

- FULL LIST OF TECHNICAL SPECIFICATIONS

PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP

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SECTION 01 30 00

SUBMITTALS

PART 1 GENERAL

1.01 EXTENT OF WORK

- A. The work to be done under this Section consists of submitting shop and working drawings, product data, certificates, instructional materials and samples.
 - 1. Related Section: Section 01 73 00 – Operation and Maintenance
- B. Specific technical requirements are specified in other Sections of these Specifications.
- C. Materials supplied for water main shall be in accordance with the relevant provisions of NSF 61, the Safe Drinking Water Act, and all amended provisions, where applicable.

1.02 WORK NOT INCLUDED

- A. Submittals directly to Owner or other party different than the Engineer will not be considered for review.

1.03 DRAWINGS, PRODUCT DATA AND CERTIFICATES

- A. The Contractor shall submit so as to avoid delay in this work, or that of any subcontractor, one electronic or three (3) paper copies of all shop, detail or working drawings, production data and certificates required for the work within ten (10) days of contract execution, and the Engineer shall review them noting comments. If required, the Contractor shall make corrections and resubmit one electronic or three (3) paper corrected copies for final review and furnish such other copies as may be needed. The Contractor shall direct specific attention in writing or on resubmitted drawings, data or certificates, to revisions other than those requested by the Engineer on previous submittals. A third submission from the same manufacturer will not be accepted.
- A. The Engineer's review of such drawings, data or certificates shall not relieve the Contractor from responsibility for deviations from the Contract Drawings or Specifications, unless he had in writing called the Engineer's attention to such deviations at the time of submission, and unless the Engineer shall have issued a written waiver of the pertinent Specification, nor shall it relieve him from responsibility for errors of any sort in shop drawings. The Engineer's review and approval or conditional approval of a submission that includes a deviation from the Contract Drawings or Specifications, without the Contractor having explicitly identified the deviation at the time of submission, shall be cause for resubmittal of the product and work stoppage if necessary. No time delay may be requested for work stoppage or additional submittal review period(s) by the Engineer.
- B. Prior to the submission of shop drawings to the Engineer for review, the Contractor shall thoroughly examine the details and check all dimensions. The Contractor shall be fully responsible for the accuracy, proper fit, and coordination of all parts of the work.
- C. All drawings, data and certificates shall be **properly identified** as the Engineer may require, the Contractor shall stamp each submission with a rubber stamp stating that he has examined and checked the submission as above and shall date and sign each. Any

submission that, upon examination by the Engineer, shows evidence of not having been thoroughly checked will be returned to the Contractor for completion of checking before it will be considered for review.

- D. If the Contractor submits for consideration and/or technical review a product or material that is substantially or significantly different, in the technical opinion of the Engineer or the Owner, than that which is in these specifications, the Contractor may be responsible for crediting the Owner a compensatory amount equal to the cost for the Engineer's time to review the different material or product. No time delay may be requested for additional submittal review period(s) by the Engineer for substantially different products or materials. The Contractor shall also at the time of submittal for consideration of the substituted product also submit a cost proposal (credit) for the adjustment.
- E. The Contractor shall provide ample time for the Engineer's review of submittals. The Contractor's failure to provide ample review time for the Engineer does not reduce the Engineer's time for review. A minimum of ten (10) working days shall be considered reasonable for basic submittals. A minimum of twenty (20) working days shall be considered reasonable for more technically involved submittals. The Engineer will review submittals in a timely manner.
 - 1. The Contractor may only proceed with fabrication and construction of items with returned submittals marked "No Exception Taken", "Approved as Noted", etc
 - 2. The Contractor shall resubmit submittals if marked "Rejected", "Revise and Resubmit" or "Submit Specified Item".

1.04 FILE TRANSFER

- A. The Contractor will be responsible for setting up an electronic file transfer site (MS-Teams, Sharepoint, etc) to be used for delivery of all project data (submittals, pay requests, change orders, etc).
- B. All parties will be responsible for uploading materials to the file transfer site for the use and approval by others and notifying the other parties of the file status.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION

SECTION 01 73 00

OPERATION AND MAINTENANCE MANUALS

PART 1 GENERAL

A. REQUIREMENTS INCLUDED

B. Obtaining and compiling product data, equipment manufacturers' data and related information required for maintenance of products for each site.

C. Preparing operation and maintenance data and instructions for systems and equipment.

D. Schedule of required submittals.

E. QUALITY ASSURANCE

F. Prepare instructions and data using personnel experienced in maintenance and operation of described products.

G. FORMAT

H. The Contractor shall submit electronic copies of O&M manuals.

I. Prepare data in the form of an instructional manual.

J. Binders: Commercial quality, 8-1/2 x 11 inch three-ring binders with hardback, cleanable, plastic covers; "D-ring" type. When multiple binders are used, correlate data into related consistent groupings.

K. Cover: Identify each binder with typed or printed title "OPERATION AND MAINTENANCE INSTRUCTIONS"; list title of Project and identify equipment covered by manual.

L. Arrange content by section numbers and provide Table of Contents.

M. Provide tabbed fly leaf for each separate product and system, with typed description of product and major component parts of equipment.

N. Text: Manufacturer's printed data, or typewritten data on 20 pound paper.

O. Drawings: Provide with reinforced punched binder tab. Bind in with text; fold larger drawings to size of text pages.

P. CONTENTS (EACH VOLUME)

Q. Table of Contents: Provide title of Project; schedule of products and systems, indexed to content of the volume.

R. For Each Product or System: List names, addresses and telephone numbers of subcontractors, manufacturers and suppliers, including local source of supplies and replacement parts.

S. Product Data: Mark each sheet to clearly identify specific products and component parts, and data applicable to installation; delete inapplicable information.

T. Drawings: Supplement product data to illustrate relationship of component parts of equipment

and systems. Show control and flow diagrams. Do not show operation and maintenance requirements on Project Record Documents.

- U. Typed Text: Prepare as required to supplement product data. Provide logical sequence of instructions for each procedure. Incorporate manufacturer's instructions for delivery, storage, assembly, installation, start-up, adjusting, finishing, operation and maintenance.
- V. MANUAL FOR MATERIALS AND FINISHES
- W. Building Products, Applied Materials, and Finishes: Include product data with catalog number, size, composition, and color and texture designations. Provide information for re-ordering custom manufactured products.
- X. Instructions for Care and Maintenance: Include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental cleaning agents and methods, and recommended schedule for cleaning and maintenance.
- Y. Moisture-protection and Weather-exposed Products: Include product data listing applicable reference standards, chemical composition, and details of installation. Provide recommendations for inspections, maintenance, and repair.
- Z. Additional Requirements: As specified in individual Specification sections.
- AA. MANUFACTURER'S MANUALS FOR EQUIPMENT AND SYSTEMS
- BB. Each Item of Equipment and Each System: Include a description of unit or system, and component parts. Give function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data, tests, and certifications where appropriate and complete nomenclature and commercial number of replaceable parts, where applicable.
- CC. Panel Board Circuit Directories: Provide electrical service characteristics and name of load on each branch circuit breaker.
- DD. Operating Procedures: Include start-up, break-in, and routine normal operating instructions and sequences. Include regulation, control, stopping, shutdown, and emergency instructions. Include summer, winter, and any special operating instructions.
- EE. Maintenance Requirements: Include routine procedures and guide for troubleshooting; disassembly, repair, and reassembly instructions; and alignment, adjusting and balancing instructions. Provide servicing and lubrication schedule, and list of lubricants required.
- FF. Controls: Provide the following:
- GG. Sequence of operation.
- HH. Original parts list, illustrations, assembly drawings, and diagrams required for maintenance.
- II. As-installed control diagrams.
- JJ. CONTRACTOR'S coordination drawings, with as-installed color-coded piping diagrams.
- KK. Charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
- LL. As-installed color-coded wiring diagrams.
- MM. Additional Requirements: As specified in individual Specification sections.

NN. SUBMITTALS

OO. Submit master list of operation and maintenance manuals to be submitted, arranged by specification section numbers, prior to submitting individual manuals. Submit one electronic and two (2) copies of a draft Operation and Maintenance Manual for equipment and component parts within 30 days after shop drawing acceptance. Manuals shall include all materials complying with the presentation and format requirements of this section. One (1) copy will be returned with ENGINEER'S comments.

PP. Submit one electronic and three (3) copies of revised manual in final form complying with ENGINEER'S comments within 30 days from the return of the reviewed manual. One (1) copy of the final manual will be returned.

QQ. SCHEDULE OF SUBMITTALS

RR. Operation and Maintenance Manuals conforming to this specification section and individual specification sections shall be submitted for the following equipment.

SS. The following schedule is not all inclusive of individual sections requiring operation and maintenance manuals. The CONTRACTOR remains responsible for operation and maintenance manuals for equipment both on the schedule and not on the schedule but called for in the individual specification sections.

<u>Section Number</u>	<u>Equipment Description</u>
11 31 60	Submersible Sewage Pumps / Shredder
26 00 00	Electrical
40 91 06	Level Measurement

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION

SECTION 11 31 60

SUBMERSIBLE PUMP STATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes a complete pre-packaged submersible pump station complete with submersible pumps, precast concrete wet well, valve chamber and force main cleanout/valve vault, shredder, slide rail pump removal system, discharge piping with required supports and fittings, discharge check valves, and plug valves, access hatches with safety grates, steps/rungs, liquid level controls, duplex pump control panel, internal wiring and other required appurtenances. All work to be in accordance with site requirements, details in the Plans, and the manufacturer's recommendations for a complete pump station packaged system.
 - 1. Wet Well: Includes structure, shredder, submersible sewage pumps, piping, and liquid level sensors, hatches, hoist and two hoist stands.
 - 2. Valve Chamber: Includes structure, piping, valves, quick disconnect fitting, pressure gauges, steps/rungs, hatch, vent.
 - 3. Force Main Cleanout/Valve Vault: Includes structure, piping, valves, quick disconnect fitting, steps/rungs, hatch.
 - 4. All necessary controls and electrical for new pumps and shredder.
- B. The Contractor shall comply with City of Suffolk Standard Specifications and all applicable governing codes unless otherwise indicated on the drawings".
 - 1. Pump Station Related Sections include the following:
 - a. Section 01 30 00 – Submittals
 - b. Section 01 73 00 - Operations and Maintenance Manuals
 - c. Section 14 61 00 – Hoist and Crane
 - d. Division 26 (all sections)
 - e. Division 40 (all sections)

1.03 GENERAL REQUIREMENTS

- A. Precast concrete units shall be designed and fabricated by an experienced and acceptable precast concrete manufacturer. The manufacturer shall have been regularly and continuously engaged in the manufacture of precast concrete units similar to that indicated in the project specifications or drawings for at least 10 years. In addition, the manufacturer shall employ a professional engineer registered in the State of Virginia.

1.04 DESIGN REQUIREMENTS

- A. Major elements and features of pump station are indicated to provide overall intent of system requirements. Coordinate and provide system complete in detail and ready for operation.
- B. Precast Underground Structures: Provide precast concrete units designed in accordance with ASTM C890 and provide anti-floatation measures with a safety factor of 1.2.

1.05 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01 30 00.
- B. General: Submit pump station drawings and literature (for structures, equipment, controls and accessories) together as one system submittal. Individual submittals will not be accepted.
- C. Product Data: Include rated capacities; furnished specialties; and accessories. Include the following and appurtenances associated with these systems.
 - 1. Precast concrete structures.
 - 2. Shredder.
 - 3. Pumps and seals.
 - 4. Guide rail and components.
 - 5. Hatches.
 - 6. Hoist.
 - 7. Vent.
 - 8. Liquid Level Transducer.
 - 9. Floats.
 - 10. Valves.
 - 11. Piping and appurtenances.
 - 12. Controls.
 - 13. Electrical components.
- D. Shop Drawings: Show fabrication and installation details for each structure, equipment, appurtenances, piping, and valves. Detail equipment assemblies and indicates dimensions, weights, loads, required clearances, method of assembly, components, and location and size of each field connection.
 - 1. Precast reinforced concrete structure plans and details.
 - 2. Pump base and slide rail, piping and valve plans and details.
 - 3. Wiring Diagrams: Power, signal, and control wiring.
 - 4. Shredder System: submit approval documents in pdf format, including equipment descriptions, functional descriptions, dimensional and assembly drawings, catalog data, job specific drawings, manufacturer's instructions, and recommended spares.
- E. Calculations:

1. Structural, loading and buoyancy calculations signed and sealed by a licensed professional engineer in the State of Virginia.
 2. Guide rail bracket structural calculations signed and sealed by a licensed professional engineer in the State of Virginia.
- F. Product Certificates: For sewage pumps, signed by product manufacturer.
1. Manufacturer certified performance of specified conditions for head, capacity, and efficiency.
 2. Include factory-tested pump curves for each pump provided:
 - a. Identify each pump by Model and Serial Number.
 - b. The pump must be tested at the specified operating speed(s).
 - c. The test points must span the published operating range of the pump and include dead head (zero flow) point and the specified operating point(s). No extrapolation of data is acceptable.
 - d. All test data and the certified curves shall be prepared and certified by a Registered Professional Engineer.
 - e. The manufacturer shall provide pumps with performance that meets or exceeds the specified head and flow while remaining within 90% of the electrical limits for the pump motor.
 3. Certify that operating point for pumps will not:
 - a. Be located within 10% of certified operating envelope/range.
 - b. That the motors provided with the pump can operate without overload within the certified operation range of the pump per requirements of HI Level 2U in accordance with Hydraulic Institute testing standards
- G. Management system certificate ISO 9001.
- H. Source quality-control certified test reports.
- I. Field quality-control test reports.
- J. Operation and Maintenance Manuals:
 1. See Section 01 73 00 "Operation and maintenance Manuals" .
- K. Warranties: Special warranties specified in this Section.
- L. The shredder supplier shall submit an operation & maintenance manual. The manual shall include equipment descriptions, operating instructions, drawings, troubleshooting techniques, a recommended maintenance schedule, recommended lubricants, and recommended spares.

1.06 QUALITY ASSURANCE

- A. Source Limitations: Provide pump station equipment from the same supplier with whom the responsibility for the proper function of all equipment, regardless of manufacturer, as an integrated and coordinated system shall be vested. This requirement is to establish unit responsibility for all the equipment with the equipment supplier. The use of the word responsibility relating to the equipment supplier is in no way intended to relieve the

Contractor's ultimate responsibility for equipment coordination, installation, operation, and guarantee.

- B. Installer Qualifications:
 - 1. An authorized representative of pumping station manufacturer for installation and maintenance of units required for this Project.
 - 2. An authorized representative of shredder manufacturer for installation and maintenance of units required for this Project.
- C. Manufacturer Qualifications: A qualified manufacturer.
- D. Product Options: Drawings indicate size, profiles, and dimensional requirements of pumping stations and are based on the specific system indicated.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. System Integrator: The identification and designation of an electrical-mechanical system integrator is a requirement of this Project.
- G. Shredder shall be identified with a corrosion-resistant nameplate affixed in a conspicuous location. Nameplate information shall include manufacturer's name and address, equipment model number, and serial number.

1.02 DELIVERY, STORAGE, AND HANDLING

- A. Deliver precast concrete units, pumps and shredder unit to Project site in such quantities and at such times to ensure continuity of installation. Store units at Project site to prevent cracking, distorting, warping, staining, or other physical damage, and so markings are visible.
- B. Lift and support units only at designated lifting and supporting points as shown on Shop Drawings.

1.03 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged pumping stations that fail in design, materials or workmanship 5 years from date of Substantial Completion.
- B. In the event a component fails to perform as specified or is proved defective in service during the warranty period, the manufacturer shall provide a replacement part without cost to the Owner. The Contractor shall further provide, without cost to the Owner such labor as may be required to replace, repair or modify major components such as the station structure, pumps, pump motors, shredder, drain piping manifold, etc.
- C. Pump and shredder warranties shall be provided by the pump manufacturer and a copy of the warranty statement shall be submitted with the approval drawings.

1.04 SPARE PARTS AND SPECIAL TOOLS

- A. The manufacturer shall furnish one set of any special tools necessary for normal operation, maintenance and calibration.
- B. Provide all manufacturer's recommended spare parts for each unit, as well as any spare parts identified in this specification section or the special requirements.
- C. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Impellers of appropriate size.
 - 2. Mechanical seal kits including upper and lower seals.
 - 3. O-Ring kits to permit routing service of pumps.
 - 4. Volute wear ring.
 - 5. Cable entry grommet assemblies.

1.05 MANUFACTURERS' SERVICES

- A. The manufacturer shall provide the services of a qualified service technician to provide start-up and training and ensure the equipment is installed in accordance with the manufacturer's recommendations and instructions. There shall be required a minimum of one-man day of field service, per pump station.
 - 1. Pumps and motors – (1) day
 - 2. Controls – (1) Day
 - 3. Shredder – (1) day
- B. The manufacturer's service engineer shall field adjust all pumps as required to place them in trouble-free operation. This service shall be performed at the request of the ENGINEER at the time or prior to start-up.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- B. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include but are not limited to, the manufacturers specified.
 - 2. Manufacturer: Subject to compliance with requirements, provide products by the manufacturer specified.

2.02 PRECAST CONCRETE UNDERGROUND PUMP STATION

- A. Conventional means, utilizing two (2) separate structures for the pump station wet well and the valve chamber will be provided; a one piece structure will not be accepted as an

equal. The Precast Structures shall be comprised of the least number of sections to keep the number of joints to a minimum.

- B. The pre-packaged pump station shall be built and tested off site to ensure product quality and consistency. The pre-packaged pump station vendor shall provide sole-source responsibility to the Owner through the warranty period.
- C. Wet Well, Valve Chamber and FM Cleanout/Valve Vault: ASTM C913.
 - 1. Design Load: A-16 (AASHTO HS20).
 - 2. Dimensions: Maintain indicated internal dimensions, clear.
 - 3. Horizontal Joints between precast sections shall be sealed with a vulcanized butyl rubber joint material conforming to AASHTO M-198. The joint material shall be "Conseal CS-102" as manufactured by Concrete Sealants or approved equal.
 - 4. Exterior Waterproofing: The system shall cause the concrete to become sealed against the penetration of liquids from any direction, and shall protect the concrete, surface to surface, from deterioration due to salt and acidic environmental conditions.
 - 5. The wet well and the area within 2 feet of the wet well has been classified as a Class 1, Division 1, A Hazardous Location as defined by the National Electrical Code. The shop drawings carry the manufacturer's certification that all equipment located in the subject area meets the requirements of NEC Class 1, Division 1 Criteria and the Underwriter's Laboratory (UL).
- D. Modular Seals: Modular mechanical assembly, with interlocking synthetic rubber links shaped to continuously fill annular space between pipe and wall opening.
 - 1. Water Pressure: 20 psig.
 - 2. Hardware: 316 stainless steel.
 - 3. Wall Opening:
 - a. New Structures: Manufacturer's non-metallic sleeve with an integrally formed water stop. Install end caps of the same material as the sleeve, at each end of sleeve.
 - 4. Available Manufacturers:
 - a. Link Seal Modular Seal by PSI/Thunderline/Link Seal.
 - b. Or approved equal.

2.03 SUBMERSIBLE SEWAGE PUMPS

- A. Manufacturer:
 - 1. Xylem, Flygt, Charlotte SC, or approved equal.
 - 2. Basis of Design Model: Flygt NP 3127 SH 248.
 - a. Quantity: Two
- B. PUMP DESIGN
 - 1. Pumps shall be submersible, closed-coupled wastewater pumps of the arrangement indicated on the drawings. Pumps impeller blades shall be self-cleaning upon each rotation. Pump performance criteria shall be as specified in this specification.

2. Materials of Construction:

- a. Pump housing: ASTM A-48 Cast iron, Class 35B.
- b. Impeller and insert ring: Class A 532 Alloy III (25% Chrome)
- c. Stator housing: ASTM A-48, Class 35B
- d. Shaft: ASTM A479 S43100-T.
- e. Shaft seal: Pump side: - Corrosion resistant Tungsten carbide WCCR
- f. Shaft seal Motor side: - Carbon-Aluminum oxide (AL₂O₃)

C. PUMP SCHEDULE

Description	Value
Number of pumps	2
Pump Tag	RW. P-1 & P-2
Pump Name	Wastewater Pumps
Location	1931 Bridge Road, Suffolk, VA
Pump Type	Submersible
Pump Arrangement	Vertical
Discharge Diameter.	3-inch
Flow & Head	Wet weather conditions: 115 gpm @ 126 ft Dry weather conditions: 161 gpm @ 116 ft
Efficiency	Wet weather conditions: 39.3 % Dry weather conditions: 48.4 %
NPSH _{re}	Wet weather conditions: 20.05 ft Dry weather conditions: 18.92 ft
Shutoff Head	158 ft
Motor Speed	3505 RPM
Motor Horsepower	11 hp
Voltage	208 volts, 3 phase, 60 hertz
Motor Enclosure	Submersible Explosion Proof, FM Class I, Division 1 (Group C & D)
Driver Arrangement	Close Coupled

D. MOTOR

1. The pump motor shall be induction type with a squirrel cage rotor, shell type design, housed in an air-filled, watertight chamber. It shall be permanently submersible according to standard IEC 60034 and protection class IP 68.
2. The motor shall be capable of no less than 30 evenly spaced starts per hour and be able to operate throughout the entire pump performance curve from shut-off through run-out even when the motor is not submerged.
3. The motor shall be equipped with 65 feet of screened cable suitable for submersible pump applications. The power cable shall be sized according to NEC and ICEA. The outer jacket of the cable shall be oil resistant chlorinated polyethylene rubber. The cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet.
4. The motor shall be protected by 3 thermal switches embedded in the stator set to open at 260°F and one leakage sensor floating type located in the stator chamber. The sensor and the switches shall be connected to the control panel which shall stop the motor and send an alarm when the sensors are activated.

