instruction to Owner's personnel covering: system debugging, program modification, troubleshooting, maintenance procedures, calibration procedures, and system operation.

END OF SECTION

SECTION 16450
GROUNDING SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install a complete grounding system in strict accordance with Article 250 of the National Electrical Code and as hereinafter specified and shown on the Drawings.

1.02 RELATED WORK

- A. Wire shall be as specified under Section 16120.
- B. Conduit shall be as specified under Section 16110.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Ground rods: Ground rods shall be copperclad steel 5/8-inch x 20 foot. Ground rods shall be Copperweld or be an approved equal product. Install ground grid at new electrical building as shown on the plans.

PART 3 - EXECUTION

3.01 GENERAL

- A. The service entrance equipment ground bus shall be grounded to the ground grid as indicated on the Drawings. The protecting conduits shall be bonded to the grounding conductor at both ends. The CONTRACTOR shall not allow the water pipe connections to be painted. If the connections are painted, they shall be disassembled and remade with new fittings.
- B. Ground bus in all panelboards shall be connected to the service entrance equipment ground bus with a No. 1/0 conductor.
- C. All steel building columns shall be bonded together and connected to the building ground grid and to the service entrance ground with a No. 1/0 copper conductor. The bond wire for all well pumps shall be connected to the well pump casing via Cadweld.

- D. Conduits stubbed-up below a motor control center shall be fitted with insulated grounding bushings and connected to the motor control center ground bus. Boxes mounted below motor control centers shall be bonded to the motor control center ground bus. The grounding wire shall, unless otherwise indicated on the drawings, be sized in accordance with Table 250-122 of the National Electrical Code, except that a minimum No. 12 AWG shall be used.
- E. Motors shall be grounded as specified in Section 16150 and as shown on the electrical drawings.
- F. Lighting transformer neutrals shall be grounded to a grounding electrode and the service entrance ground.
- G. Grounding electrodes shall be driven as required. Where rock is encountered, grounding plates may be used in lieu of grounding rods.
- H. All equipment enclosures, motor and transformer frames, conduits systems, cable armor, exposed structural steel and similar items shall be grounded.
- I. Exposed connections shall be made by means of approved grounding clamps. Exposed connections between different metals shall be sealed with No-Oxide Paint Grade A or approved equal. All buried connections shall be made by welding process equal to Cadweld.
- J. For reasons of mechanical strength, grounding conductors extending from the plant grounding grid to the ground buses of control centers and unit substations shall be No. 1/0 AWG.
- K. The plant grounding grid conductors shall be embedded in backfill material around the structures.
- L. All underground conductors shall be laid slack and where exposed to mechanical injury shall be protected by pipes or other substantial guards. If guards are iron pipe or other magnetic material, conductors shall be electrically connected to both ends of the guard.
- M. The CONTRACTOR shall exercise care to insure good ground continuity, in particular between the conduit system and equipment frames and enclosures. Where necessary, jumper wires shall be installed.

3.02 TESTS

- A. The CONTRACTOR shall test the ground resistance of the system. All test equipment shall be provided by the CONTRACTOR and approved by the Engineer. Dry season resistance of the system shall not exceed 5 ohms. If

such resistance cannot be obtained with the system as shown, the CONTRACTOR shall provide additional grounding as directed by the Engineer, without additional payment. The Contractor shall submit all grounding system test results to the Engineer for review. The CONTRACTOR shall test the ground resistance of the system by 3 point method fall of potential.

END OF SECTION