E. IMPELLER

1. The impeller shall be mounted on the motor shaft. Couplings shall not be accepted.
2. The impeller blades shall be self-cleaning upon each rotation as they pass across a sharp relief groove in the Insert ring and shall keep the impeller blades clear of debris.
3. The clearance between the insert ring and the impeller leading edges shall be adjustable.

F. BEARINGS

1. The pump shaft shall rotate on two bearings. Motor bearings shall be permanently grease lubricated and have a nominal L10 lifetime of 50,000 hours.
 - a. The upper bearing shall be a single deep groove ball bearing.
 - b. The lower bearing shall be a two-row angular contact bearing to compensate for axial thrust and radial forces.
 - c. Single row lower bearings are not acceptable.

G. MECHANICAL SHAFT SEAL

1. Each pump shall be provided with a lubricant chamber for the shaft sealing system. The shaft shall be sealed by a tandem mechanical shaft seal system consisting of two seals, each having an independent spring system
 - a. The seals shall require neither maintenance nor adjustment and shall be capable of operating in either clockwise or counterclockwise direction of rotation without damage or loss of seal function.

H. COATING

1. All castings must be blasted before coating.
 - a. All wet surfaces are to be coated with two-pack oxyrane ester Duasolid 50.
 - b. The total layer thickness should be at least 120 microns.
 - c. Zinc dust primer shall not be used.

I. LIFTING CABLE OR CHAIN

1. Chain: Stainless steel, sized according to pump weight, of sufficient length to extend from top of pump unit to top of wet well
 - a. Provide with each pump.

2. Hook: Stainless steel, to attach to access hatch, for securing lifting chain when not in use.
 - a. Provide with each pump.

2.04 EQUIPMENT FOR WET WELL INSTALLATION:

- A. The pump station shall be supplied with a stainless-steel guide rail pump removal system, to facilitate emergency and routine maintenance in removing and re-installing the submersible pumps from the top of the station. The guide rail system will include lower guide brackets incorporated in the pump base elbow, 316-stainless upper guide brackets, 316-stainless intermediate guide brackets as may be required per the pump manufacture, and 316 stainless steel Sch 40 guide rails of size and quantity as dictated by the select pump manufacturer and model.
 1. Pump manufacturer to provide guide rail base elbow system.
- B. Guide rail components shall be assembled and installed plumb to the pump station structure and shall allow for pump removal and re-installation without interfering with the access hatch or frame. All assembly hardware shall be 316-stainless steel.
- C. For each pump the contractor shall supply and install a discharge connection made of cast iron ASTM A-48, Class 35B.
- D. The outlet flange of the discharge connection shall be 3" drilled according to ANSI B16.1-89; tab.5.
- E. The pump(s) shall be automatically and firmly connected to the discharge connection, guided by no less than two parallel guide bars extending from the top of the station to the wet well mounted discharge connection. The material of the guide bars shall Stainless steel AISI 316.
- F. There shall be no need for personnel to enter the wet-well.
- G. The sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal to metal contact. Sealing of the discharge interface with a diaphragm, O-ring or profile gasket will not be accepted. The entire weight of the pump/motor unit shall be borne by the pump discharge elbow. No portion of the pump/motor unit shall bear on the sump floor directly or on a sump floor mounted stand.

2.05 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 6/A 6M, W or HP shapes, or ASTM A36/A 36M, plates or beams.
- B. Grout: ASTM C 1107, Grade B, non-shrink cement grout.
Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

2.06 LEVEL SENSORS

- A. See Division 40 Section "Process Controls and Instrumentation".

2.07 SHREDDER

- A. Grinder shall be of two-shafted design consisting of individual cutters and spacers driven by hexagonal shafts. The cutters shall actively grab and pull material into the stack for shredding. Grinder shall have a main body housing with integral side rails, bottom end housing, top cover, and bottom cover. Grinder shall have a motor and speed reducer to drive the cutter shafts. The equipment shall operate at low speed with a maximum cutter shaft speed of 60 rpm.
- B. Manufacturer:
 - 1. Muffin Monster In-Channel Grinder Model # 10002-0008-DI, immersible as manufactured and supplied by JWC Environmental Inc. Santa Ana, CA.
 - a. Model: Muffin Monster: 10002-0008-DI meeting the following specifications and criteria.
 - b. Supplier shall be ISO9001 certified and have a minimum of 40 years' experience as a manufacturer of municipal wastewater equipment and a minimum of 1000 prior installations of similar equipment.
 - c. Supplier shall conduct factory testing and verification of equipment prior to shipment.
 - d. No substitutions will be allowed.
- C. Description: Motor-operated, cutter-design unit with controls; for equalization tank / wet well installation, capable of continuous operation, processing wet or dry.
 - 1. Design Flow Capacity: 182 GPM
 - 2. Cutter type: 11-tooth.
 - 3. Cutter Stack Height: 7-inches
 - 4. Shaft seal type: Mechanical, Tungsten Carbide
- D. Body: Stainless steel or ductile iron.
- E. Motor: Explosion-proof, TENV-XP Immersible.
 - 1. Horsepower: 3 HP.
 - 2. Phase: 3 phase
 - 3. Supply power characteristics: 208 volt / 3 phase / 60 Hertz
- F. Wall Mounting Frame and supports: Wall-mount, Type 304 stainless steel with stainless steel hardware. The frame shall allow installation or removal without any disassembly of the frame or grinder. Frame shall provide proper support and interface to prevent unwanted bypass.
- G. Housings and top cover shall be of ASTM A536 ductile iron. Bottom cover shall be of A36 carbon steel.
- H. Lifting Brackets: Grinder shall be fitted with two (2) lifting rings
- I. Motor Controller: Controller shall provide programmable operation of the grinder system. Controller shall have switches, indicator lights, and other control devices.

2.07 ACCESS HATCH AND SAFETY GRATE

- A. The S1R (single leaf) and S2R (double leaf) series access frames and covers as manufactured by Halliday Products, Inc. of Orlando, Florida shall have a ¼-in. thick one-piece, mill finish, extruded aluminum frame, incorporating a continuous concrete anchor. Door panel shall be ¼-in. aluminum diamond plate. Door shall open to 90 degrees and automatically lock with a T-316 stainless steel hold-open arm with an aluminum release handle. Door shall close flush with the frame. Hinges and all fastening hardware shall be T-316 stainless steel. Unit shall lock with a non-corrosive locking bar and have a non-corrosive handle.
- B. All access hatches to be supplied with integral safety grating systems. The protective grating panel shall be 1 inch aluminum "I" bar grating with Safety Orange powder-coated finish. Grating shall be hinged with tamper proof stainless steel bolts, and shall be supplied with a positive latch to maintain unit in an upright position. Grating shall have a 6-in. viewing area on each lateral unhinged side for visual observation and limited maintenance. Grating support ledges on 300 lb/ft² live load access covers shall incorporate nut rail with a minimum of four (4) stainless steel spring nuts. A padlock hasp for owner-supplied padlock shall be provided. Unit shall carry a Lifetime guarantee against defects in material and/or workmanship.
- C. Units shall carry a Lifetime Guarantee against defects in material and/or workmanship.
- D. Available Manufacturers:
 - 1. Halliday Products, Inc., Orlando, FL.
 - 2. Or approved equal.

2.09 ACCESS STEPS AND LADDER UP ASSEMBLY

- A. The valve chamber and force main cleanout/valve vault shall be supplied with copolymer polypropylene plastic-coated steel steps, 12" O.C. The steps shall be precast into wall section and shall meet OSHA standard 1910.27 requirements.
 - 1. Ladder Rungs: Ribbed and slip resistant.

2.10 PIPING AND FITTINGS

- A. Piping Internal to Structures:
 - 1. Pressure Pipe: ANSI/AWWA C115-A21.15, Class 53 ductile iron, flanged.
 - 2. Fittings: Flanged ductile iron, ANSI/AWWA C110-A21.10, Class 125.
 - 3. Lining: Double cement-mortar, ANSI/AWWA C104-A21.4
 - 4. Joint Restraint Device
 - a. Ductile Iron and PVC Pipe: Ductile iron, ASTM A536, Grade 65-45-12.
 - 5. Vent Pipe: Class 53 Ductile iron with passive carbon canister for odor control
 - 6. Condensate Drain: PVC, ASTM D1785, Schedule 80.
 - 7. Drain Pipe: PVC, ASTM D1785, Schedule 40.
 - 8. Pipe Supports and Accessories: Type 316 stainless steel.

2.11 VALVES

A. Gate Valves:

1. Resilient wedge Gate Valve: Cast-iron body with flanged ends and handwheel. AWWA Standard C-509 latest revision. Class 125 flanged valve body shall be rated for 250 psi.
2. Available Manufacturers:
 - a. Clow
 - b. Or approved equal.

B. Plug Valves:

1. Non-lubricated, quarter-turn, eccentric, 175 psi working pressure, with flanged ends, and resilient faced plugs, manually actuated with hand wheel.
2. Available Manufacturers:
 - a. Clow
 - b. Or approved equal.

C. Check Valves:

1. Air-Cushioned Check Valve: Cast-iron body with bronze trim and flanged ends. AWWA Standard C-508 latest revision. Class 125 flanged valve body shall be rated for 250 psi.
2. Available Manufacturers:
 - a. American Flow Company
 - b. Or approved equal.

2.12 PRESSURE GAUGES

A. Gauge: Black case with phosphor bronze bourbon tubes, bracket supported, with factory-mounted protective diaphragm attachment snubber to allow cleaning of lower diaphragm assembly without recalibrating gauge.

1. Available Manufacturers:
 - a. Ametek U. S. Gauge Division, Sellersville, PA.
 - b. Or approved equal.
2. Diameter: 4 ½ inches nominal.
3. Dial: Black figures with white plastic dial face.
4. Movement: Stainless steel rack and pinion.
5. Accuracy: 0.5 to 1 percent of scale range.
6. Bottom Connection: ¾ inch NPT male threaded connection.
7. Gauge Assembly: Complete with brass pipe and fittings, saddle, brass shutoff valve or a cock and tee with brass test cock arranged to allow field testing with 4-1/2 inch test gage. Include manufacturer's standard pulsation dampener.
 - a. Length of brass nipples: 2-inch minimum.

8. Discharge gauges shall be selected at the nearest standard range which provides a top limit 150 percent above the pump shut off head.

2.13 PRESSURE GAUGE SERVICE SADDLE

- A. Double strap service saddle with the following:
 1. Ductile Iron Body: ASTM A536, Grade 65-45-12.
 2. Finish: Shop coat paint or 10 mils of fusion-applied nylon.
 3. Bolts, Nuts and Washers: Type 304 stainless steel.
 4. Straps: Type 304 stainless steel with Teflon coated threads.
 5. Gasket: Suitable for sewer service.

2.14 FINISH COATING - PIPES, FITTINGS, AND VALVES

- A. Do not provide bituminous coating for valves or piping internal to structures.
- B. Shop Coat: One coat of rust-inhibitive primer.
 1. Available Manufacturers:
 - a. Koppers Co., Inc.
 - b. Inertol Rust Inhibitive Primer 621
 - c. Mobil Chemical Company
 - d. Chromox
 2. Field Primer Coat and Finish Coat: One coat of each.
 - a. Tnemec Company
 - b. 66-1211 Epoxoline Primer
 - c. Koppers Co., Inc.
 - d. Valspar.
 - e. Or approved equal

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of sewerage piping systems to verify actual locations of piping connections before pumping station installation.
 1. Field verify location and invert elevation of piping in relation to underground structures including wet well, valve chamber and valve vault.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 IDENTIFICATION

- A. Install identifying labels permanently attached to equipment.
- B. Install operating instruction signs permanently attached to equipment or on pumping station wall near equipment.

3.03 PRECAST CONCRETE UNDERGROUND STRUCTURES

- A. Install structures level and plumb.
- B. Install anti-floatation materials before backfilling.
- C. Install modular seals in accordance with manufacturer's instructions.
- D. Install Access hatch in accordance with manufacturer's instructions.

3.04 PUMP STATION COMPONENTS

- A. Install pump station components where indicated, according to specific equipment and piping arrangement indicated.
 - 1. Install pump equipment under supervision of manufacturer's service representative.
- B. Guide Rails. Anchor rails to wet well with brackets and bolts to prevent deflection.

3.05 CONNECTIONS

- A. Electrical power and wiring are specified in Division 26 Sections.
- B. Joint Restraint: Install devices at fittings, for sufficient length on either side of bends, on branch outlet of tees, and behind dead-ends.

3.06 PAINTING

- A. Prepare and paint ferrous piping in wet wells, structural-steel supports that are non-stainless steel with coal-tar epoxy-polyamide paint according to SSPC Paint 16.
- B. Paint field-welded areas to match factory coating.

3.07 ELECTRICAL WORK

- A. Perform instrumentation and control work and electrical work in accordance with the requirements of the appropriate Division 26 and Division 40 sections. Install systems to provide a complete and operational power and control system for the pump station and generator.

3.08 FIELD QUALITY CONTROL

- A. Perform field testing to verify proper installation and operation of pumps, accessories and electrical controls as a completely integrated, automatic, unattended pumping system. Repeat field testing
 - 1. Perform testing in presence of Owner, Engineer, and manufacturer's service representative.

2. Provide Owner with two days written notice of scheduled testing.
- B. Perform the following field quality-control tests and inspections and prepare test reports:
 1. Perform vacuum test on precast structures in accordance with requirements in the City of Suffolk Standard Specifications
 2. After installing pumping station equipment and after electrical circuitry has been energized, test for compliance with requirements. Furnish water required for pump tests.
 - a. At a minimum, test each pump for three cycles:
 - i. Two at normal starting levels to check operation and alternation of pumps; and
 - ii. One at highest level to check operation with both pumps running.
 - b. Pump Curve: Plot curve for each pump based on field data. Include at a minimum, shutoff head and three other points.
 3. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - a. Engage qualified factory trained personnel to test and verify valves are operational, voltage is correct; alarm sounds, illuminates and can be silenced; proper amperage while the pump is running; and pump turns on/off at the proper liquid level.
 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Test each alarm condition signal.
- C. Remove malfunctioning units, replace with new units, and retest as specified above.
- D. Remove and replace at no additional cost units rejected by Engineer. Engineer will reject units that do not operate free from vibration and heating, and that do not perform required service satisfactorily. Retest as specified above.

3.09 SHREDDER

- A. The Contractor shall coordinate installation of the equipment in accordance with the manufacturer's installation instructions, drawings and related specification sections, and in accordance with all OSHA, local, state, and federal codes and regulations.

3.10 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions.
 1. Adjust pump, accessory, and control settings, and safety and alarm devices.

3.11 CLEANING

- A. Clean dirt and debris from wet well, valve chamber, valve vault, pumps, and piping.

- B. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finishes to match original finishes.
- C. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove dirt and construction debris and repair damaged finishes.

3.12 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain shredder and pumping stations.
 - 1. Provide seven days written notice to Owner.
 - 2. Provide a minimum of Two days of training sessions for pumps & control and one day for shredder.

END OF SECTION

SECTION 14 61 00

HOIST AND CRANE

PART 1 GENERAL

1.01 DEFINITION AND EXTENT OF WORK

- A. CONTRACTOR shall provide all labor, material and equipment required to furnish and install, complete and make ready to operate one (1) portable hoist system with two (2) base units with accessories as herein described and as noted on the Drawings. One hoist and base unit shall be located for the purpose of removing the submersible pumps. The second base unit shall be located for the purpose of lifting the shredder.

1.02 SUBMITTALS

- A. Shop Drawings shall be submitted in accordance with Section 01 30 00. Shop drawings shall be reviewed concurrently with shop drawings for the structural components of the wetwell as well as the equipment components to be lifted. Shop drawings will not be approved until the shop drawings for the equipment they are to lift are approved and the shop drawings for the structural members supporting the crane bases are approved.
- B. Submit shop drawings or catalog cuts showing any special equipment or accessories.
- C. Operation and Maintenance Manuals shall be submitted in accordance with Section 01 73 00.

1.03 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 01 30 00 - Submittals
- B. Section 01 73 00 - Operations and Maintenance Manuals
- C. Section 11 31 60 – Submersible Pump Station

1.04 GUARANTEE

- A. All material, equipment and workmanship shall be guaranteed for the life of the equipment

PART 2 PRODUCTS

2.01 HOISTS

- A. Hoist specification is based on the following products as manufactured by Halliday Products:
 - 1. D3B with 36" reach and 1300-pound maximum load rating.
 - 2. The hoists shall be designed to be placed in a cast-in-place support provided by Halliday Products. A bolted-on base for each hoist shall also be provided.
 - 3. The Contractor may submit for acceptance any item meeting the specification as an "or equal product" for the Engineer's Review.
- B. Hoists
 - 1. Provide 304 Stainless Steel Construction.

2. Provide Marine Grade Brake Winch
3. Provide 30 feet of stainless-steel cable rated for maximum load.
4. Provide 1 ton lifting hook.

2.02 SPARE PARTS

- A. Spare parts shall be provided, as recommended by the manufacturer. Bolt on bases shall be provided and installed at the direction of the ENGINEER.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Equipment shall be installed in accordance with the manufacturer's recommendations.
- B. Coordinate location of cast-in-place base with precast manufacturer and supplier.

3.02 SYSTEM TEST

- A. After hoists have been erected and aligned, the hoist shall be given running tests. Test loads shall be a minimum of 90% and a maximum of 125% of the design load and shall be provided by the CONTRACTOR.
- B. Contractor shall demonstrate the use of hoist for the removal of sewage pumps and shredder from the wet well.

END OF SECTION

SECTION 26 00 00

BASIC ELECTRICAL

PART 1 GENERAL

1.01 SCOPE

- A. The CONTRACTOR shall provide the labor, tools, equipment, and materials necessary to furnish and install the complete electrical work in accordance with the plans and as specified herein. The work shall include but not be limited to the following:
1. Electrical duct banks, conductors, grounding, metering, etc.
 2. Complete power distribution systems including, over current devices, wiring devices, raceway, cable, wire and etc.
 3. All motor wiring, safety disconnects, and motor starters unless integral with equipment.
 4. Control wiring not provided by other Divisions.
 5. Complete grounding and surge protection system.
 6. All support material and hardware for raceway, cable tray and electrical equipment.
 7. Underground system.
 8. Termination of all cable and wire unless otherwise noted. This includes, but is not limited to, final termination of all control and instrumentation wiring in Process Equipment and Control panels and Consoles.
 9. Structure wall, floor and roof penetrations for raceway and cable tray.
 10. Fire rated and hazardous area sealing of all electrical penetrations.
 11. Miscellaneous equipment.
 12. Start up, acceptance testing test reports and instruction of systems operation to the OWNER.
- B. This Section also includes general construction materials and methods for application with electrical installations as follows:
1. Miscellaneous metals for support of electrical materials and equipment.
 2. Joint sealers for sealing around electrical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
 - a. Concrete used for the following:
 - 1) Housekeeping pads.

2) Pipe supports.

- C. Related Work. Division 26 is responsible for installation, wiring and raceways for electrically operated equipment, cabinet, starters, controls, instrumentation and related items furnished under other divisions. Division 26 shall furnish and install disconnect switches for equipment furnished under other divisions. This shall include but not be limited to the following:
 - 1. Process equipment control panels.
 - 2. Instrumentation.
 - 3. Mechanical equipment starters, disconnects, panels, etc.
- D. Related Work Not Included:
 - 1. Excavation and backfilling including gravel or sand bedding for underground electrical work, concrete encasement for conduit shall be performed by CONTRACTOR under other division of this specifications.
- E. Examination of Site:
 - 1. Before submitting a bid, visit and carefully examine site to identify existing conditions and difficulties that may affect the Work of this Section. No extra payment will be allowed for additional work caused by unfamiliarity with site conditions.

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this Section.

1.03 QUALITY ASSURANCE

- A. Codes and Standards. Perform all work associated with basic electrical materials in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein. Where provisions of the pertinent codes and standards conflict with this specification, the more stringent provision shall govern.
 - 1. Massachusetts Electrical Code (MEC).
 - 2. National Fire Protection Association (NFPA).
 - 3. Underwriters Laboratories, Inc. (UL).
 - 4. Local and State Building Codes.
 - 5. All electrical equipment shall be listed and labeled by UL or an approved independent nationally recognized electrical testing laboratory.

B. Inspector Certifications

1. Provide two copies of the electrical inspector's certificate of approved showing acceptability of work done under this contract.

1.04 SUBMITTALS

- A. Furnish manufacturer's product data, test reports, and materials certifications as required.
- B. Shop drawings shall be submitted to the OWNER'S REPRESENTATIVE for approval. Shop drawings shall identify the specific equipment and material being supplied; the quantity being supplied; and all accessories, dimensions, descriptions, mounting and connection details, wiring diagrams, elementary control diagrams, equipment interface diagrams and any other information necessary to determine compliance with the plans and specifications. Fabrication and installation shall be in accordance with the approved shop drawings.
- C. As-built copies of all shop drawings shall be submitted to the OWNER. This shall include but not limited to the following:
1. As built one-lines.
 2. Control Panels.
 3. Auxiliary devices.
- D. Permits and Easements. Submit copies of reports, permits, and easements necessary for installation, use, and operation.
- E. Test Reports. Submit copies of reports of tests, inspections, and meter readings as specified. Tests, inspections, and meter readings shall be performed using the temporary power source unless otherwise specified.

1.05 RECORD DRAWINGS

- A. Maintain a complete and separate set of prints of Contract Drawings and specifications at job site for duration of the contract. Record work completed and all changes from original Contract. Drawings shall clearly and accurately include work installed as a modification or as an addition to the original design.
- B. At completion of work and prior to final request for payment, submit a complete set of reproducible record drawings showing all systems as actually installed.

1.06 JOB CONDITIONS

- A. Existing Conditions:
1. Maintain and protect existing building services, which transit the area affected by selective demolition.
 2. Existing Utilities. Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.

3. Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.
4. Verify that the electrical installation may be made in complete accordance with all pertinent codes and regulations and the original design.

B. Coordination.

1. Coordinate the installation of electrical items with the schedules for work of other trades to prevent unnecessary delays in the total work.
2. Coordinate with all utility and telephone companies and make all installations for their services in accordance with all utility company requirements.
3. Any changes shall be done at the contractor's expense.
4. Where lighting fixtures and other electrical items are shown in conflict with locations of structural members and mechanical or other equipment, furnish and install all required supports and wiring to clean the encroachment.
5. Any work installed contrary to or without acceptance by the OWNER shall be subject to change as directed by the OWNER, and no extra compensation will be allowed to the CONTRACTOR for making these changes.

C. Accuracy of Data:

1. The Drawings are diagrammatic and functional only, and are not intended to show exact circuit layouts, number of fittings, components and place in satisfactory operational power, lighting, and other electrical systems shown. Install additional circuits, components and material wherever needed to conform to the specific requirements of the equipment whether or not indicated or specified.
2. Information and components called for in the specification but not shown on plans or vice versa, shall apply and shall provided as though required expressly by both.
3. The locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Field measurements shall take precedence over scaled dimensions from Drawings. Exact locations shall be as accepted by OWNER 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 OWNER and furnish all labor and materials necessary to complete the work in an acceptable manner.
4. The Contract Drawings and the specifications are intended to comply with all pertinent codes, regulations and standards. In the event of discrepancy, the CONTRACTOR shall immediately notify the OWNER in writing of said discrepancies and apply for an interpretation and, unless an interpretation is offered in writing by the OWNER prior to the execution of the Contract, the applicable rules and regulations shall be complied with as a part of the Contract.

5. In case of difference between building codes, specifications, state laws, industry standards and the Contract Documents, the most stringent shall govern. Should the CONTRACTOR perform any work that does not comply with the requirements of the applicable building codes, state laws, and industry standards, he shall bear all cost arising in correcting these deficiencies.
6. Verify size and ratings of motors and other electrically operated devices supplied by others.
7. Check with OWNER before installation of work for outlets not specified as to location or for work that interferes with other trades.

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Protection. Use all means necessary to protect electrical system materials before, during and after installation and to protect the installed work and materials of all other trades.
- B. Replacements. In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the OWNER and at no additional cost to the OWNER. 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 OWNER, at the cost and expense of the CONTRACTOR, or shall be replaced by the CONTRACTOR at his own expense.
- C. Protect the work of other trades. Restore any damage caused to other trades to the condition existing prior to damage at no additional cost to the OWNER.
- D. Investigate each space in the building through which 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.

1.08 SPECIAL WARRANTY

- A. Compile and assemble the warranties specified in Division 26 into a separate set of vinyl covered three ring binders, tabulated and indexed for easy reference.
- B. Provide complete warranty information for each item. Information to include:
 1. Product or equipment list.
 2. Date of beginning of warranty or bond.
 3. Duration of warranty or bond.
 4. Names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.09 DEFINITIONS

- A. As used in this specification, "provide" means "furnish and install", "furnish" means "to purchase and deliver to the project site complete with every necessary appurtenance and support and to store in a secure area in accordance with manufacturers instructions", and "install" means "to unload at the delivery point at the site or retrieve from storage, move to

point of installation and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project".

- B. Finished Areas. In general, areas with carpet or tile floors, lay-in or fixed ceiling tile, special architectural ceiling treatment, or tiled, plastered, or paneled walls shall be considered finished areas.
- C. Interior. For the purposes of this specification, interior is any area within the boundaries of the foundation of any building within the superstructure or other structures not classified as a building.

1.10 TEMPORARY POWER:

- A. The CONTRACTOR shall furnish, install, maintain, and remove the temporary electrical power and lighting systems, including lamps, and pay for all labor, materials, and equipment required therefore. All such temporary electrical work shall meet the requirements of the National Electrical Code, the local utility company, and OSHA.
- B. The CONTRACTOR shall secure and pay for all required permits and back charges for work performed by others, and other expenses incidental to the installation of the temporary electric service.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Materials and equipment shall be listed by UL unless it can be demonstrated that no UL standards exist for a specific item or class of equipment.
- B. All other materials, not specifically described but required for a complete and operable electrical installation, shall be new, first quality of their respective kinds, specification grade or better, and as selected by the CONTRACTOR subject to the acceptance by the OWNER.

2.02 INTERCHANGEABILITY

- A. In all design and purchasing, interchangeability of items of equipment, subassemblies, parts, motors, starters, relays and other items is essential. All similar items shall be of the same manufacturer, type, model and dimensions.
- B. For ease of maintenance and parts replacement, to the maximum extent possible, use equipment of a single manufacturer.
- C. The OWNER reserves the right to reject any submittal which contains equipment from various manufacturers if suitable materials can be secured from fewer manufacturers and to require that source of materials be unified to the maximum extent possible.

PART 3 EXECUTION

3.01 COORDINATION

- A. Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.
- B. Field verify all locations and dimensions to ensure that the equipment will be properly located, readily accessible, and installed in accordance with all pertinent codes and regulations, the contract documents, and the referenced standards.
- C. The work shall be carefully laid out in advance, and where cutting, drilling, etc., of floors, walls, ceilings, or other surfaces is necessary for the proper installation, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the OWNER.
- D. In the event any discrepancies are discovered, immediately notify the OWNER'S REPRESENTATIVE in writing. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.02 INSTALLATION

- A. Install all equipment and fixtures in complete accordance with the manufacturer's recommendations and all pertinent codes and regulations.
- B. Thoroughly inspect all items of equipment and any items dented, scratched, or otherwise damaged in any manner shall be replaced or repaired and painted to match original finish.
 - 1. All items so repaired and refinished shall be brought to the attention of the OWNER for inspection and acceptance.
- C. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete or supported from or on other structural components, as they are constructed.
- D. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing in the building and equipment which must be placed in service before further construction can take place.
- E. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
- F. The final routing of raceways shall be determined by structural conditions, interference with other trades and by terminal locations on apparatus. The OWNER reserves the right of a reasonable amount of shifting at no extra cost up until time of roughing in the work.
- G. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation.

- H. In general, wiring and raceway systems for security alarm, fire alarm, telephone and intercommunications systems are not indicated on the drawings but shall be furnished and installed under this Section.
- I. Each lighting and each receptacle circuit shall have its own neutral, dedicated to that circuit. A common neutral for more than one signal phase circuit is not allowed.
- J. Surface mounted panel boxed, junction boxes, conduits, etc., shall be supported by spacers to provide a clearance between wall and equipment.
- K. Upon completion of all installation, lamping, and testing, thoroughly inspect all exposed portions of the electrical installation and completely remove all exposed labels, soils, markings and foreign material.

3.03 MARKING AND LABELING

- A. All panelboards, indoor transformers, cabinets, control panels and other specified equipment shall be labeled with engraved laminated plastic plates, minimum $\frac{3}{4}$ " high with $\frac{3}{8}$ " engraved letters. Punch tapes with mastic backings are not acceptable.
- B. All starters, disconnect switches and other specified equipment shall be marked with engraved laminated plastic plates, minimum $\frac{1}{2}$ " high with $\frac{1}{4}$ " engraved letters. Where individual switches are circuit breakers in power or distribution panelboards do not have cardholders, they shall be marked with $\frac{1}{2}$ " high labels.
- C. All empty conduits shall have labels tied to the pull string at each end of each empty conduit, marked as to identification of each end. Junction boxes with circuits provided for future use shall be labeled with appropriate circuit designation.
- D. All panelboards directories shall be filled out with typewritten identification of each circuit.

3.04 TESTS & SETTINGS

- A. Provide the services of an independent Testing Agency to perform the specified tests for the following systems:
 - 1. Harmonic analysis for variable frequency drives.
 - 2. Ground resistance.
- B. The Testing Company shall perform all testing in accordance with National Electrical Testing Association (NETA) standards and procedures. All testing results shall be submitted on NETA forms and the testing data shall be certified by the respective Agency. Test results shall indicate recommended action for a sub-par test results. Results shall list recommended test values that should be obtained for new installation.
- C. Provide necessary material, equipment, labor and technical supervision to perform and complete the Electrical Acceptance Tests as required.
- D. Acceptance tests as herein specified are defined as those tests and inspections required to determine that the equipment involved is acceptable as delivered to the job site, that the equipment may be energized for final operational tests and is in accordance with the Specifications.

- E. Final acceptance of the equipment and/or workmanship will depend upon performance characteristics as determined by the subject tests, in addition to complete operation tests, on all electrical equipment to show that it will perform the functions for which it was designed.
- F. If the test and inspection data submitted should indicate deficiencies in the operation of the electrical apparatus or in the manufacturer thereof, the CONTRACTOR shall promptly implement the necessary adjustments, corrections, modifications and/or replacements necessary to be made to meet the specified requirements.
- G. Upon completion of the remedial work, the Testing Agency shall repeat all of the tests on components previously found deficient on the first test or any additional test if they are required. It shall be the responsibility and obligation of the Contractor to have all remedial work accomplished as may be required by second and/or additional tests.

3.05 CLEANING

- A. General. When all work is completed and has been tested and accepted by the OWNER'S REPRESENTATIVE, the CONTRACTOR shall clean all light fixtures, equipment, and exposed surfaces that have been directly affected by this work. The CONTRACTOR, insofar as the work is concerned, shall at all times keep the premises in a neat and orderly condition and at the completion of the work shall properly clean up and remove from the site any excess materials.

END OF SECTION

SECTION 26 05 15
INDUSTRIAL CONTROL PANELS

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR shall provide complete industrial disconnect switches as indicated herein or in other Sections of the Specifications.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Industrial disconnect switches shall comply with the requirements of NEC (including Article 409), NEMA, and UL.

1.3 CONTRACTOR SUBMITTALS

- A. Furnish Shop Drawings in accordance with Sections 26 00 00 – Electrical Work, General.
 - 1. Include catalog cuts of control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. The CONTRACTOR shall provide the disconnect switches to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation and Control specifications and the Electrical Elementary Schematics. Each panel and station shall be fabricated with UL labeled components. Equipment not specifically indicated as being WORK of other Sections shall be provided under this Section. All equipment, panels and stations shall be wired under this Section.
- B. Disconnect Switches
 - 1. Heavy duty, fusible, single throw switches shall be rated not less than 65 KA at 480 VAC.
 - 2. Horsepower rated
 - 3. UL listed
 - 4. Padlockable in "Off" position and door interlock
 - 5. Enclosure per area classification in Section 26 00 00 – Electrical Work, General.
 - 6. 480 V, 3-phase, 3-pole.
 - 7. Auxiliary control contact as applicable and where indicated.
 - 8. As manufactured by **G.E., Eaton Electrical, Square D**, or equal.
- C. Identification of electrical components shall be in accordance with Section 26 00 00 – Electrical Work, General.

- D. Panel-mounted devices shall be mounted a minimum of 3-feet above finished floor elevation, but not higher than 6'-6" above finished floor, unless noted otherwise.

PART 3 -- EXECUTION

3.1 INSTALLATION

- A. Panels/stations shall be installed in accordance with in Section 26 00 00 – Electrical Work, General and in accordance with the manufacturer's recommendations.
- B. Panels/stations shall be protected at the site from loss, damage, and the effects of weather. Panels/stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.
- C. Panels/station interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.
- D. Conduit, conductors, and terminations shall be installed in accordance with Section 26 00 00 – Electrical Work, General.

3.2 FIELD TESTING

- A. Each panel/station shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

END OF SECTION

SECTION 26 05 19

WIRE AND CABLES

PART 1 GENERAL

1.01 SCOPE

- A. The CONTRACTOR shall provide the labor, tools, equipment, and materials necessary to install wires, cables, and connectors in accordance with the plans and as specified herein.
- B. This Section includes wires, cables, and connectors for power, lighting, signal, control, and related systems rated 600 volts and less.

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this Section.
- B. Related Sections:
 - 1. Section 26 00 00 Basic Electrical

1.03 QUALITY ASSURANCE

- A. Reference Standards:
 - 1. National Fire Protection Association (NFPA) 70 "National Electrical Code (NEC)."
 - 2. Underwriter's Laboratories, Inc. (UL) Compliance.
 - a. UL Standard 83 Thermoplastic Insulated Wires and Cables.
 - b. UL Standard 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 - c. UL Standard 854 Service Entrance Cable.
 - 3. National Electrical Manufacturers Association (NEMA) Compliance.
 - a. WC-5 Thermoplastic Insulated Wire and Cable for the
 - b. WC-7 Cross Linked Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - c. WC-8 Ethylene Propylene Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - 4. Institute of Electrical and Electronic Engineers (IEEE) Compliance.
 - a. Standard 82 Test Procedure for Impulse Voltage Tests on Insulated Conductors.

1.04 SUBMITTALS

- A. Furnish manufacturer's product data, test reports, and materials certifications as required.
- B. Submit the following in accordance with Conditions of Contract and Division 1 specification sections:
 - 1. Product data for electrical wires, cables, and connectors.
 - 2. Product data for Megger insulation testing instrument.
 - 3. Report sheets for Megger testing.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver wire and cable properly packaged in factory fabricated type containers, or wound on NEMA specified type wire and cable reels.
- B. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General
 - 1. Provide factory fabricated wires of sizes, ampacity ratings, and materials for applications and services indicated. Where not indicated, provide proper wire selection as determined by Installer to comply with project's installation requirements, NEC and NEMA standards. Select from the following UL types those wires with construction features which fulfill project requirements:
 - 2. Provide color coding for phase identification in accordance with requirements in Section 26 05 53.
 - 3. Provide factory applied nylon or polyvinyl chloride (PVC) external jackets on wires and cables for pulls in raceways over 100 feet in length, for pulls in raceways with more than three equivalent 90 degree bends, for pulls in conduits underground or under slabs on grade, and where indicated.
- B. Service Wiring:
 - 1. 98 percent conductivity copper.
 - 2. 600 volt insulation, type RHW-RHH.
 - 3. U.L. listed for underground use in wet locations at 75° C.
- C. Building Wiring:
 - 1. 98 percent conductivity copper.

2. 600 volt insulation, type XHHW-2.
3. Stranded conductor
4. Minimum branch circuit: #12 AWG.
5. Minimum control wiring: #14 AWG, unless otherwise indicated.

D. Instrumentation

1. Instrumentation wiring for remote monitoring of equipment shall be #14 AWG, copper stranded.
2. Instrumentation wiring for transmitting 4-20mA DC signals shall be shielded, 2-conductor, minimum #16 AWG, equal to Belden No. 8179.

E. Splices:

1. Compression connectors shall be Burndy "Hi Lug", Thomas & Betts "Shure Statek", or equal. Threaded connectors, and pressure type, twist-on connectors will not be acceptable
2. General purpose insulating tape shall be Scotch No. 33, Plymouth "Slip-knot", or equal. High temperature tape shall be polyvinyl as manufactured by Plymouth, 3M, or equal
3. Wire connector systems for use with underground conductors shall be UL listed specifically for such use.
4. Service entrance conductors shall be installed without splices. Electrical equipment feeders shall be spliced only where shown or specifically approved. Control and metering conductors shall be installed without splices.
5. All splices shall be made only by specific permission of the OWNER and then only in manholes or pull boxes and shall be sealed watertight with a heat shrunk insulation.
6. Tighten electrical connectors and terminals in accordance with manufacturer's published torque tightening values. Where manufacture's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B.
7. Use UL listed splice for all underground wires, ducts buried, in conduit and in ducts. Connectors and splices shall be waterproof.

2.02 ACCEPTABLE MANUFACTURERS

A. Wire and Cable.

1. American Insulated Wire Corp.
2. Brintec Corp.

3. Carol Cable Co., Inc.
 4. Pirell.
 5. General Cable.
 6. Rome.
 7. Triangle.
- B. Connectors and Terminals for Wires and Cable Conductors.
1. AMP.
 2. Burndy Corporation.
 3. Ideal Industries, Inc.
 4. 3M Company
 5. O-Z/Gedney Co.
 6. Raychem.
 7. Thomas and Betts Corp.

PART 3 EXECUTION

3.01 WIRE AND CABLE INSTALLATION

- A. All wire and cables shall be installed in conduit of size and type indicated on the drawing and specifications.
- B. Install electrical cables, wires, and connectors in compliance with NEC.
- C. Coordinate cable installation with other work.
- D. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.
- E. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.
- F. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours, where possible.
- G. Power conductors shall be No. 12 AWG minimum. Control conductors may be No. 14 AWG where circuit amperes and the NEC allow and when length does not pose a voltage drop problem.
- H. Conductors shall be sized such that voltage drop does not exceed 3 percent for branch circuits or 5 percent for feeder/branch circuit combination.

- I. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.
- J. All feeder and branch circuit wiring shall be color coded at all termination and splice locations. System neutrals shall be designated in addition to phase conductors. Equipment grounds shall be green.
- K. The number of conductors shown on the Drawings is not necessarily the correct number required. As many conductors as are required in each case shall be installed.

3.02 FIELD QUALITY CONTROL

- A. Test each electrical circuit after permanent cables are in place with terminators installed, but before cable or wire is connected to equipment or devices to demonstrate that each circuit is free from improper grounds and short circuits.
- B. Megger Test, the insulation resistance between phases and from each phase to ground for each of the following feeder and motor branch circuits:
 - 1. Panelboards.
 - 2. Motors.
- C. The Megger Testing shall be witnessed by the OWNER. The OWNER shall be notified at least 48 hours in advance of testing.
- D. Measure the insulation resistance at 1000 volts dc with a hand cranked or motor driven "Megger" insulation testing instrument for one minute duration. Battery operated test instruments are not permitted. All test instruments are to be provided by the CONTRACTOR.
- E. If any insulation resistance measures less than 50 megohms, the cable shall be considered faulty with the cable failing the insulation test. In moist environments, bag the ends of the cable to prevent a faulty Megger test.
- F. Any cable which fails the insulation tests or which fails when tested under full load conditions shall be replaced with new cable for the full length and retested at no additional cost to OWNER.
- G. The below grade service or feeder splice shall be water immersion Megger tested in the presence of the OWNER. Each splice shall be immersed in a grounded water immersion bath for 24 continuous hours prior to and during the test. Criteria for failure shall be as described for cable above.

END OF SECTION

SECTION 26 05 26

GROUNDING

PART 1 GENERAL

1.01 SCOPE

- A. The CONTRACTOR shall provide the labor, tools, equipment, and materials necessary to furnish and install grounding materials in accordance with the plans and as specified herein.
- B. Grounding. This Section includes solid grounding of electrical systems and equipment.

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this Section.
- B. Related Sections
 - 1. Section 26 00 00 - Basic Electrical
 - 2. Section 26 05 19 - Wires and Cables

1.03 QUALITY ASSURANCE

- A. Reference Standards.
 - 1. "Massachusetts Electrical Code" (MEC), as applicable to electrical grounding and bonding, Art. 250. Use of conduit system for ground conductor shall not be allowed.
 - 2. Underwriters' Laboratories, Inc. (UL). UL 467 "Electrical Grounding and Bonding Equipment."
 - 3. Institute of Electrical and Electronic Engineers (IEEE) IEEE 81 and 142.
 - a. 80-1986, "IEEE Guide for Safety in AC Substation Grounding."
 - b. 81-1983, "IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounded System (Part 1)."
 - c. 141-1993, "IEEE Recommended Practice for Electric Power Distribution for Industrial Plants."
 - d. 142-1991, "IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems."

1.04 SUBMITTALS

- A. Submit the following in accordance with Conditions of Contract and Division 1 specification sections:
 - 1. Submit manufacturer's product information for connectors, clamps, and all grounding system components, showing compliance with the requirements of this Section.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Provide each electrical grounding system with assembly of materials required for complete installation including wires/cables, connectors, lugs, clamps, ground rods, bonding jumpers and accessories.
- B. Provide electrical grounding conductors for grounding connections matched to power supply wiring materials and sized according to N.E.C.
- C. Provide electrical connectors, lugs, clamps, bonding jumpers and accessories as recommended by the respective manufacturer for the particular application, unless other indicated.
- D. Ground rods; copper-clad steel conforming to ANSI/UL 467, 3/4-inch diameter by 10 feet long.
- E. Insulated conductors: Green in color.
- F. Ground Bus. Bare annealed copper bars of rectangular cross section, 1/4" x 3" x length as required, with 98 percent conductivity, rigidly attached to structure.
- G. Bonding Strap Conductor/Connectors. Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.
- H. Pressure Connectors. High conductivity plated units.
- I. Bolted Clamps. Heavy duty units listed for the application.
- J. Exothermic Welded Connections. Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

2.02 ACCEPTABLE MANUFACTURERS

- A. Copperweld
- B. Thermoweld
- C. Burndy
- D. Thomas and Betts
- E. OZ Gedney

PART 3 EXECUTION

3.01 GROUNDING AND BONDING

- A. Ground main service entrance distribution panel ground bus or lug to neutral of incoming service, to enclosure, to building steel and to main cold water pipe. Install grounding bushings or service conduits.
- B. Provide equipment grounding conductors in all conduits containing power, control, or instrumentation conductors on the load side of the service equipment or on the load side of a separately derived system.
- C. Comply with MEC Article 250 for sizes and quantities of equipment grounding conductors, except that larger sizes indicated or shown on the Contract Documents shall take precedence. Use of metallic conduit systems for equipment grounding as recognized by the MEC shall not be permitted under this specification.
- D. Separately derived systems required by MEC to be grounded shall be grounded in accordance with MEC 250-26.
- E. In addition, bond the grounded conductor of the separately derived system to the nearest available point on the interior metal water piping system, per MEC 250-80(a), or if no water piping extend to main service disconnect ground.
- F. Install grounding bushings on conduits at both primary and secondary entrances to transformers. Ground transformer enclosures to bushings.
- G. Install bonding jumper for flexible metal conduit unless fittings are approved for grounding or otherwise comply with N.E.C.
 - 1. Size jumper to match over-current device.
 - 2. Green insulation.
 - 3. Connect to grounding bushing at each end.
- H. Ground each metal lighting pole or standard with a common bare copper equipment grounding conductor run with the circuit conductors.
- I. Ensure that entire electrical system is electrically continuous and permanently and effectively grounded, including all electrical equipment and motors.
- J. Locate ground rods with a minimum of one rod length from each other and at least the same distance from any other grounding electrode. Connect ground conductors to ground rods by means of exothermic welds except at test wells and as otherwise indicated. Drive rods until tops are 24 inches below finished floor or final grade except as otherwise indicated.
- K. Route grounding electrode conductors along the shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated.

- L. Ensure that grounding electrode conductor connections to interior piping, structural members, and the like are accessible for periodic inspection during the life of the structure.

3.02 BONDING FOR OTHER TRADES

- A. Signal raceways, water piping, heating piping and metallic air ducts shall be bonded together and to the grounding conductor with No. 8 soft drawn bare solid conductors. Connections to pipes shall be made with cast clamps of like material as the pipes to which attached, to ducting terminated in a secure manner by best practical means, bonding across any flexible or insulated connections.
- B. All bonding conductors shall be installed in a neat and workmanlike manner, properly shaped for contour of surface involved and properly supported. At locations remote from the switch gear, bond to the largest raceway nearby.

3.03 FIELD QUALITY CONTROL

- A. Independent Testing Organization. Arrange and pay for the services of a qualified independent electrical testing organization to perform tests described below.
- B. Measure ground resistance without the soil being moistened by any means other than natural precipitation or natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the three point fall of potential method in accordance with Section 9.03 of IEEE 81. Simple moisture addition is not acceptable.
- C. Ground/resistance maximum values shall be as follows:
 - 1. Equipment rated 500 kVA and less. 10 ohms.
 - 2. Equipment rated 500 kVA to 1000 kVA. 5 ohms.
 - 3. Equipment rated over 1000 kVA. 3 ohms.
 - 4. Unfenced substations and pad mounted equipment. 5 ohms.
 - 5. Fence Grounds. 10 ohms.
- D. Where ground resistances exceed specified values, and if directed, modify the grounding system to reduce resistance values. Where measures are directed that exceed those indicated under the provisions of the Contract, covering change orders will be provided.

END OF SECTION

SECTION 26 05 33

RACEWAY

PART 1 GENERAL

1.01 SCOPE

- A. The CONTRACTOR shall provide the labor, tools, equipment, and materials necessary to install raceways in accordance with the plans and as specified herein.
- B. All raceway systems shall be complete with fittings, boxes, and necessary connections as required.
- C. Types of raceways in this Section include the following:
 - 1. Liquid tight flexible conduit.
 - 2. Rigid galvanized steel conduit (RGS).
 - 3. Rigid nonmetallic conduit (PVC).
 - 4. Wireways.
 - 5. Underground ducts.

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this Section.
- B. Related Sections. The following sections contain requirements that relate to this Section:
 - 1. Section 26 00 00 Basic Electrical
 - 2. Section 26 05 19 Wires and Cables (for other wiring methods).

1.03 QUALITY ASSURANCE

- A. Reference Standards:
 - 1. National Fire Protection Association (NFPA) 70 "Massachusetts Electrical Code" (MEC).
 - 2. National Electrical Manufacturers Association (NEMA) Compliance.
 - 3. Underwriter's Laboratories, Inc. (UL) Compliance and Labeling. Provide raceway products and components listed and labeled by UL, Electrical Testing Laboratories (ETL), or Canadian Standards Association (CSA).

1.04 SUBMITTALS

- A. Furnish manufacturer's product data, test reports, and materials certifications as required.

- B. Submit in accordance with Conditions of Contract and Division 1 specification sections:

PART 2 PRODUCTS

2.01 MATERIALS

A. Metal Conduit and Tubing

1. Provide rigid steel conduit conforming to ANSI C80.1.
2. Provide liquid tight flexible metal conduit and fittings conforming to UL 360.

B. Nonmetallic Conduit

1. Rigid Nonmetallic Conduit. PVC, Schedule 40 or 80, 90° C, conforming to NEMA TC-2, UL 651, and MEC Article 347.

C. PVC Coated Rigid Steel

1. PVC coated RGS shall be manufactured in accordance with the following standards:
 - a. UL-6
 - b. ANSI C80.1
 - c. NEMA RN1

D. Fittings and Couplings:

1. Threaded for rigid.
2. Solvent weld for PVC, NEMA TC3.
3. Ferrous fittings shall be cadmium or zinc-coated, UL 614B.
4. Conduit Bodies

E. PVC Coated Fittings

1. Fittings for use with PVC coated RGS shall be PVC coated and shall be products of the same manufacturer as the conduit.

F. Wireways

1. Watertight Wireways. NEMA 4X, watertight, corrosion resistant stainless steel with hinged gasketed cover, screw clamps, and flanged gasketed joints.

2.02 ACCEPTABLE MANUFACTURERS

A. Conduit.

1. National.
2. Allied Tube and Conduit.

3. Carlon.
4. Electri-Flex Company.
5. Republic.
6. Perma-Cote Industries.
7. Robroy Industries, Inc.
8. Triangle PWC, Inc.
9. VAW of America, Inc.
10. Wheatland Tube Co.

B. Conduit Fittings and Accessories.

1. Pyle-National.
2. American Electric.
3. Appleton Electric Co.
4. Carlon.
5. Crouse-Hinds Division, Cooper Industries, Inc.
6. Thomas & Betts.
7. Killark Electric Mfg. Co.
8. Kraloy Products Co.
9. O-Z/Gedney.
10. Perma-Cote Industries
11. Raco
12. Robroy Industries.
13. Unistrut Corp.

C. Wireways

1. American Electric
2. B-Line Systems, Inc.
3. Circle AW Products.
4. GS Metals Corp.

5. Hoffman Engineering Co.
6. Square D Company.

2.03 HANDHOLES AND PULLBOXES

A. Frames and Covers

1. Provide traffic-type covers with an H-20 loading.
2. Identify handhole and pullbox covers as "ELECTRIC" by providing raised letters cast into the covers.
3. Provide frost-proof and water-tight grey iron frames and covers with solid lids and inner lids, and with 28-inch clear openings.
4. Bolt the covers and lids to cast-in-place steel frames using corrosion-resistant hardware.
5. Factory-prime the frames.
6. Provide covers constructed of cast-iron, and provide pick holes.
7. Provide frames with a 1/2-inch drilled and tapped hole and lug in order to accommodate a No. 4/0 AWG bare stranded copper conductor connected to a ground rod and the ground conductor of power cables passing through the handhole.
8. Handhole frames and covers shall be Neenah Foundry No. NF-1755GT18 or equal.

B. Equip handholes and pullboxes with pulling-in irons, opposite and below each ductway entrance.

1. Provide handholes and pullboxes with closed bottoms; open-bottom handholes and pullboxes will not be accepted.
2. Provide PVC ductbank conduits with end bells.

3. Brackets

4. Provide non-metallic, non-conductive brackets and stanchions in handholes for racking wiring through the handholes. Attach to handhole walls using stainless steel anchors and hardware.
5. Brackets and stanchions: Underground Devices, Inc., or equal.

C. Precast handholes and Pullboxes Manufacturer, or Equal

1. Jensen Precast
2. 2Mack

3. Quikset
4. U.S. Precast

PART 3 EXECUTION

3.01 INSTALLATION

A. Uses Permitted

1. Use liquidtight flexible metal conduit for the final 24 inches of connections to motors or control items subject to movement or vibration.
2. Use RGS for all exterior aboveground installations unless otherwise noted. Where noted on the contract drawings use PVC coated RGS.
3. Use Schedule 40 PVC conduit for exterior direct buried installations.
4. Use Schedule 40 PVC conduit for exterior concrete encased installations. The transition from concrete encasement to riser shall be rigid steel conduit.
5. Use RGS for all other interior installations not exposed to severe moisture or corrosive conditions such as chemical feed area unless otherwise noted.
6. Use Schedule 40 PVC conduit within chemical feed area except for analog signal wiring (4-20mA dc, 1-5VDC, 0-10VDC, etc.) that shall be in PVC coated RGS conduit.
7. Use Where conduit emerges from concrete encasement, a PVC coated RGS elbow shall be utilized for transition from the concrete. Conduit shall emerge from the concrete perpendicular to the surface whenever possible
8. Use PVC coated RGS for installation in the classified area.

B. Routing

1. Install exposed conduits, parallel or perpendicular to walls, ceilings, or structural members. Do not run through structural members. Avoid horizontal runs within partitions or side walls. Avoid ceiling inserts, lights, or ventilation ducts or outlets. Do not run conduits across pipe shafts or ventilation duct openings and keep conduits a minimum of 6 inches from parallel runs of flues, hot water pipes, or other sources of heat. Wherever possible, install horizontal raceway runs above water and steam piping.
2. Conduits installed in other interior areas shall not be embedded in waterproofed or water bearing walls. Where possible, conduits to motors or equipment more than 3 feet from walls shall be run in or under the slab and stubbed up to the junction box. For all other interior applications, conduits shall be installed, exposed, or concealed as indicated on the plans.
3. For conduits installed in exterior areas:
 - a. Do not run conduits exposed on the exterior surface of buildings.

4. Conduits penetrating exterior walls below grade, at grade floors, or below grade floors shall be sealed to prevent moisture migration. The exterior of the conduit shall be sealed with a mechanical pipe seal. The interior conduit seal shall be a gland type sealing bushing or RTV closed cell silicone foam. Ensure that conduits do not retain water against these seals.
5. Conduits shall penetrate roofs only where specifically shown on the plans. Provide all required flashing.
6. Raceways penetrating fire rated walls, floors, and partitions shall be sealed with a fire rated sealant.
7. All conduits must be supported with materials specifically made for this purpose. Do not use wire hangers. Do not attach any parts of the raceway system to ventilation ducts. Conduit supports shall be attached to the building. Support conduits on each side of bends and on a spacing not to exceed the following: 6 feet for conduits smaller than 1 1/4 inches and 8 feet for conduits 1 1/4 inches and larger. Support riser conduits at each floor level with clamp hangers. All underground conduits shall be securely anchored to prevent movement during placement of concrete or backfill. Use precast separators and heavy gauge wire ties or other approved fasteners.
8. Install accessible pull boxes in runs over 100 feet or with more than three 90° bends or equivalent.
9. All empty conduits shall have #14 galvanized steel pull wire and terminate in accessible junction boxes or have accessible capped ends for future use.

C. Underground Conduits

1. When installed in concrete or underground, apply two coats of approved asphalt paint to metallic conduits. Provide protection for conduit in areas subject to vehicle traffic.
2. Where conduits are installed in concrete slabs, on the ground, underground, or exposed to the weather, make all joints liquid tight and gas tight.
3. Bury all underground conduit, except under concrete slabs placed on fill, to a depth of at least two feet below finished grade unless otherwise indicated on the Drawings.
4. Slope ducts to drain away from buildings into handholes and/or handholes. Adjust final slopes to coordinate with existing site utilities.
5. Install on undisturbed soil where possible. Concrete encase conduits as shown on Drawings. Use pit run gravel and sand, placed in 8-inch lifts and compacted for backfill.
6. After installation, clean and swab ducts.
7. Install galvanized steel pull wires in spare ducts. Cap spare ducts.

GARDEN HOMES DEVELOPMENT
100-104 West Street, Wilmington, MA

STANTEC 210400170
June 10, 2025

END OF SECTION

RACEWAY
26 05 33 - 7

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SCOPE

- A. The CONTRACTOR shall provide the labor, tools, equipment, and materials necessary to perform the work in accordance with the plans and as specified herein.
- B. This Section includes requirements for electrical identification components including, but not limited to, the following:
 - 1. Identification labeling for conduit, cables and conductors.
 - 2. Operational instruction signs.
 - 3. Warning and caution signs.
 - 4. Equipment labels and signs.
 - 5. Provide conduit labeling per National Electric and MA Electric Code

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this Section.
- B. Related Sections.
 - 1. Section 26 00 00 - Basic Electrical
 - 2. Section 26 05 19 - Wires and Cables

1.03 QUALITY ASSURANCE

- A. National Fire Protection Association (NFPA) 70
- B. Massachusetts Electrical Code (MEC).
- C. American National Standards Institute (ANSI) Compliance.

1.04 SUBMITTALS

- A. Submit manufacturer's technical product data sheets for each type of product specified.

PART 2 PRODUCTS

2.01 PRODUCTS

- A. Name Plates & Signs

1. Laminated Plastic Signs and Labels. Engraving stock melamine plastic laminate, 1/16 inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes; punched for mechanical fasteners.
2. Exterior Warning and Caution Signs. Weather resistant, nonfading, preprinted cellulose acetate butyrate signs with 20 gauge, galvanized steel backing, with colors, legend, and size appropriate to the location.
3. Interior Warning and Caution Signs. Aluminum signs with preprinted baked enamel finish and punched for fasteners. Colors, legend, and size appropriate to location.

B. Wire and Cable Markers

1. Underground Line Marking Tape. Permanent, bright colored, continuous printed, metal backed, plastic tape compounded for direct burial service not less than 6 inches wide. Printed legend indicative of general type of underground line below.
2. Wire Labels. Wires small than No. 4. Vinyl or vinyl cloth, self-adhesive, wraparound, wire markers with preprinted numbers and letters. Wire sizes No. 4 and larger and multi conductor cables shall be marked with one-piece, nylon locking marker ties equal to Panduit PLM Series.

2.02 Acceptable Manufacturers.

- A. American Labelmark Co.
- B. Almetek.
- C. Brady.
- D. Emed Co., Inc.
- E. Ideal Industries, Inc.
- F. Kraftbilt.
- G. LEM Products, Inc.
- H. Markal Corp.
- I. Panduit Corp.
- J. Seton Name Plate Co.
- K. Standard Signs, Inc.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.

3.02 INSTALLATION

- A. Warning Signs. Install warning or caution signs where required by MEC, where indicated, or where reasonably required to ensure safe operation and maintenance of electrical systems and of the items to which they connect.
- B. Equipment Name Plates
 - 1. Install engraved plastic laminate identification labels on each major unit of electrical, communication and signaling equipment. Black lettering on a white field to match terminology and numbering on the Contract Documents and shop drawings.
 - 2. Provide labels with 1/2 inch high lettering on 1 1/2 inch high label (2 inches high where two lines are required) for each unit of the following categories of equipment.
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Access doors and panels for concealed electrical items.
 - c. Motor starters.
 - d. Power transfer equipment.
 - e. Contactors.
 - f. Transformers.
 - g. Control stations.
 - h. Frequency converters.
 - i. Power generating units.
 - j. Enclosed circuit breakers.
 - k. Disconnect switches.
 - l. Control panels.
 - m. Motor control centers.
 - 3. Provide a framed, typed circuit schedule for each panelboard.
- C. Junction and Pullbox. Where required by codes, install pressure sensitive, self-adhesive labels on box cover to indicate system voltage. Black on orange background.
- D. Underground Electrical Line. Install continuous underground plastic line markers, directly above all underground lines and conduits at 6 to 8 inches below finished grade.
- E. Wire and Cable Markers

1. Tag control circuit conductors at both ends and at junction box splices using wire and cable markers with identification numbers as designated on equipment wiring diagrams. Provide typed listing to identify conductors by number and use.
2. Identify spare conductors, individually, at both ends and at junction box splices with number between 1 and 999. Do not duplicate numbers.
3. Identify wire numbers on terminal block marking strips.
4. Provide permanent plastic name tag indicating load for each feeder for all junction boxes, handholes and manholes. Label all process motor wires to yard equipment in handholes and manholes.

<u>240/120 Volts</u>	<u>Phase</u>	<u>480/277 Volts</u>
Black	A	Brown
Red	B	Orange*
	C	Yellow
White	Neutral	White
Green	Ground	Green

*Where not permitted by inspecting authority, use purple

END OF SECTION

SECTION 40 91 00 - PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

The CONTRACTOR shall provide Process Control and Instrumentation Systems (PCIS) complete and operable, in accordance with the Contract Documents. For the purpose of this CONTRACT, PCIS is synonymous and interchangeable with supervisory control and data acquisition (SCADA), where applicable. The requirements of this Section apply to every component of the PCIS unless indicated otherwise.

A. Responsibilities

1. The CONTRACTOR, through the use of a single System Supplier and qualified electrical and mechanical installers, shall be responsible to the OWNER for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.
2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the System Supplier will be responsible to the CONTRACTOR for the integration of the PCIS with existing devices and devices provided under this and other Divisions with the objective of providing a completely integrated control system free of signal incompatibilities.
3. As a minimum, the implementation of the PCIS by the CONTRACTOR shall include the following WORK:
 - a. Prepare the required PCIS submittals
 - b. Design and develop project-wide loop diagrams including those associated with equipment provided under other Divisions and Owner-furnished and existing equipment
 - c. Design and develop control panel drawings
 - d. Prepare factory and field test submittals
 - e. Prepare training plan
 - f. Prepare spare parts submittal
 - g. Procure hardware and software
 - h. Configure and factory test the PCIS
 - i. Bench calibrate instruments and verify calibration after installation
 - j. Terminate signals inside control and network panels; terminate communication and network devices and nodes

- k. Supervise and coordinate installation and termination of field signals, power, and utilities associated with the PCIS. Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.
 - l. Loop test in accordance with the loop diagrams. Validate and certify loops
 - m. Oversee, document, and certify system commissioning
 - n. Conduct system performance test
 - o. Prepare technical manuals
 - p. Conduct training classes
 - q. Prepare PCIS as-built final construction drawings
4. Any Instrumentation Supplier responsibilities in addition to the list above are at the discretion of the CONTRACTOR and the Instrumentation Supplier. Additional requirements in this Section and throughout Division 40 that are stated to be the CONTRACTOR's responsibility may be performed by the Instrumentation Supplier if the CONTRACTOR and Instrumentation Supplier so agree.

B. RELATED WORK AND REQUIREMENTS SPECIFIED AND SHOWN ELSEWHERE

- 1. All electrical work required under this section shall conform to the requirements of this Section and the applicable requirements of the Sections in Division 01 and Division 26.

1.2 PRICE AND PAYMENT PROCEDURE

- A. General: The CONTRACTOR shall develop a schedule of values based upon the payment milestones noted below for inclusion in the Supplementary to the General Conditions Section 007313.

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of other requirements of these Specifications, all WORK specified herein shall conform to or exceed the applicable requirements of the referenced documents to the extent that the requirements therein are not in conflict with the provisions of this Section; provided, that where such documents have been adopted as a code or ordinance by the public agency having jurisdiction, such code or ordinance shall take precedence.

B. Definitions

- 1. System Supplier: The System Supplier shall be a single firm, corporation, or other entity assuming full responsibility through the CONTRACTOR to perform all engineering and to select, furnish, configure, integrate, supervise the installation and connections, test, calibrate, and place into operation all instrumentation, controls, communication hardware and software. The System Supplier shall specialize and have an experienced engineering and technical staff in the design, integration, and supply of systems similar to the one in these Contract Documents.

The term "System Supplier" shall mean the same as "SCADA System Supplier" or "PCIS Supplier."

- C. The PCIS WORK shall conform to or exceed the applicable regulations, standards, specifications, and codes which are referenced in Section 014219 Reference Standards, and current as of the date of the final inspection for this Contract, including, but not limited to, those which are established by the following sources:
1. The International Society of Automation (ISA)
 2. National Electrical Code (NEC)
 3. National Fire Protection Association (NFPA)
 4. Institute of Electrical and Electronic Engineers (IEEE)
 5. Occupational Safety and Health Administration (OSHA)
 6. American National Standards Institute (ANSI)
 7. National Electrical Manufacturers Association (NEA)
 8. Insulated Cable Engineers Association (ICEA)
 9. Local Power and Telephone Companies
 10. Local Authorities having jurisdiction over the work
 11. Federal Communication Commission (FCC)
 12. Underwriter Laboratory (UL)
- D. Where the requirements set forth in these Specifications or on the Drawings are greater or more rigid than the mandatory requirements referenced above, the applicable Specifications or Drawings shall govern.
- E. In the case of conflict between any mandatory requirements and Specifications or Drawings, the mandatory requirement shall be followed in each case, but only after submitting such proposed changes to the ENGINEER for approval.
- F. Nothing contained in these Specifications or shown on the Drawings will be so construed to conflict with any national, state, municipal, or local laws or regulations governing the installation of work specified herein, and all such acts, ordinances, and regulations, including the National Electrical Code, are hereby incorporated and made a part of these Specifications. All such requirements will be satisfied by the CONTRACTOR at no additional expense to the OWNER.
- G. The Drawings and Specifications are complementary to each other; what is called for by one shall be as binding as if called for by both. If a conflict between Drawings and Specifications is discovered, this shall be referred to the ENGINEER as soon as possible for resolution. Should a conflict exist between the Drawings, Specifications, and/or mandatory requirements (i.e., codes, ordinances, etc.), it will be assumed that the more

expensive method has been estimated, unless such alternate has been agreed to prior to submission of bids.

1.4 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

A. The CONTRACTOR shall provide submittals in accordance with Section 01 33 00- Contractor Submittals and the additional submittal requirements specified in this Section, in Division 40, and the following:

1. The CONTRACTOR shall coordinate the PCIS part of the WORK so that a complete instrumentation and control system will be provided and will be supported by accurate Shop Drawings and as-built drawings.
2. The submittals and their schedules shall be in accordance with the requirements listed below: Any incomplete submittal will be rejected and returned without comments.
3. Interface between instruments, motor control centers, engines, starters, control valves, flowmeters and other equipment related to the PCIS shall be included in the shop drawing submittal. Interface between existing equipment, instruments and control panels shall also be included,
4. Exchange of Technical Information: During the period of preparation of these submittals, the CONTRACTOR shall authorize a direct, informal liaison with the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized informally by the ENGINEER, but will not alter the scope of WORK or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the ENGINEER shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.
5. Symbols and Nomenclature: In these Contract Documents, systems, meters, instruments, and other elements are represented schematically, and are designated by symbols as derived from Instrument Society of America Standard ISA S5.1 - Instrumentation Symbols and Identification. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout Shop Drawings, and similar materials. No other symbols, designations, or nomenclature unique to the manufacturer's standard methods shall replace those prescribed above, used herein, or on the Drawings.

B. Shop Drawings Submittal Organization

1. Shop Drawings shall include the letter head or title block of the System Supplier. The title block shall include, as a minimum, the System Supplier's registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing.
2. Organization of the Shop Drawing submittals shall be compatible with eventual submittals for later inclusion in the Technical Manual. Submittals not so organized will not be accepted.

3. For a project with multiple sites the CONTRACTOR shall provide a separate and unique set of drawings for each site.
4. Drawings that require more than one sheet due to space limitation or continuation in the subject of the drawings (e.g. loop diagrams, etc.) shall be given the same drawing number but with different sheet number (e.g. sheet 1 of x, sheet 2 of x, etc.).
5. Each submittal shall include a complete index appearing in the front of each bound submittal volume. Drawings and/or system groups shall be separated by labeled tags. The organization of the initial shop drawing submittal required above shall be compatible to eventual inclusion with the Technical Manuals submittal and shall include final alterations reflecting as-built conditions.
6. Interfaces between new and existing instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders, panels, and other equipment related to the PCIS shall be included in the Shop Drawing submittal.

C. Field Instrument Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete field and process instrument submittal, **all at one time, within 60 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR.
2. Submittal Contents: The submittal shall include a complete index which lists each device by tag number, type, and manufacturer in accordance with the specified data sheets provided in this CONTRACT. A separate manufacturer technical brochure or catalog sheet shall be included with each specified instrument data sheet. If, within a single system or loop, a single instrument is employed more than once, one manufacturer brochure or catalog sheet may cover multiple identical uses of that instrument in that system. Each manufacturer brochure or catalog sheet shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags. Special options and features which are furnished shall be identified.

D. System Hardware Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete system hardware submittal, **all at one time, within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. This submittal shall be submitted together with the submittal for the System Architecture, and Communication Diagrams submittal and the Project-Wide Wiring Diagrams and Panel Drawings submittal specified below.
2. Submittal Contents:
 - a. The submittal shall be for the hardware specified under 40 95 13 - Control Panels.
 - b. The submittal shall include a complete index which lists each device by type, and manufacturer in accordance with the contract documents. A separate manufacturer technical data sheet or brochure shall be included for each hardware component. If, within a single system a single component is employed

more than once, one manufacturer technical data sheet or brochure may cover multiple identical uses of that component in that system. Special options and features which are furnished shall be identified.

- c. The submittal shall include load calculations and size of the various UPS systems to demonstrate that the UPS is able to accommodate present and future load requirements, as well as overload capacity requirements.
- d. Spare Parts and Tools List: A list of spare parts and tools shall be submitted, covering items which are specified and furnished under this Contract. The list shall include the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts. The list shall also include recommended spare parts and tools, quantities and prices from which the OWNER will select the "Additional Recommended Spare Parts and Tools".

E. Project-Wide Wiring Diagrams and Panel Drawings Submittal:

- 1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete set of project-wide wiring diagrams (PWWD) and panel drawings, **all at one time within 120 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. The PWWD and panel drawings shall be a singular complete hard copy bound package and accompanied with a PDF on a CD. This submittal shall be submitted together with the System Hardware submittal and the System Architecture and Communication Diagrams submittal specified herein.
- 2. Submittal Contents: The PWWD and panel drawings shall be submitted as a single and comprehensive set of drawings. The submittal shall include a complete index in the front of each part of the submittal. The drawings shall be indexed by systems, sites, or process areas. Diagrams shall be tagged in a manner consistent with the Contract Documents and shall include the following:
 - a. Project-Wide Wiring Diagrams: The PWWD shall define and document the contents of each analog and discrete monitoring, alarming, hardware interlock, and control functions associated with equipment provided under Division 40 sections. The PWWD shall also cover equipment provided under sections in other Divisions, existing, and OWNER-furnished equipment. The PWWD shall also include both field and panel wiring diagrams.
 - 1) Drawings showing definitive diagram for every analog and discrete instrumentation loop system. These diagrams shall show and identify each component in each loop or system using legend and symbols. The wiring diagrams shall be presented on an 11"x17" drawing with no more than 8 loops per drawing.
 - 2) In general, loops shall be grouped and organized by PLC (if used) and the I/O cards within the PLC. Each I/O card shall be presented on a separate sheet(s) and on the right side of the drawing. The type of card, part number and its slot location shall be identified. Each I/O shall be identified as well as its location on the card and its address. Existing, spare, and future I/Os shall also be shown. Power supply wiring to the card/loops, wire colors, and terminal numbers shall be shown on the wiring diagrams. The I/O cards, the loops and any device in the loop shall be shown together. Each

loop shall be complete, including the source/destination within new or existing panels, device(s) in the loop, field connection panels or field junction boxes, field and PLC interface terminal blocks and wire numbers.

- 3) In addition wiring diagrams shall show the following details
 - a) Functional name of each loop
 - b) Reference name, drawing, and loop diagram numbers for any signal continuing off the wiring diagram sheet.
 - c) MCC panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.
 - d) Wiring type, size and color
 - e) Designation, and if applicable, terminal assignments associated with every manhole, pull box, junction box, conduit in which wiring is to be located, and panel through which the loop circuits pass.
 - f) Vendor panel, instrument panel, conduit, junction boxes, equipment and DCS terminations, termination identification wire numbers and colors, power circuits, and ground identifications.
 - 4) Wiring diagrams shall be developed for loops in equipment vendor-supplied packages, equipment provided under Division 40, and OWNER-furnished equipment.\
- b. Panel Wiring Diagrams: Panel wiring and/or piping diagrams shall be prepared in concert with the PWWD and shall include the following information:
- 1) Name of panel
 - 2) Power distribution schematic diagrams associated with each panel or system (120VAC, 24VDC and other DC systems, control circuits). The schematic diagram shall show source of power for the panel (circuit breaker panel and breaker) and fuses. All power backup system distribution shall also be shown.
 - 3) Schematic diagrams for control circuits in accordance with ANSI standards. The diagrams shall show complete details on the circuit interrelationship of all devices within and outside each Control Panel. Including primary measurement and control devices.
 - 4) Communication diagram(s) for the equipment inside the panel.
 - 5) Surge protection and signal and safety grounding circuits
 - 6) Wiring type and piping size and material
 - 7) Terminal block numbers and wire numbers

- c. Panel Drawings: Panel drawings, including console, and cabinet layout drawings, shall be prepared and submitted for each panel and shall include the following information: These drawings shall include enough other details to define exactly the style, the contents, and overall appearance of the panel assembly.
 - 1) Name of Panel.
 - 2) Panel Dimensions; front, side, and plan views and layout to scale.
 - 3) Arrangement of internally and externally mounted instruments and equipment to scale. Note: Control panel layouts shown on the Contract Drawings are diagrammatic.
 - 4) Location of terminal blocks, electrical devices, and conduit entry location(s).
 - 5) Tag number or item number and functional name of items mounted in and on panel, console, or cabinet.
 - 6) Nameplate legend which includes text, letter size, and colors to be used.
 - 7) Complete and detailed Bills of Materials shall include all items within a panel and shall be presented on the panel layout drawing. The bill of material list shall include quantity, description, manufacturer, and part number.
 - 8) Panel mounting information, including conduit entrance location.
 - 9) Communication hardware installation, such as radio, mast and antenna.
 - 10) Assembly and construction drawings. These drawings shall include dimensions, identification of all components, construction material and gauge, surface preparation and finish data, panel door locks and hinge mechanism, nameplates, and the like.

F. Startup and Commissioning Submittals

1. Submittal Schedule: The CONTRACTOR shall submit for approval a proposed procedure to be followed during startup and commissioning of the PCIS and its components **complete within 210 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR, but not later than **60 calendar days** prior to startup and commissioning.
2. Preliminary Submittal: Outlines of the specific procedures and examples of proposed forms and checklists.
3. Detailed Submittal: After approval of the Preliminary Submittal, the CONTRACTOR shall submit the proposed detailed procedures, forms, and checklists.

G. Training Plan and Training Manual Submittals:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a training plan and a training manual submittal **complete and within 300 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR, but no later than **60 calendar days** prior to start of the first training session.
2. Submittal Contents: The Training submittal shall consist of two parts:
 - a. Training Plan, which shall include:
 - 1) Schedule of training courses including dates, durations, and locations of each class. Number of times each class will be offered, if applicable and the number of people expected in each class.
 - 2) List of courses and lessons and who will conduct them
 - 3) Resumes of the instructors who will actually conduct the training classes. The CONTRACTOR shall identify in the submittal the courses and lessons that will be performed by the equipment manufacturer.
 - 4) List of material used for the training, which shall include the Technical Manuals for the PCIS.
 - b. Training Manual
 - 1) Training subjects' syllabus and associated lesson plans. The training subjects are listed in Part 3 "Execution "of this Section. If, in the opinion of the System Supplier, additional subjects that are not listed and are pertinent to the training and will benefit the OWNER's staff, these subjects shall also be included in the training manuals and taught in the class.

1.5 CLOSEOUT SUBMITTALS

A. Technical Manuals Submittal

1. Submittal Schedule:
 - a. The CONTRACTOR shall submit for approval Technical Manuals for the PCIS: Initial set shall be submitted **complete and within 300 days** after the date of Notice to Proceed is given to the CONTRACTOR. But at least **60 days** prior to the starts of the OWNER's training.
 - b. Each set shall consist of one (1) or more volumes and provided in PDF on a CD. In addition, a hard copy of the technical manual shall be provided in bound standard size, 3-ring, loose-leaf, vinyl plastic hard cover binders, suitable for bookshelf storage. Binder ring size shall not exceed 3 inches.
2. Submittal Contents:
 - a. Information in the Technical Manual shall be based upon the approved Shop Drawing submittals as modified for conditions encountered in the field during the

WORK. The Technical Manuals shall therefore contain the as-built drawings and information.

- b. The Technical Manuals shall include installation, connection, operating, calibration, set points (e.g., pressure, pump control, time delays, etc.) adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
- c. The Manuals shall have the following material organized in volumes and divided by subject and tabs The Technical Manual shall have the following organization for each process (the number and the enumeration of the sections shall be project specific):
 - 1) Section A - Process and Instrumentation Diagrams (as built copy)
 - 2) Section B - System Architecture and Communication System Block Diagram(s)
 - 3) Section C - Wiring Diagrams. A separate set of drawings shall be provided for each site. Each set shall be arranged in a separate tab (drawings shall also be provided in PDF format).
 - 4) Section D – Functional design report. It shall include a description how the Contractor provided MCCs, starters, VFDs, actuators, and control panels function specific for each site. Calibration, set points (e.g., pressure, pump control, time delays, etc.) shall also be included.
 - 5) Section E - Instrument Data Sheets and corresponding manufacturer's data sheet/catalog cuts/brochure that was used in the hardware submittal and the operation and maintenance/user manual.
 - 6) Section F - Calibration Documentation
 - 7) Section G – Equipment configuration parameters for all new or modified equipment
 - 8) Section H - Loop, Commissioning and Performance Test Results

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. The CONTRACTOR shall provide the specified spare parts and tools. In addition, The ENGINEER and the OWNER will select from the priced list of "Additional Recommended Spare Parts" in the Hardware Equipment Submittal. The CONTRACTOR shall furnish these parts and will be paid for them from the corresponding allowance item in the Bid. The total price will not exceed the amount of the allowance item.
- B. The CONTRACTOR shall furnish a priced list of special tools required to calibrate and maintain the instrumentation provided from which the ENGINEER or the OWNER will select the needed tools. After approval the CONTRACTOR shall furnish tools on that list. The cost of these tools will be included in the allowance.

- C. The CONTRACTOR shall furnish one (1) portable instrument loop calibrator with current simulator with charger and carrying case. The calibrator shall be **Fluke 709H series, Ametek AccuPro Calibrator CL-9005**, or equal.

1.7 QUALITY ASSURANCE

- A. Field Tests: The CONTRACTOR's attention is directed to the Article "EXECUTION" of this Section which delineates all the tests that are required to be performed in the field in order to demonstrate compliance with the Contract Documents.
- B. The CONTRACTOR shall provide and assign to the OWNER all user software and hardware licenses. Computer and software system shall be purchased on behalf of the OWNER who shall also be designated as the licensee. Each software package shall be provided with a "Site License" or with as many licenses as a "Site License" includes (site is defined as the name of the OWNER). The CONTRACTOR shall include in the bid price all license fees.
- C. The CONTRACTOR shall provide the proper number of software licenses for all the servers, workstations, and laptops to provide concurrent and simultaneous user operation.
- D. Prior to final acceptance of the PCIS System and related equipment, the CONTRACTOR shall propose and present in writing to the OWNER a one-year maintenance contract and quotation which will become effective upon the expiration of the warranty. The maintenance contract is an option that the OWNER may purchase from the System Supplier. The contract shall offer different maintenance, site visit and help-desk with options each with its respective cost.

1.8 FIELD SITE CONDITIONS

- A. The PCIS shall be designed and constructed for satisfactory operation and long, low maintenance service under the following environmental conditions:
 - 1. Wastewater Storage Tank and Pumpstation
- B. Site Equipment:
 - 1. Ambient temperature range: -18° through 60° C
 - 2. Thermal shock: 1.0° (1.8° F) per minute maximum
 - 3. Relative humidity: 95 percent maximum non-condensing

1.9 WARRANTY

- A. All parts, material labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period shall be borne by the CONTRACTOR under the guarantee specified in Division 1. Equipment, software, and materials that do not achieve their intended purpose shall be replaced by the CONTRACTOR to attain compliance, at no additional cost to the OWNER.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. **Standard and Current Technology:** All PCIS hardware, software, materials, and equipment furnished under this contract shall be new, free from defects, and shall be standard products and technology produced by manufacturers regularly engaged in the manufacture of these products. Meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

The CONTRACTOR shall submit a Substitute Item Request Form in case of discontinued or upgraded product or other cases where changing technology requires changes in equipment or software.

- B. **Adverse Environmental Impact:** No component of an instrumentation system shall contain liquid mercury.
- C. **Hardware Commonality and Modularity:** Instruments which utilize a common measurement principle shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer. All equipment shall be of modular design to facilitate interchangeability of parts to assure ease of servicing and expandability.
- D. **Instrument and Loop Power:** Power requirements and input/output connections for components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2 wire" transmitters is preferred, and use of "4 wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as specified and/or as required by the manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.
- E. **Loop Isolators and Converters:** The CONTRACTOR is responsible to resolve any signal level incompatibilities where required.
- F. **Signal Levels:** Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals outside control panels shall be 4 to 20 milliamperes DC except as indicated. Signals within enclosures may be 1 to 5 volts DC. Electric signals shall be electrically or optically isolated from other signals. Pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.
- G. **Alternative Equipment and Methods:** Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through the "or equal" process of Division 01. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

PART 3 -- EXECUTION

3.1 EXAMINATION

- A. Shipping: After completion of shop assembly, factory test, and approval, the tested PCIS equipment, cabinets, panels, and computer hardware shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.
- B. Special Instructions: Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.
- C. Tagging: A permanent stainless steel or other non-corrosive material tag marked with the instrument or equipment tag number shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.
- D. Storage: It is the CONTRACTOR's responsibility to assure proper handling and on-site storage of instrumentation and control equipment in accordance with the System Supplier's recommendations. All equipment and materials delivered to the jobsite shall be stored in a location which will not interfere with the operations of other contractors or the OWNER. Equipment shall not be stored outdoors. Storage and handling will be performed in manners which will afford maximum protection to the equipment and materials.
- E. Equipment shall be stored in dry shelters, including in-line equipment, and shall be adequately protected against mechanical damage. If any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR. If any apparatus has been subject to possible damage by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER. If such tests reveal defects, the equipment shall be replaced.

3.2 INSTALLATION

- A. General
 - 1. All systems and instrumentation, including instrumentation furnished under other Divisions, shall be installed, connected calibrated, tested, started, and placed into operation in accordance with CONTRACT documents under Division 40 and the manufacturers' instructions. The installation shall be coordinated with the ENGINEER and the OWNER. This shall include final integration in concert with equipment specified and provided by others.
 - 2. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all PCIS equipment.
 - 3. The CONTRACTOR shall furnish the services of an on-site engineer to supervise and coordinate installation, adjustment, testing, and start-up of the PCIS. The engineer shall be present during the total period required to affect a complete

operating system. A team of engineering personnel shall be at the site to check equipment, perform the tests indicated in this Section, and furnish startup services.

4. Equipment Locations: The monitoring and control system configurations indicated in the contract documents are diagrammatic. The locations of equipment are approximate unless dimensioned. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the OWNER exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the CONTRACTOR shall make such changes without additional cost to the OWNER.
5. The CONTRACTOR shall review the existing site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.
6. The Contract Documents identify conduits and instruments required to make a complete PCIS. The CONTRACTOR shall be responsible for providing any reasonable additional or different type connections as required by parts of the PCIS' specific installation requirements, or as practical.

B. Conduit, Cables, and Field Wiring

1. Conduits, process equipment control wiring, 4 to 20 mA signal circuits, signal wiring to field instruments and to control panels, DCS input and output wiring, and other field wiring and cables shall be provided under Division 26 and without delay to the WORK of Division 40.
2. Terminations and wire identification inside PCIS equipment and panels furnished under this or any other Division shall be provided under Division 40.
3. The CONTRACTOR shall supervise and coordinate installation and termination and identification of field signals, power, and utilities associated with the PCIS. Resolve signal, power, or functional incompatibilities between the PCIS and new and existing interfacing devices.

C. Installation and Connections:

1. Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site. Appropriate mounting stands and bracket materials and workmanship shall be provided and shall comply with requirements of the Contract Documents.
2. Existing Instruments that are to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The CONTRACTOR shall provide certification of this WORK prior to reinstallation of each instrument.

3. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation. The CONTRACTOR shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing that WORK. Such changes shall not be a basis of claims for extra WORK or delay.
4. Field Connection Panels and Interface Terminal Blocks: In cases where field I/O wiring has to be extended to a control panel or from enclosures or devices that are removed, the CONTRACTOR shall provide separate enclosures or junction boxes with interface terminal blocks that will serve as a Terminating Junction Box (TJB). The TJB and the terminal block shall be shown on the project-wide wiring diagrams.
5. Conduits and/or raceways in building interior locations shall be surface mounted on walls or ceilings wherever possible and run perpendicular and parallel to building lines. Conduits shall not be routed on floors in areas subject to foot traffic. In exterior locations conduit shall be routed below grade.
6. Wires and cables shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically approved by the ENGINEER. Wiring shall be protected from sharp edges and corners.
7. Signal and low voltage wiring shall be run in a separate conduit from power and 120-volt control wiring.
8. Field wiring shall terminate at terminal blocks in the control panel. Field wiring shall not be wired directly to equipment in the control panel except communication and specialty cables that must be wired directly to their respective equipment.
9. Power and signal wires shall be terminated with crimped type lugs.
10. Wires shall be marked clearly with an identification wire number labels that are of a permanent nature. Computer system equipment cables shall be identified and marked for their location at each end of the cable. Computers and peripheral equipment connections/ports shall also be identified as to what cable is connected to its port location.
11. Connectors shall be, as a minimum, water tight.
12. Sensing Lines and Tubing:
 - a. Instrument process sensing lines shall be installed in conduit under Section 26 00 00 - Electrical General Provisions and in a manner similar to the conduits. Individual tubes shall run parallel and near the surfaces from which they are supported. Supports shall be used at intervals of not more than 3-feet of rigid tubing.
 - b. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual

plastic tubes parallel. Ends of tubing shall be square cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at panels requiring pipe or tubing entries.

13. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.
14. Differential pressure elements shall have 3 valve manifolds.
15. The CONTRACTOR shall verify the correctness of each installation, including polarity of electric power and signal connections. The CONTRACTOR shall certify in writing all discrepancies have been corrected for each loop or system checked out. In addition, the CONTRACTOR shall make sure process connections are free of leaks.

- D. Removal of Abandoned Equipment: Unless otherwise specified, all existing equipment in each facility that is no longer required after the new system has been put in service shall be removed by the CONTRACTOR. The CONTRACTOR is responsible for disposal and salvage of the equipment.

3.3 FIELD QUALITY CONTROL

A. General:

1. Devices provided under Division 40 shall be initially calibrated by the manufacturer at the manufacturer's facility prior to shipment. Following installation, the devices shall be field calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements. The CONTRACTOR shall also field calibrate exiting instruments if it is part of a modified loop.
2. Each instrument shall be field tested, inspected, and adjusted to the indicated performance requirement in accordance its manufacturer's specifications and instructions. Any instrument which fails to meet any contract requirement, or, in the absence of a contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER.

- B. Calibration Points: During bench and field calibration each instrument shall be calibrated at least at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs and outputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.
- C. Bench Calibration: Instruments that have been bench-calibrated by the manufacturer shall be verified in the field after installation to determine whether any of the calibrations are in need of adjustment.
- D. Field Calibration: Instruments which were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.

- E. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.
- F. Calibration Sheets: Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:
 - 1. Project name
 - 2. Loop number and site or process name and number
 - 3. Tag number
 - 4. Manufacturer
 - 5. Model number
 - 6. Serial number
 - 7. Calibration range
 - 8. Calibration data: Input, output, and error at 0 percent, 50 percent, and 100 percent of span
 - 9. Switch setting, contact action, and dead-band for discrete elements
 - 10. Space for comments
 - 11. Space for sign-off by System Supplier and when applicable by the manufacturer and date
 - 12. Test equipment used and associated serial numbers
- G. Calibration Tags: A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the ENGINEER. The CONTRACTOR shall have the System Supplier sign the calibration sheet when calibration is complete. The ENGINEER will sign the calibration sheet when the calibration and testing has been accepted.
- H. Loop Testing: The Contractor shall test newly installed and modified existing loops for continuity and functionality. The up-to-date wiring diagrams shall be used as reference.
- I. The CONTRACTOR shall notify the OWNER and the ENGINEER of scheduled demonstrations a minimum of 30 calendar days prior to the estimated completion date of installation and wiring of the PCIS. After the ENGINEER's review of the submitted loop diagrams for correctness and compliance with the specifications and after CONTRACTOR loop testing is completed, loop demonstrations shall proceed. The loop demonstrations shall be witnessed by the OWNER and/or the ENGINEER, and the OWNER'S PROGRAMMER.

- J. Control Valve Tests: Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to insure that no changes have occurred since the bench calibration.
- K. Interlocks: Hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers, and packaged equipment controls shall be checked to the maximum extent possible.
- L. Loop Validation:
 - 1. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the HMI displays. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested.
 - 2. Accuracy tolerances for each analog network are defined as the root-mean-square (RMS) summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by contract requirements or by published manufacturer accuracy specifications, whenever contract accuracy requirements are not indicated. Each analog loop shall be tested by applying simulated analog or discrete inputs to the first element of an analog loop. For loops which incorporate analog elements, simulated sensor inputs corresponding to 0, 25, 50, 75, and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated RMS summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. Analog loop test data, including calculated RMS summation system accuracy tolerance, shall be documented by the CONTRACTOR on the loop validation sheets. The validation sheets shall be included in the O&M Manuals.
- M. Loop Validation and Certification Sheets:
 - 1. Loop Validation: The CONTRACTOR shall prepare loop validation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop validation sheets shall form the basis for operational tests and documentation. Each loop validation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the System Supplier:
 - a. Project name
 - b. Loop number
 - c. Tag number, description, manufacturer, and model number for each element
 - d. Installation bulletin number

- e. Specification sheet number
 - f. Loop description number
 - g. Adjustment check
 - h. Space for comments
 - i. Space for loop sign-off by the System Supplier and date
 - j. Space for ENGINEER witness signature and date
2. Loop Certification: A certified copy of each loop test validation sheet signed by the System Supplier, the ENGINEER or the ENGINEER's representative as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that the loops have been tested and the instrumentation in the loop has been successfully calibrated, inspected, and tested.

N. Manufacturer's Services

- 1. The CONTRACTOR shall provide jobsite visits and services of a manufacturer's technical field representative for supervision of the following:
 - a. Oversee installation: Supervise installation and connection of all instruments, elements, and components of every system, including connection of instrument signals to primary measurement elements and to final control elements such as VFD, smart starters, pumps, valves, engines and chemical feeders
 - b. Verify that installed instrument and software meet manufacturer's recommendations
 - c. Certify installation and reconfirm manufacturer's accuracy statement
 - d. Oversee loop testing, prepare loop validation sheets, and certify loop testing
 - e. Certify when testing is completed.
 - f. Training the OWNER's personnel
- 2. Manufacturer's services shall be furnished for the following equipment:
 - a. Vibration monitoring.

3.4 PRE-COMMISSIONING

A. General:

- 1. Pre-commissioning is basically the demonstration of proper operation of every part in the PCIS with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible. All systems shall be exercised through field operational tests, as a complete PCIS in

accordance with the approved test procedures and in conjunction with the OWNER. Pre-commissioning shall confirm to the requirements of Division 01.

2. Pre-commissioning shall commence after completion and acceptance of continuity tests, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with contract requirements.
3. Pre-commissioning Procedures and Documentation: Pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step. Completion of system pre-commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the ENGINEER with a clear and unequivocal statement that system pre-commissioning and test requirements have been satisfied. The result of the testing shall also include a punch list developed by the ENGINEER.
4. The burden of proof of conformance of the system to specified functions and performance is on the CONTRACTOR. Tests that fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the OWNER or ENGINEER.
5. The CONTRACTOR shall supply necessary test equipment and technical personnel if called upon to prove accuracy and/or performance, at no separate additional cost to the OWNER, wherever the OWNER or ENGINEER has reasonable doubt or evidence of malfunction or poor performance appears.
6. The CONTRACTOR shall coordinate the scheduling of tests among all parties involved so that the tests may proceed without delays or disruption by uncompleted work. Field operational and functional testing must be successfully completed prior to the start of the 30-day final acceptance test.

B. Operational Validation:

1. Where feasible, system pre-commissioning activities shall include the use of the actual process to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, PLCs, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational.
2. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of process controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control

parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

3. The testing shall include manual and automatic control modes, fail-safe and backup control modes, and PLC interlocks and control strategies provided by the System Supplier.
- C. Loop and Equipment Tuning: Controllers incorporating proportional, integral and/or derivative control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed set point settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.
- D. Pre-commissioning Validation Sheets: Pre-commissioning shall be documented on test forms as follows:
1. The validation form, which shall include:
 - a. Project name
 - b. Loop number
 - c. Loop and function description
 - d. Tag number, description, manufacturer, and data sheet number for each component.
 - e. Pre-Commissioning Certification - A statement certifying that the contract requirements have been met. It shall also include a listing of instrumentation and control system maintenance and repair activities conducted during the pre-commissioning testing. Acceptance of the instrumentation and control system testing must be provided in writing by the ENGINEER before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.
 - f. Space for sign-off and date by the CONTRACTOR, the System Supplier, and the OWNER or ENGINEER.

3.5 COMMISSIONING

- A. Commissioning is the verification that the complete WORK functions on an extended basis are in full conformance with the Contract requirements.
- B. As part of the commissioning, the entire PCIS shall operate continuously without failure for 30 consecutive days without failure (see test details below), thus extending its operation test longer than the commissioning period specified in Section 017500.

3.6 STARTUP OPERATION

- A. General: Startup is defined as testing, demonstrations, and other activities as required to achieve Substantial Completion. Pre-commissioning and commissioning activities, manufacturer's services, certifications of readiness for testing, and troubleshooting, checkout, and shakedown activities must be completed before startup activities begin.
- B. When all equipment and systems have been assessed by the CONTRACTOR to have been successfully carried through complete operational and functional tests with not less than a minimum of simulation, and the ENGINEER concurs in this assessment, system startup by the OWNER'S operating personnel can follow.
- C. Each facility, process, or site startup shall be performed in accordance with the approved test procedures.
- D. Scheduling of startup shall be coordinated by the CONTRACTOR among all parties involved so that the tests may proceed without delays or disruption by uncompleted work. System startup and training and instruction of the OWNER's personnel must be completed a minimum of seven (7) days prior to the final acceptance test.

1. Troubleshooting and Corrections

- a. The Contractor shall participate in all start-up activities. If problems occur, the CONTRACTOR and the System Supplier shall jointly participate in the diagnosis wiring, control interface, hardware and software problems and correct deficiencies. The Contractor shall be responsible and bear all expenses to diagnose and correct all the deficiencies for work and equipment furnished under this CONTRACT.
- b. If a problem is found to be a result of the CONTRACTOR's workmanship or equipment and work furnished under this CONTRACT, the CONTRACTOR shall be responsible and bear the expenses for correcting the deficiencies.

3.7 FINAL ACCEPTANCE TEST (AS PART OF COMMISSIONING)

- A. After the pre-commissioning, functional tests and startup have been completed, the CONTRACTOR shall submit a report/letter states that CONTRACT requirements have been met and the PCIS is ready for the Final Acceptance Test.
- B. The entire PCIS shall go through a final 30-day acceptance test. For the purpose of this CONTRACT, the terms "Final Acceptance Test" and "Final Performance Test" are synonymous and are used interchangeably. The 30-day test must be successfully completed prior to the date of and as a condition to substantial completion of the entire project WORK. During the testing period, all system functions shall be exercised, and any system interruption and accompanying component, subsystem, software, or program failure shall be logged for cause of failure, as well as time of occurrence and duration of each failure.
- C. In addition to the requirements of Section 017500, the CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements. The CONTRACTOR shall also provide a competently programmer on call during all normal working days and hours from the start of the acceptance test until final

acceptance of the system. The on-call programmers shall be ready to respond within two hours of the notification of the problem.

- D. Testing: The entire PCIS shall be tested and shall include, but not limited to, the field instrumentation, control and PLC panels and PLC programs, application SCADA software, graphics and trends, reports, and the control and monitoring functions. Each system function, e.g., status report-backs, alarms, logs, and displays shall be exercised several times at a minimum, and in a manner which approximates "normal" system operation. At least two displays and reports shall be generated during the test.
- E. Failure During Testing: Failure of the system during the testing shall be considered as indicating that part of the PCIS does meet the requirements of the specifications and corrective action shall be required before restarting the acceptance test.

Failures shall be classified as either major or minor as follows, and it is at the discretion of the ENGINEER how to classify the failure:

- 1. Minor Failure: A minor failure would be a small and non-critical component failure which can be corrected by the OWNER's operators. This occurrence shall be logged, but shall not be reason enough for stopping the test and shall not be grounds for non-acceptance or –restart, provided that the function(s) can be provided by backup equipment and repairs can be made and equipment returned to service within one (1) working day.

However, should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance and termination of the test.

- 2. Major Failure: A major failure shall be considered to have occurred when a major component of the PCIS, subsystem, communication, or program fault causes a halt in operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system. A major failure shall cause termination of the acceptance test. When the causes of a major failure have been corrected, a new acceptance test shall be started.
- F. Technician Report: Each time a technician is required to respond to a malfunction in the PCIS he/she must complete a report which shall include details concerning the nature of the complaint or malfunction and the resulting repair action required and taken. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report shall be required (logged as specified above). Each report shall be submitted within 24 hours to the ENGINEER or its representative, and the OWNER.

3.8 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. The CONTRACTOR shall train the OWNER'S personnel on the PCIS operation, maintenance, calibration, and repair of equipment provided under this Contract. The training shall be by qualified instructors. The training courses shall be given on-site to a minimum of four (4) people of the OWNER's personnel. All instruction, tools and training material shall be provided by the CONTRACTOR.

2. These courses shall be designed to provide the operations, maintenance and supervisory personnel with training in routine and preventive maintenance of all the PCIS including instrumentation and communication. The training course shall include instruction on the use of all maintenance equipment and special tools provided under the contract.
3. Instructions: The training shall be performed by qualified instructors. The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.
4. Training Manuals and Material: The CONTRACTOR shall use the approved Training syllabus and Training Manuals to develop training material. The training material shall be designed to provide the operations, maintenance and supervisory personnel with training in routine operation procedures, and preventive maintenance and troubleshooting of the PCIS.
5. Schedule: Training shall be performed on-site during the calibration, loop and functional testing of the PCIS prior to the 30-day Final Acceptance Test. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated. Due to availability and scheduling of the OWNER's staff, the CONTRACTOR shall coordinate with the OWNER the schedule of the classes. The OWNER reserves the right to videotape the training sessions for later use. Due to possible limited availability of the OWNER's staff, the CONTRACTOR shall provide the number of identical courses/sessions of each of the following training courses as indicated, each up to four (4) people of the OWNER's staff.
6. Training Subjects, Duration, and Agenda: The training shall include operation and maintenance procedures, troubleshooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment. During the course, hands-on experience with the system equipment shall be provided. Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the PCIS . Operator classes shall stress operational theory and use of the PCIS.
 - a. Field Instruments
 - 1) Duration – an average of thirty (30) minutes per each type of instrument
 - 2) Subjects - installation, setup, configuration, maintenance, calibration, and troubleshooting:
 - a) Level transmitter
 - b) Flow Transmitter
 - b. Control Panel

3.9 CRITERIA FOR SUBSTANTIAL COMPLETION

- A. For the purpose of this Section and all Division 40, the following conditions shall be fulfilled before the WORK is considered substantially complete:
1. Submittals have been completed and approved.
 2. The PCIS has been calibrated; loop tested, pre-commissioned, commissioned, and the startup completed.
 3. The OWNER's training has been performed.
 4. Spare parts and expendable supplies and test equipment have been delivered to the OWNER.
 5. The Final Acceptance Test has been successfully completed.
 6. Major punch-list items have been corrected.
 7. As built drawings in both hard copy and electronic format have been submitted.
 8. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.
 9. Debris associated with installation of instrumentation has been removed.
 10. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

END OF SECTION

PART 1 -- SECTION 40 91 02 -- IN-LINE LIQUID FLOW MEASURING GENERAL

1.1 THE SUMMARY

- A. General: The CONTRACTOR shall provide in-line liquid flow measuring systems, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Section 40 91 00 - Process Control and Instrumentation Systems.
- B. Applicable Sections in Division 40 and 43 – Instrumentation and Control for Process Systems.
- C. Division 26 – Electrical.

1.3 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

- A. Submittals shall be provided in accordance with the requirements specified in Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 MAGNETIC FLOW MEASURING SYSTEMS

- A. Manufacturers: The Magnetic flow meter manufacturer and model flow meters for process flows shall be as follows and or equal:

1. **Rosemount 8705 Sensor and 8732E/8712E Transmitter**
2. **Siemens SITRANS FM MAG 5100W Sensor and SITRANS FM MAG 6000 Transmitter**
3. **Badger Meter M2000**
4. **Approved Equal**

- B. Description: Magnetic flowmeter systems shall be the low frequency electromagnetic induction type that produces a DC pulsed signal directly proportional to and linear with the liquid flow rate.

- C. Performance / Design Criteria: Magnetic flowmeter system shall be suitable for the intended service and shall be based on the conductivity properties and solid content of the process fluid, in accordance with the manufacturer's recommendations.

1. Magnetic flowmeter system shall be capable of measuring fluid velocities in the range of 0.04 and 39 ft. /sec. in both forward and reverse flow in all sensor sizes.

2. Accuracy: The flow metering system shall be installed in accordance with the manufacturer's recommendations to provide at least 0.2 percent of flow rate from 10 to 100 percent full scale for velocities over 3 feet per second.
 3. Repeatability: 0.1 percent of reading.
 4. Power input requirements shall be as indicated on the drawings.
- D. Materials / Components: The magnetic flow metering system shall include a metering tube, transmitter, and signal cable and flowmeter grounding rings.
1. Metering Sensor/Tube:
 - a. The metering sensor shall employ a pulsed DC technique to drive flux-producing coils. Sensors using high pulsed DC signals shall be used in accordance with the manufacturer's recommendations for the required service application.
 - b. The metering tube sizes shall be available from at least 1/2-inch to 48-inch line size. It shall be sized in accordance with the installation application and the intended service and as recommended by the manufacturer. If fractional size or larger size meters are required, the manufacturer shall be consulted for availability. A wafer type magnetic flow meter shall be provided for applications and installations as recommended by the manufacturer. Metering tube size availability shall be 0.15-inch to 8-inches.
 - c. Metering Sensor/Tube
 - 1) Flanged Connections: The flanges' size, style, type and construction material shall be in accordance with the required installation and the intended service application and as recommended by the manufacturer, and as indicated in the data sheet. Pressure ratings shall be as indicated in the data sheet and in accordance with the requirements of Section 40 05 00 – Piping, General as recommended by the manufacturer for the intended service. The metering tube body for the wafer (flangeless) type meter shall be constructed of stainless-steel wafer type painted with epoxy paint.
 - 2) A minimum of two (2) electrodes shall be provided. The electrodes' material shall be suitable for the required service as recommended by the manufacturer. A reference electrode shall be provided as recommended by the manufacturer for the required installation application.
 - 3) Lining material shall be in accordance with the manufacturer's recommendation for the intended service.

- 4) Meter housing shall be rated for NEMA 6P (IP68) (limited depth) and shall be offered with certified ratings for different hazardous locations as specified in the data sheet. It shall be able to operate between -20 to 140 Degrees F (-29 to 60 degrees C).
- 5) Meter tube shall have epoxy protective coating.
- 6) Grounding rings shall be provided and designed to protect and shield the liner's edge interface from abrasion at the meter end. Grounding rings shall conform to the manufacturer's bore and material recommendation for the intended service. Grounding shall conform to the manufacturer's recommendations. The wafer flow meter system shall utilize two (2) grounding rings for a system ground. Grounding ring material and installation shall conform to the manufacturer's requirements.

2. Transmitter/Converter

- a. The transmitter/converter shall be capable of being mounted integral to the metering tube or remotely as indicated on the drawings. Mounting hardware shall be provided.
- b. The transmitter/converter shall be rated for NEMA 4X (IP67). Certified ratings for different hazardous locations shall be offered as an option as specified in the data sheet. It shall be able to operate in ambient temperatures of -20 to 140 degrees F (-29 to 60 degrees C).
- c. The transmitter shall convert the DC pulse signal from the metering tube to a linear 4 to 20 mA DC signal into a minimum of 700 ohms. The 4-20 mADC signal shall comply with HART protocol. Output signal shall be continuously adjustable over the full scale. Other digital outputs options shall be available.
- d. The transmitter shall have an LCD display for flow rate, percent of span, totalization, operator configuration interface, and diagnostic information.
- e. The transmitter shall have an adjustable integral low flow cutoff and zero return.
- f. The transmitter shall perform self-diagnostics and automatic data checking and activate a switch closure output when a transmitter fault is detected.

3. Cables

- a. Remote transmitter configuration shall be provided with the required lengths and types of electrodes and coil drive cables as recommended by the manufacturer for the required installation application. Maximum distance of transmitter from the metering tube shall be as recommended by the manufacturer.

- E. Calibration: Each flow metering system shall be hydraulically calibrated at a facility that is traceable to the National Institute of Standards and Technologies. The calibration procedure shall conform to the requirements of ANSI/NCSL Z 540-1 Calibration. A real-time computer generated printout of the actual calibration data shall be submitted to the ENGINEER at least 30 Days prior to shipment to the site.

PART 3 -- EXECUTION

3.1 FIELD QUALITY CONTROL

- A. In-line liquid flow measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 40 91 00 Process Control and Instrumentation Systems. Manufacturer's service, supervision, and training shall also be in accordance with Section 40 91 00 Process Control and Instrumentation Systems.

END OF SECTION

SECTION 40 91 06 - LEVEL MEASURING

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. General: The CONTRACTOR shall provide level measuring systems, complete and operable in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Section 40 91 00 - Process Control and Instrumentation Systems.
- B. Applicable Sections in Division 40 – Instrumentation and Control for Process Systems.
- C. Division 26 – Electrical.

1.3 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

- A. Submittals shall be provided in accordance with the requirements specified in Section 40 91 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.1 SUBMERSIBLE TRANSDUCER TYPE LEVEL MEASUREMENT

- A. Manufacturers:
 - 1. Submersible level transducers/transmitters manufacturer and model shall be KSPI 320, GE/Druck Model PTX 1880/1885, Dwyer/Mercoid PBLT2/PBLTX Measurement Specialties, Viatran, or equal.
 - 2. Termination enclosure manufacturer and model shall be **GE/Druck model STE 110**, or equal.
- B. Description: The submersible level measurement system shall be designed for level and depth measurements, such as wells, where small transducer size is required. The level measurement system shall consist of a submersible transducer, electronic transmitter, support cable, and interconnecting cable with cable shield, termination enclosure, and vent tube for atmospheric reference. The installation shall allow easy removal of the transducer and cable assembly for maintenance purposes
- C. Performance / Design Criteria:
 - 1. The transducer shall be the strain gauge type suitable for sensing pressure equivalent to the measured liquid level range. Various pressure ranges shall be available from 1 to 900 psig.
 - 2. The transducer' shall be less than 1-inch in diameter and shall be integral to and suspended by a corrosion resistant cable, as recommended by the manufacture.

3. The transmitter shall produce a 24 VDC, 4 - 20 mA DC signal linearly proportional to the required level range as indicated in the data sheet. The measurement system shall operate over a temperature range of -5 to 140 degrees F with an accuracy of plus or minus 0.1 percent of full scale.

D. Materials / Components:

1. Submersible Transducer/Transmitter:

- a. The wetted parts of the transducer/transmitter's body assembly shall be as recommended by the manufacturer. The transducer/transmitter shall be provided with a lightning surge arrestor. It shall be rated IP68/Type 6. Based on installation location rating, the unit shall be intrinsically safe and rated for Class I Div. II area. Intrinsically safe barriers shall be provided as required.
- b. Vent Tube: The vent tube shall be used for atmospheric reference and terminated in a sensor termination enclosure. Vent tube shall be able to support a load of up to 115 lb. and its material shall be compatible with the measured liquid level as recommended by the manufacturer for the intended service and as indicated in the data sheet.
- c. Termination Enclosure: The vent tube and the pressure transducer shall be terminated in an enclosure rated for the installation location. The enclosure shall contain a replaceable desiccant module with an integral moisture status indicator, and a replaceable micro filter assembly against ingress of dust. A DIN standard terminal block shall also be included. Mounting hardware shall be included for the required installation requirements.

PART 3 -- EXECUTION

3.1 FIELD QUALITY CONTROL

- A. Level measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested in accordance with Section 40 91 00 Process Control and Instrumentation Systems. Manufacturer's service, supervision, and training shall also be in accordance with Section 40 91 00 Process Control and Instrumentation Systems.

END OF SECTION

SECTION 40 95 10 – PLC-BASED CONTROL SYSTEM HARDWARE

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes

1. The Contractor through the use of the pre-qualified System Supplier shall provide the programmable logic controllers (PLC)-based control system (PBCS) hardware for the PCIS, complete and operable, in accordance with the Contract Documents. The PBCS shall be furnished complete with all software as indicated on the drawings.
2. The System Supplier shall be responsible for selecting, sizing, and providing the correct and necessary type and quantity of hardware for the entire PBCS and for each PLC. The necessary hardware and software shall include but not limited to, workstations, network hardware, PLC input/output (I/O) modules, interconnecting cables, accessories, communication ports, adapters and cards, and all appurtenances for proper operation of the PBCS and to meet the functional requirements described in these specifications, and as shown on the system architecture diagram or network diagram. The System Supplier shall be responsible for the interface to existing systems or those furnished by others.
3. The System Supplier shall be responsible for the PLC interface with systems furnished by others or by the Owner.

B. Related Sections

1. Section 01 33 00 – Submittal Procedures.
2. Section 01 78 36 – Warranties.
3. Division 26 – Electrical.
4. Section 40 90 10 – Control Descriptions
5. Section 40 91 00 – Process Control and Instrumentation System.
6. Section 40 95 13 – Control Panels.

1.02 SUBMITTALS

A. Action Submittals

1. Submittals and shop drawings in accordance with Section 01 33 00.
2. Operation and Maintenance Manuals in accordance with Section 01 78 23.
3. The PLC submittal shall be provided in accordance with the requirements specified in Section 40 91 00.

B. Closeout Submittals:

1. Software: The Contractor shall provide and register the Owner with all user software and hardware licenses. Additional contract, agreements and licenses requirements shall be in accordance with Section 40 91 00.

1.03 WARRANTY

A. Warranty in accordance with Section 01 78 36.

- ##### **B. The Contractor shall guarantee the performance of all the new PLCs and the programming software for them as specified elsewhere in the Contract Documents.**

- C. All parts, material labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period shall be borne by the Contractor under the guarantee. Equipment, software, and materials that do not achieve their intended purpose shall be replaced by the Contractor to attain compliance, at no additional cost to the Owner.
- D. Guarantee and special corrections of defects and software upgrade requirements and warrantee shall be in accordance with Section 40 91 00.

PART 2 -- PRODUCTS

2.01 COMMON FOR ALL CONTROL SYSTEMS.

- A. PROGRAMMABLE LOGIC CONTROLLER (PLC)
 - a. PLC Control System Software and Programming
 - 1) General
 - a) The Contractor shall furnish the latest version, standard, field proven, fully debugged and supported PLC programming and diagnosis software package for this application with a minimum of additions or changes. Customized or specially written software shall be furnished if required to meet all of the functional requirements specified herein. Any custom applications software required shall be fully integrated into the basic software and shall not require unique command structures.
 - b) All programs shall be self-configuring, such that they obtain the size and configuration of the system from parameters contained in the various files created during system generation. No parameters related to the hardware configuration shall be hard coded into any of the software.
 - c) All programming, monitoring, searching, and editing shall be accomplished using this PLC programming software. The programming software shall be usable while on-line (connected to the PLC), or off-line. The PLC program shall display multiples of series and parallel contacts, coils, timers, counters and mathematical function blocks. It shall have the capability to disable/force all inputs, outputs and coils to simulate the elements of the ladder logic by means of color change. The software shall include a search capability to locate any address or element and its program location PLC status information, such as error indication and amount of memory remaining shall be shown on the display screen.
 - d) The PLC programming software package shall be able to monitor and/or control PLCs via the communication network. It shall contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables. It shall also monitor devices at each drop on the communication link for proper communication.
 - e) The PLC programming software shall be able to generate a PLC program printout which is fully documented. Fully documented program listings shall have appropriate rungs, address, and coils shown with labels, descriptors and identifiers. Comments shall clarify to a reader what each segment of the program accomplishes. A fully documented listing shall also include a cross reference report of program addresses.
 - f) The PLC programming software shall run on Windows 10 platform or latest windows operating system recommended by Rockwell Automation for PLC Programming software. The programming language and format shall be

IEC 61131-3 compliant and allow programming to use Ladder Diagram (LD), Sequential Function Chart (SFC), Functional Block Diagram (FBD), and basic PLC Structured Text (ST) programming languages.

- g) The PLC shall be easily programmed with a laptop plugged into the controller. Programming functions shall be done both "on-line" while the processor is scanning, or "off-line." On-line programming and upload/downloads of control programs shall be able to be done over the Ethernet network.
- h) Furnish a minimum of 1-user licensed copy of the PLC programming software registered to the Owner. The software shall be provided with all the options the necessary option to meet the requirements in these specifications.

2.02 PUMP CONTROL PANEL

- A. PLC Processor Base Unit
 - 1. Provide **Allen-Bradley MicroLogix 1400 model 1766-L32BWA Base PLC, no equal, with (12) digital fast 24V dc inputs, (8) digital normal 24V dc inputs, (12) relay outputs integral to the base**, no substitutions.
- B. PLC Expansion Input/output Modules – provide quantities as needed for IO points for each PLC Panel and for spare points as required by the Contract Documents)
 - 1. Provide **Allen-Bradley 1762-IQ16 Discrete Input Modules**, no substitutions.
 - 2. Provide **Allen-Bradley 1762-OW8 Relay Output Modules**, no substitutions.
 - 3. Provide **Allen-Bradley 1762-IF4 Analog Input Modules**, no substitutions.
 - 4. Provide **Allen-Bradley 1762-OF4 Analog Output Modules**, no substitutions.
- C. OPERATOR INTERFACE TERMINAL (OIT)
 - 1. Manufacturers: The PLC and the OIT specified herein shall be of the same manufacturer. Provide **Allen-Bradley Panelview 7 Plus Performance series** OIT, or Approved Equal.
 - 2. Description: The Contractor shall furnish an Operator Interface Terminals (OIT's) and software for each PLC or as indicated on the drawings with the following features:
 - 3. Materials / Components:
 - a. 9-inch active matrix color TFT LCD monitor with touch screen controls. Resolution shall be standard WVGA (min 800 x 480 pixels) with 18-bit color graphics.
 - b. Ports: Ethernet (IEEE802.3, 10/100 BASE-T), 2- USB
 - c. Protocol Supported – Ethernet/IP, two ports.
 - d. Memory – 512 MB storage, 512 MB RAM and 80MB for non-volatile storage.
 - e. Power – 24 VDC
 - f. UL Listed., NEMA 4x (indoor and outdoor application)
 - g. Memory Card: provide units with factory-installed 2GB Secure Digital (SD) card.
 - h. Configuration and development software running on Windows 10 with password protection.
 - i. Software and Configuration - The OIT shall be configured to display simple graphics that include facility graphic similar to those displayed on the HMI. The OIT shall enable access to change operational set points in the PLC the operator access. Additionally, the OIT shall display process variables trending, and display/manage facility alarms. The software shall be of the same manufacturer as the OIT.

D. LOCAL AREA NETWORK HARDWARE

1. Manufacturers:
 - a. The unmanaged Ethernet Switches shall be **Allen-Bradley STRATIX 2000 series**, no substitutions.
2. Description
 - a. Network devices shall be furnished and installed by the Contractor as detailed in this Section and as shown and/or specified on the Control Architecture. Firmware modules, where applicable shall be installed. The network devices shall be of the latest revision. If the specified model has been or is currently scheduled to be discontinued by the manufacturer, the Contractor shall furnish (with the approval of the Engineer) the manufacturer recommended replacement model of equal or better functionality, performance and reliability.
 - b. The Contractor shall also be responsible for configuring new hardware, verifying the firmware, adding communication modules (and other network hardware components as specified) and configuring the network modules to ensure successful working integration with the control system communication network per the contract requirements.
3. Performance / Design Criteria
 - a. The new LAN hardware shall comply with the IEEE 802.3 standards for Ethernet and operate at a minimum bandwidth of 100Mbps.
 - b. The network topology shall permit either switched 100BASE-TX or 1000BASE-TX connections through an auto-negotiating switched hub.
4. Materials / Components
 - a. Ethernet Switch
 - 1) The Contractor shall provide an industrial type (5-port minimum) Unmanaged Ethernet Switch at each of the locations identified on the drawings. Each RJ45 (copper) port shall provide a dedicated 100Mbps (200 Mbps in full duplex) connection between the switch and a node. Each port shall be auto-negotiating (speed and duplex mode) to allow for the fastest possible connection.
 - 2) The switch shall have at least one medium dependent interface/medium dependent interface crossover (MDI/MDIX) configurable port and shall have memory dedicated for media access control (MAC) address storage. The switch shall be equipped with full-firmware pre-installed by the factory. The switch shall support Network Address Translation (NAT) and Common Industrial Protocol (CIP) IEEE 1588 time synchronization.
 - 3) It shall be supplied with all necessary power supplies, connecting cables, firmware and software as necessary to obtain the specified functionality.
 - 4) The switch shall be installed within the control panel.
 - 5) Additionally, the switch shall meet the following requirements.
 - 6) Power Input- 24 VDC.
 - 7) UL listed.
 - 8) Din rail mount.
 - 9) 30-percent of the ports shall be kept unused (spare).
 - 10) Network Interface Cards: the Contractor shall provide all necessary network interface cards to reconcile protocols incompatibilities.

2.03 CABLES

A. Ethernet Patch Cable

1. Ethernet patch cables shall be non-plenum EIA/TIA rated category 6A and shall be compatible with patch panel and faceplate assemblies specified herein. Patch cables shall be center-tuned for optimal connection. Cables shall be snag less plug design. Provide adequate quantities to patch at field device and at network cabinet. Network cabinet cables shall be 3' length. Field equipment patch cables shall have length as necessary, but shall be 3', 7', or 15' length. Patch cables shall have a white jacket. Provide the following as required:
 - a. 3' cables: Ortronics OR-MC610-03-09.
 - b. 7' cables: Ortronics OR-MC610-07-09.
 - c. 15' cables: Ortronics OR-MC610-15-09.
- B. Ethernet Cable
 1. Ethernet bulk cables shall be non-plenum, Category 6A cable as per ANSI/TIA-568.2-D Category 6A.
 2. Conductor material: solid bare copper
 3. Conductor size and type: 23 AWG unshielded twisted pairs
 4. Number of conductor pairs: 4 (with rip cord)
 5. Conductor insulation: Polyolefin
 6. Jacket material: PVC
 7. Impedance: 100 Ohms
 8. Maximum capacitance, unbalanced: 330 pf/100m
 9. UL approved, Riser rated / CMR rated cable.
 10. Product and Manufacturers: **Belden 10GX32 or approved equal.**
- C. Fiber Optic Cable, Patch Cables and Patch Boxes
 1. Comply with the requirements of Division 26

PART 3 -- EXECUTION

3.01 FIELD QUALITY CONTROL

- A. The Contractor shall provide the Owner with training on the subjects of use, maintenance, operation, troubleshooting and repair of all the components of the PLCs and the rest of the PBCS hardware. The training shall be specifically tailored to this project and reflect the hardware and the installation. All training shall be conducted on site unless another location is approved by the Engineer and Owner. Hardware training subjects and the allocated hours for each class shall be in accordance with Section 40 91 00.

END OF SECTION

SECTION 40 95 13 – CONTROL PANELS

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. General: The CONTRACTOR through the use of the System Supplier shall provide control panels for the PCIS, complete and operable, in accordance with the Contract Documents.
- B. The System Supplier shall be responsible for selecting, sizing, and providing the correct and necessary type and quantity of the panels for each process control application. The necessary hardware and responsibilities shall include but not limited to:
 - 1. Mounting the panel
 - 2. Locating and mounting interior and exterior instruments, hardware and equipment in the panel
 - 3. Field interface terminal blocks
 - 4. Terminating panel internal wiring and signals
 - 5. Terminating communication and network cabling and wiring

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Section 40 91 00 - Process Control and Instrumentation
- B. Division 26 – Electrical
- C. The provisions of this Section apply to local panels provided in equipment systems specified in other sections unless indicated otherwise in those sections.
- D. All panels shall conform to the specifications; codes and standards requirements specified Section 40 91 00 - Process Control and Instrumentation System.
- E. Each control panel, including panels for service entrance equipment, shall meet all UL listing and labeling requirements including UL Standard 508 and UL Standard 508A and shall be UL labeled accordingly. Contractor shall arrange components and wiring to meet UL requirements stated above.

1.3 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

- A. The Submittals shall be provided in accordance with the requirements specified in Section 40 91 00 – Process Control and Instrumentation System.

1.4 QUALITY ASSURANCE

- A. Factory and field tests shall be performed in accordance with Section 40 91 00 – Process Control and Instrumentation System.

1.5 WARRANTY

- A. Guarantee and Special corrections of defects and software upgrade requirements and warrantee shall be in accordance with Section 40 91 00 - Process Control and Instrumentation System.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. All PCIS control panel assemblies, such as new PLCs, communication systems, etc. shall be mounted inside a new outdoor NEMA-rated type enclosure, suitable and designed for the application for which it was intended, as specified or as shown on the drawings. If required, PCIS panel assemblies shall be mounted in existing enclosures. Control panels shall be either freestanding, pedestal-mounted or equipment skid-mounted.
- B. The enclosure and back panel shall be sized to contain the equipment required to make the installation complete and suitable for its intended purpose. Field conditions and the guidelines provided in the specifications and/or the drawings shall be followed. Accessibility for ease of maintenance, future expansion and good installation and industry practices shall be considered when sizing an enclosure. Spare space shall be kept clear of wiring, etc., to give contiguous clear space for future additions.
- C. In cases where existing panel is used, the CONTRACTOR shall review the available space in the field or in the existing panel to determine the proper size of back panel suitable to accommodate the required equipment for the facility. It should be noted that control panel layouts shown on the Drawings are diagrammatic. The control panel submittal shop drawing shall reflect the accurate layout of the equipment in the panel.
- D. Environmental Suitability and NEMA Rating
 - 1. Outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain instrumentation devices 20-percent within the minimums and maximums of their rated environmental operating ranges. The CONTRACTOR shall provide power wiring for these devices. Enclosures shall be suitable for the environment that they are installed. Panel instruments and equipment in hazardous areas shall be suitable for use in the particular location in which it is to be installed.
 - 2. Control panels shall be sized to adequately dissipate heat generated by equipment mounted in or on the panel.
 - 3. NEMA Rating
 - a. All PCIS panel assemblies, such as PLCs, remote I/Os, analyzer systems, communication systems, etc. shall be mounted in a NEMA-rated type enclosure suitable for the environment that it is located. Different NEMA rated enclosures and suitable materials of construction (e.g. stainless steel, fiberglass, etc.) shall be used for specific applications, project requirements and for corrosive and/or hazardous environments.
 - b. In the minimum rating of all outdoor mounted panels shall be NEMA 4X (IP66) stainless steel construction.

2.2 CONSTRUCTION

A. Material and Fabrication.

1. Wall mounted type enclosure shall be constructed of a minimum of 12-gauge 304 stainless steel, depending of the size of the enclosure, application, environment, and the project requirements.
2. Seams shall be continuously welded and ground smooth. Corners shall be welded and ground smooth.
3. Each enclosure shall have a heavy gauge, continuous piano hinge pin which shall support each door.
4. Door and body stiffeners shall be provided where required. The stiffeners shall be welded to the inside of enclosures to prevent deformation due to the weight of face-mounted instruments.
5. Doors shall be sealed with a closed cell neoprene gasket.
6. The interior rear and sides of each enclosure shall have steel mounting channels for supporting mounting panels.
7. Enclosures shall be provided with external mounting feet as shown, as well as door clamps, hasp and staple for padlocking, data pocket, and closed-cell oil-resistant gasket. Removable lifting lugs to facilitate handling shall be provided on large enclosures.

- B. Back and Side Panels: Each enclosure shall be provided with a removable back panel. Depending on the size of the enclosure more than one back panel may be required. Removable side panels shall be provided as required for additional mounting space.

- C. Enclosure interior, and back and side panels shall be white.

- D. Ventilation, Louvers, Vents, and Filters: In enclosures where excessive internal heat or internal moisture is a problem, the enclosure shall be equipped with louvers with filters and a cooling fan. The perimeters of the louver plate shall be sealed with a gasket. Louver shall be of the same material and finish as the enclosure. The louver shall be sized for effective heat rejection.

- E. Accessories: The CONTRACTOR shall provide additional panel accessories to meet the specifications, such as floor stand and mounting kits, door handle and lock kits (common key shall be provided for all doors), 3-point latch, etc.

F. Instruments Mounting

1. Equipment mounted at the rear of enclosure shall be installed to allow for commissioning adjustments, operation and servicing requirements. The CONTRACTOR shall arrange components and wiring to meet UL requirements.
2. Spare space shall be kept clear of wiring, etc., to give maximum space for future additions.

3. For front mounted hardware, cutouts and holes may be cut or drilled by any standard method that does not cause deformation. Burrs shall be ground smooth. Mounting the instruments shall not degrade the NEMA rating of the enclosure.
 4. DIN rail mounted equipment shall be used as much as possible.
 5. Each enclosure shall be provided with interior nameplates to identify equipment tags and functions.
- G. Enclosures shall be **Hoffman, Hubbel-Wiegmann, SCE** or equal.

2.3 ELECTRICAL REQUIREMENTS

- A. The control panel controls shall be 120 VAC, 60 Hz. The CONTRACTOR shall provide the main power supply from an external source.
- B. The CONTRACTOR shall provide wireways, wire, and electrical fittings and components for 120V and 24VDC circuits to instruments and other electrical devices in the panel for a complete and operable installation. Wiring methods and materials for all panels shall be in accordance with the NEC requirements.
- C. The circuits for 24VDC shall run in separate wireways from the 120 VAC circuits.
- D. Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks. Each control panel shall be provided with identified terminal strips for the connection of all external foreign voltage. A "CAUTION- Foreign Voltage" nameplate shall be attached to the outside of the enclosure door warning of foreign voltages inside the enclosure.
- E. Terminal Blocks
 1. The control panel shall be provided with sufficient terminal blocks for the connection of external field conductors, signals, and power and for use inside the panel for power distribution and for future expansion. In order to facilitate easy and safe loop maintenance, each analog input loop shall have a disconnect with test plugs built into its field terminal block.
 2. Spare Terminal Blocks for Signals: The CONTRACTOR shall provide sufficient spare terminal blocks to connect additional signals for future use (implemented and future spares). Implemented spare signals shall be wired to terminal blocks and the percent of these terminals shall be in accordance with the growth requirements specified in Section 40 95 10 – PLC-Based Control System Hardware. For future signals (i.e. the source of inputs or final control elements are not yet known or available in the field), the CONTRACTOR shall provide 20-percent spare terminals in the panel for each type of actual I/O in the PLC. The number of terminals shall take in account the types of I/O for which spares are provided (Three (3) terminals for each AI or AO shall be provided).
 3. Spare Terminal Blocks for Power and Other Applications: In addition to the spare terminals for signals, The CONTRACTOR shall provide spare terminals for 3 additional power distribution and grounding applications circuits.
 4. Terminal blocks for all wiring shall be modular terminals, DIN rail mounted type rated at 15 amperes at 600 VAC and have a minimum width of 8-mm suitable for No. 12

gauge stranded wire. Terminals shall be the solderless box lug type with pressure plates in actual contact with the wire to minimize wire breakage. Each terminal shall have a light colored strip for marking the terminal number or circuit designation. Double high terminal blocks are not acceptable.

5. External connections to and from enclosures shall terminate on terminal blocks, except approved communication and data cables. Circuit isolating switches and fuse terminals shall include non-conducting pullers which can be removed with finger alone, without tools. Additionally, the panel shall be provided with identified terminal strips for the connection of external/field conductors.
6. Terminals shall be as manufactured by **Square D Class 9080 Type M, Allen-Bradley Bulletin 1492 Type H or J, by Entrellec**, or equal.

F. Electrical Hardware Accessories: The control panel shall be equipped with the following:

1. A duplex 15 amp, 120 VAC GCFI type receptacles for service and maintenance use. The receptacle shall be 2-pole, 3-wire grounding, and heavy duty industrial grade by **Hubbell, Leviton**, or equal.
2. A duplex 15-amp 120 VAC GCFI type receptacle dedicated for a powering an uninterruptible power supply (UPS). The receptacle shall be color coded, 2-pole, 3-wire grounding, heavy duty industrial grade by **Hubbell, Leviton**, or equal
3. A 120 VAC LED light strip lamp with guards and a toggle switch (**IDEK LUMIFA LF1B Series**, or equal) mounted on the top of the enclosure or on the part the side or back panel shall be provided for panel lighting. A separate fuse/circuit breaker shall be provided for the lamp mounted inside and in the top of the back-of-panel area. Control panels that are longer than 72-inches, two lamps shall be provided.
4. A ¼-inch by one (1)-inch copper grounding bus bar with multiple connecting terminals. The grounding bus shall be complete with solderless connector for one 4 AWG bare stranded copper cable and with tapped holes to accommodate ground connections from various devices in the enclosure. Provide ground connections for different AWG wires and shield connection clamps by **Phoenix Contact**, or equal. Provide separate ground buses for analog and discrete/digital signals. The copper cable shall be provided by the CONTRACTOR and be connected to a system ground loop.
5. 120 VAC Heater and thermostat. Heater by **Pfannenber**g and thermostat by **Stego model KTO-011**, or equal, if required.
6. Ventilation fan and filter kit by **Cooltron FA and FAA series**, or equal, if required

G. Circuit Breakers, Fuses, and Disconnects

1. Circuit breakers, fuses and disconnects shall be installed in the control panel to protect against fault current the 120 VAC and 24 VDC branch circuits and the instruments and the electrical components that these circuits power. Circuit breakers shall be installed as disconnects of external power feeds for control circuits from outside the enclosure and branch circuits within the enclosure.
2. The circuit breakers, fuses and disconnects shall also allow disconnecting the power from these instruments in a safe manner. Individual plug and cord set power supply

connections, such as for a UPS, may be used without switches. Each circuit breaker and fuse shall be identified by a service nametag.

3. The fuses shall be mounted in a DIN mounted fuse holder terminal block and shall have a blown fuse indicator light. The fuse holders for 120 VAC applications shall have a neon light indicator and shall **Entrelec part number 0115-661.21, or equal**. The holders for 24 VDC applications shall have an LED indicator light and shall be **Entrelec part number 0115-663.23, or equal**.
4. The number of power distribution circuits depends on the type of electrical devices they power. A 120 VAC, 60 Hz single pole circuit breakers or a fuse, as noted, with the following minimum rating shall be provided in each branch circuit as listed below. The circuit load shall not exceed 10-amp. The circuit breakers shall be DIN rail mounted type. The 120 VAC breakers shall be **Square D model QUO-120 and QUO-115**, depending on the amperage rating, or equal.
 - a. 20-amp main circuit breaker for the 120 VAC control panel power supply and the distribution of the power.
 - b. 15 amp circuit breaker for the duplex 15 amp, 120 VAC GCFI type receptacle used for service and maintenance, and the LED light
 - c. 15-amp circuit breaker (or as required by the UPS manufacturer) for the dedicated duplex GCFI type receptacle used for the UPS.
 - d. 15-amp circuit breaker for the heater and thermostat and ventilation fan.
 - e. 5-amp circuit breaker for the protection of the PLC if it is powered by a 120 VAC power.
 - f. 2-amp fuse, 120 VAC for each of the 120 VAC power input circuits to the two(2) redundant 24 VDC power supplies
 - g. A 1/8 – amp fuse to protect the 24 VDC LED light
 - h. A fuse, sized as required, shall be provided for the protection of each 24 VDC branch (including spares) and equipment that is powered by the 24 VDC power supply. Each analog and discrete input loop shall also be protected by a fuse. A fuse shall be provided to each instrument regardless if it is equipped with integral replaceable fuse.

H. Uninterruptible Power Supply

1. The CONTRACTOR shall provide an uninterruptible AC power supply (UPS) system for each control panel to back up the power for the panel in case utility power fails. The UPS shall be a “smart” type, use on-line, high frequency, double-conversion technology. The batteries shall be integral to the UPS enclosure
2. Capacity and Duration: The continuous output capacity of the UPS shall be at least 30 minutes backup time at 150% load. It shall be sufficient to supply the computers, interface and peripheral equipment (present and future) with regulated AC power for a minimum of thirty (30) minutes from batteries only. Additional batteries or larger UPS size shall be provided to meet the specified backup time.

3. The CONTRACTOR shall submit load calculations and size each UPS to justify the selection of present and future load requirements, as well as overload and inrush capacity requirements.
4. Under normal conditions the AC power line shall feed the UPS to power the protected load. The UPS shall also maintain the batteries in fully charged "float" condition. Whenever the normal AC power fails or dips below the normal range, the critical load shall be continuously supplied from the batteries and the double conversion system. The transfer from normal to AC line to backup power shall be bumpless and without a break in the output of the UPS (0 transfer time).
5. Provide a make-before-break maintenance bypass switch to transfer load to line power.
6. Features and Options
 - a. Input Power Range: 100 to 132 volts, 60 Hertz +/- 5 Hertz, auto-sensing.
 - b. Output Power Range: 110/120 (selectable), +/- 3 percent of nominal, 60 Hertz +/- 0.5 percent.
 - c. Output Receptacles: Minimum of six (6) built-in outlets.
 - d. Overload Capacity: The UPS shall have the ability to supply 110 percent of system requirements for 10 seconds, without degradation of the service life.
 - e. Protection: The UPS output shall be protected (IEEE standards) from lightning, surges overload, and short circuit. The input shall be protected by a circuit breaker, sized in accordance with manufacturer's recommendations.
 - f. Battery: Lead acid type, maintenance free, sealed suspended electrolyte, and leak-proof. Recharge Time (with half load): three (3) hours.
 - g. Alarms and Status: The UPS shall be provided with a relay output to provide a common dry contact output that represents the health/status of the UPS and battery functions (i.e. low battery, UPS on batteries, UPS fault, batteries failed on battery self-test).
7. **Manufacturer: Schneider Electric-APC Smart-UPS SMT LCD, with AP9810 relay output card, or Eaton 9130 with relay interface cards, or or Approved Equal.**

I. Control Panel 24 VDC Power Supplies

1. Control panels shall be provided with redundant power supplies which shall be configured in a fault-tolerant manner to prevent interruption of service upon failure and interruption of service necessitated by the replacement of a power supply.
2. The CONTRACTOR shall size the power supplies to meet the control panel requirement and the instruments and loops they support. Power supplies shall have an excess rated capacity of 40 percent. The failure of a power supply shall be alarmed at the SCADA System.

3. Power Supplies – 24 VDC: The control and PLC panels shall be the source of power for any 24 VDC two-wire field device, devices in the panel requiring 24 VDC power, or where applicable, solenoid valves interconnected with the panel.
4. All 24VDC Power Supplies to be backed up by UPS (120VAC input).
5. The failure of a power supply shall generate a dry relay contact output that can be used as an input to the PLC/ SCADA system.
6. **Power supplies shall be Phoenix Contact 24 VDC Quint series, Allen Bradley 1606-XLB 24VDC or approved equal.**

J. Control Panel Signal, Control and Power Wiring

1. General: The signal, control and power wiring specified herein shall apply only to the wiring inside the control panel. Field wiring shall be in accordance with requirements specified in Division 26.
2. Wire type and sizes: Conductor shall be flexible, stranded, copper UL approved type wires, and shall be rated 600 volts. The following wire sizes and insulation types and color shall be used inside the control panel for the listed applications:
 - a. 120 VAC power wires: Main 120 VAC power wiring for distribution in the control panel (line, neutral and ground) shall be a minimum of 12 AWG, or heavier as required by the panel load, with **THHN/THWN** insulation.
 - b. Power conductors in branch circuits such as for lighting, receptacle, heater and thermostat, etc. shall be a minimum of 14 AWG also with **THHN/THWN** insulation.
 - c. Wiring for 600 volt class power and lighting shall be as manufactured by **Okonite, General Cable, Southwire**, or equal.
 - d. The following insulation color code designation shall be used:
 - 1) Line Power – Black
 - 2) Neutral (grounded circuits) – White
 - 3) Power Ground – Green
 - 4) Ungrounded 120 VAC control circuit conductors (switched power) – Red
 - 5) Wires energized by 120 VAC source external to the control panel (usually used for DO) shall have yellow insulation
 - e. 120 VAC Control Wires: For AC control wiring shall be No. 14 AWG machine tool grade type **MTW**, rated for 90 degrees C at dry locations and be as manufactured by **American, General Cable**, or equal.
 - f. 24 VDC power, status, alarm, and control wires shall be a minimum of 16 AWG or heavier as required, with **TFFN/MTW** insulation.
 - g. The following insulation color code designation shall be used:

- 1) Positive (+) – Blue
- 2) Common (-) – Blue/White
- 3) DC Ground – Green/Yellow

h. Signals and Instrumentation Wires and Cables

- 1) Analog and instrumentation signal wiring inside the panel shall be No. 18 AWG minimum twisted shielded pair of stranded tinned copper conductors rated at 600 volts. Insulation shall be color coded PVC/Nylon - black-white for 2 conductor cable and black-red-white for 3 conductor cable.
- 2) Multi-conductor cables where indicated shall consist of No. 18 AWG copper stranded tinned copper signal wires twisted in pairs, with 90-C, 600V fault insulation. Multi-conductor cables shall be sized to allow for 10 percent spare signal wire.
- 3) All analog and Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 22 or larger AWG stranded tinned copper drain wire, and a PVC outer jacket with a minimum thickness of 0.047-inches.
- 4) Insulation color code designation for 2- conductor cable shall be as follows:
 - a) Positive (+) – Black
 - b) Negative (-) - White
- 5) Insulation color code designation for Triad cable shall be Black-Red-White.
- 6) Single pair, No. 18 AWG, twisted, shielded cable shall be **Belden Part No. 3088AE**, similar by **General Cable**, or equal.
- 7) Single triad, No. 18 AWG, twisted, shielded cable shall be **Belden Part No. 3089A**, similar by **General Cable**, or equal.

K. Wire Markings: Each conductor in the control panel connected to a given electrical point shall be designated by a single unique wire number which shall be shown on all shop drawings. These numbers shall be marked on all conductors at every terminal connection using numbered wire marking sleeves or heat shrink plastics by **Brady**, or equal.

L. Surge Protection Devices: Surge protection devices (SPD) shall be provided to protect control loops, instruments, and networks (e.g. Modbus, etc.) for protection against induced current surge and transient surge sources (e.g. lightning, power switching, static discharge, etc.). The SPD shall divert the resulting surges safely to earth and limit voltages to acceptable levels.

1. Provide incoming power line surge suppressors. Unit shall feature 120VAC dry contact to indicate failure. Unit shall be **Citel or approved equal**.
2. Each end of a loop shall be protected by a SPD - at the control panel side and at the instrument, device, or equipment in the field side.

3. Technical Data and Design:

- a. The SPD shall be of the fast acting type, capable of limiting the surge destructive high voltage transients, and shall feature accurate voltage control. It shall be maintenance-free and fully automatic self-resetting, once the over voltage has ceased.
- b. The SPD shall be of a multi stage hybrid circuit design, incorporating gas-filled discharge tubes (for high surge current diversion) with zener diodes for fast operation. It shall have the following features:
 - 1) Withstand a minimum of 10kAmp at 8/20 μ s total surge current impulse per wire for all 24VDC discrete and analog control panels interfaces.
 - 2) Withstand at least 1.4 KAmp lightning impulse current at 10/350 μ s total surge current impulse per wire for all 24VDC discrete and analog control panels interfaces.
 - 3) Housing shall be modular, 7mm maximum width, and of the DIN rail mount type for all 24 VDC analog and discrete control panel interfaces. Field SPD shall have ½ NPT threaded connection and shall be housed in a NEMA 4 rated housing and NEMA 4X rated for corrosive environment.
 - 4) Operating Ambient Temperature Range -40°C to +80°C
 - 5) 120VAC discrete circuits shall be protected by 7mm maximum width DIN rail mount, metal oxide varistor (MOV) SPDs for control panel interfaces
 - 6) Field instrument SPDs shall be of the threaded conduit entry type with 20kA maximum surge current per wire. 7mm maximum width DIN rail mount units may also be used for 120VAC field instruments as specified.
 - 7) Range of voltage ratings to suit all process I/O applications

4. Applications (non-hazardous locations):

- a. Each 4-20 MADC, 2-Wire, 24 VDC analog loop and each 24 VDC digital (discrete) loop shall be protected by installing one (1) **MTL series SDM model SD32M** at the control panel side, and one (1) **MTL TP-48** or equal, on the instrument side in the field.
- b. Each 4-20 MADC, 4-wire analog loop shall be protected by installing two (2) SPD on each end of the loop. The SPDs shall be the same as those used for a 2-wire analog loop.
- c. Each 120 VAC digital (discrete) shall be protected by installing one (1) **MTL series SD SD150X** at the control panel side, and one (1) **MTL TP-AC 420-N or SD150X** or equal, on the instrument side in the field, depending on the mounting conditions.

M. Intrinsic Safety Barriers

1. Barriers shall be provided to service circuits entering areas designated as Class 1 Division 1 – Group A, B, C, or D - or Class 1, Division 2 – Group A, B, C, or D - or as

identified in the Contract Documents and as identified in the Contract Drawings. Barriers shall be panel mounted and wired strictly in accordance with manufacturer installation instructions and in accordance with the National Electric Code.

- a. Barriers shall be DIN-rail mounted in panels or enclosures rated for the environment where the panel or enclosure shall be located.
 - 1) For barriers requiring vendor-specific DIN rail mounting hardware, provide 25% spare mounting space for additional barriers on the DIN-rail.
 - b. Provide power supplies for barriers requiring external power. Barrier power supplies shall be dedicated to only servicing barriers and no other devices. Provide power supplies sized to provide 2-times the required current capacity to allow for future expansion.
 - c. Coordinate grounding requirements with the barrier manufacturer's installation instructions and the requirements of Division 26 of the Contract Documents.
2. Barriers shall be made to service a single field signal. Multiple signals per barrier shall not be acceptable.
 3. Provide 4500 series barriers by Eaton/MTL, K-system barriers by Pepperl+Fuchs, or approved equal.

2.4 ELECTRICAL COMPONENTS

A. General Purpose Relays

1. General purpose relays in the control panel(s) shall be compact plug-in type with contacts rated 10 amperes at 120-volts ac; or 24 VDC. Quantity and form of contacts shall be as required by the application. However, the relay shall have a minimum of two (2)-form C contacts (double pole-double throw), except when used as interpose relay for the PLC's DO modules they shall have a minimum of one (1)-form C (single pole single throw) contacts. Each relay shall be provided with a neon light to indicate energized state.
2. The relay socket and mounting shall be a standard DIN rail mount with pullover wire spring ("horseshoe clip").
3. Relays shall be **IDEC compact relays type RHXB-UL with SHXB-05 sockets where X indicates the number of form C contact or Approved Equal.**

- B. Slave and Interposing Relays: Additional slave relays shall be provided when the number or type of contacts required exceed the contact capacity and/or rating of the specified relays and timers. Additional relays shall be provided when higher contact rating is required in order to interface with starter circuits or other equipment. The slave and interposing relays shall be as the general purpose relays specified above.

- C. Time Delay Relays - Electronic Type: Time delay relays shall be plug-in electronic type with on-delay or off-delay actuation as required. Output contacts shall be DPDT rated 10-amperes at 120-volts ac minimum. Each unit shall include an adjustable time delay with a time range scale. Operating temperature range of the units shall be -20 to +120 degrees-F minimum and each device shall be rated for 10,000,000 mechanical operations

and 500,000 electrical operations. Time delay relays shall be **Idec RTE series, Schneider Electric, Agastat Series SCC, Omron, or Approved Equal.**

D. Indicating Pilot Lights

1. Indicating lights shall be ultra-bright multiple LED cluster lamps, push-to-test transformer type and shall be heavy-duty, oil-tight construction. Operators shall be nickel or chrome plated. Each light shall have a screwed-on prismatic lens approximately 1-inch in diameter. Miniature style devices are not acceptable.
2. Lens colors shall be red for "run," "open," or "on"; green for "stopped," "closed," or "off"; and amber for alarm.
3. Indicating lights shall be **Square D Company, Class 9001 Type K, General Electric Company Type CR104P, or Approved Equal.** Each light shall have a factory-engraved legend plate, as shown on the Contract Documents.

E. Selector and Pushbutton Switches: Selector and pushbutton switches shall be rated 10-amperes at 600 volts; shall be heavy-duty, oil-tight construction; and shall have the number of positions and poles required. Miniature style devices are not acceptable. Operators shall be nickel or chrome plated. Switches shall be **Square D Company, Class 9001 Type K, General Electric Company Type CR104P, or equal.** Each switch shall have a factory-engraved legend plate as shown on the Contract Documents.

F. Signal Isolators, Conditioners and Converters

1. Signal isolators conditioners and converters shall be provided as required to resolve any signal level incompatibilities, to ensure adjacent component impedance match where feedback paths may be generated, or to maintain loop integrity during the removal of a loop component.
2. Signal isolators, integrators and converters shall be 24 VDC or 120 VAC powered as applicable, and shall DIN rail mounted. Isolators shall be by **Phoenix Contact, Acromag, or Approved Equal.**

G. Nameplates: Nameplates shall be provided for instruments, function titles for each group of instruments, and other components mounted on the front or the inside of the control panel. A nameplate shall be provided for each instrument and device. The nameplates shall be descriptive to define the function and system of such device in accordance with the CONTRACT DOCUMENTS or the approved shop drawings. Adhesives shall be acceptable for attaching nameplates, but stainless-steel nameplates shall be fastened with screws. Nameplates shall be fabricated from white-face, black-center, laminated engraving plastic

2.5 CELLULAR MONITORING SYSTEM

a. Type

- 1) Cellular based remote monitoring system with web interface

b. Operation

- 1) To accept a N.O./N.C. contact input and 4-20mA input and transmit the data to be integrated into the existing monitoring system.

- 2) Alarm data: real-time
 - 3) Pump information: pump run times and starts summarized hourly
 - 4) Analog reporting: current value reported hourly
 - 5) Device health: built-in inputs reported hourly
- c. Functional
- 1) I/O: 8 digital inputs; 4 analog inputs; 4 digital outputs
 - 2) Cellular Communication
 - 3) Modbus interface: RS-232, RS-485, or Ethernet
 - 4) Operating temperature: -25C to 70C
 - 5) Input power: 115VAC 60Hz
 - 6) Backup battery: 12V 3-5 days
- d. Physical
- 1) Case size – 10-in W x 12-in H
 - 2) Case Material - NEMA 4X Polycarbonate enclosure
 - 3) Mounting – External Unistrut mounting
- e. Manufacturer
- 1) High Tide HTT GEN-2 or Approved Equal.
- f. Programming and setup
- 1) The cellular monitoring system shall be connected to the Pump Station PLC for communication of alarm and status signals. The CONTRACTOR shall setup the cellular monitoring system to monitor the pump station and equipment including the setup of personalized dashboard for the OWNER. Signals to be communicated via the cellular monitoring system shall be as shown in the contract drawings. The Contractor shall hold a 2hr virtual meeting with the OWNER and ENGINEER to discuss the monitoring dashboard configuration, trending, reporting of data and alarming. The CONTRACTOR shall update the cellular monitoring system programming per the results of this meeting.

2.6 SPARE PARTS AND SPECIAL TOOLS

- A. Control panel spare parts selected by the ENGINEER or the OWNER and special tools shall be furnished in accordance with Section 40 91 00 - Process Control and Instrumentation System.

PART 3 -- EXECUTION

3.1 EXAMINATION

A. Preparation for Shipment and Shipping

1. Control panels shall be crated for shipment using a heavy framework and skids as required and cushioned to protect the finish and the instruments during shipment. Shipments shall be by air-ride vehicle. Suitable cushioning material shall be used to protect interior hardware that could be damaged due to mechanical shock.
2. Depending on panel size, each separate panel unit shall be provided with removable lifting lugs to facilitate handling.
3. Control panels shall be installed in accordance with Section 40 91 00 - Process Control and Instrumentation System.

3.2 INSTALLATION

A. CONTROL PANEL SIGNAL AND CONTROL CIRCUIT WIRING

1. Wiring Installation

- a. Wiring methods and materials for panels shall be in accordance with the NEC requirements and industry practices.
- b. Wires shall be run in plastic wireways except (1) field wiring, (2) wiring between mating blocks in adjacent sections, and (3) wiring from components on a swing out panel to components on a part of the fixed structure.
- c. Neatly grouped using nylon tie straps, and shall be fanned out to terminals. Wiring run from components on a swing out panel to other components on a fixed panel shall be made up in tied bundles. These bundles shall be tied with nylon wire ties and shall be secured to panels at both sides of the hinge loop so that conductors are not strained at the terminals.
- d. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and be secured to the inside face of the panel using adhesive mounts.
- e. Splicing of shall be kept to a minimum and only if the wire cannot be replaced. Splicing shall be either soldered or pressure crimped type. Data and communication wires/cables shall not be spliced.

2. Wiring Termination

- a. All field wiring shall terminate at a terminal block in the enclosure. Field wiring shall be terminated first at the field interface terminal block and then wired to the devices/instrument or PLC inside the panel. Except for antenna cable, Cat 6 cables and other specialty cables, such as data cables, field wiring shall not be wired directly to the panel mounted device.
- b. Terminals and fuses for each conductor and shield drain wire of a twisted shielded pair or triad cable shall be mounted consecutively next to each other.

- c. Terminal blocks shall be grouped based on their function and voltage. Each group of terminal blocks shall be located in the panel to provide easy access, safety, practicality, and minimization of internal wiring.
- d. Terminal blocks for 24 VDC signals shall be grouped separate from the power and other 120 VAC terminals.
- e. Terminal blocks for 24 VDC signals shall be grouped separate from the 24VDC power as well. Likewise, terminal blocks for 120 VAC power and distribution shall be grouped separate from the 120 VAC terminals for control signals.
- f. Each terminal and wire connection shall be tagged in accordance with the approved shop drawings or OWNER's standard tagging/numbering, if available.

3.3 FIELD QUALITY CONTROL

- A. General: Calibration, testing, and instruction shall be performed in accordance with Section 40 91 00 - Process Control and Instrumentation System.

3.4 ADJUSTING

- A. As specified elsewhere in these specifications and as shown on the drawings, the CONTRACTOR is required to remove or disconnect some existing equipment as a result of their complete or partial replacement of their functionality, and in some cases to provide space for the new equipment. In all cases the CONTRACTOR shall disconnect the replaced equipment and functions and ensure that the remaining equipment and their remaining (not replaced) functionality shall continue to function/operate as originally intended. The CONTRACTOR shall also restore the condition of the modified operational control or monitoring circuits.
- B. Analog Loops: Whenever an existing analog loop is modified, the CONTRACTOR shall ensure that the integrity and isolation of the loop is maintained and the shield is grounded correctly. In modifying the analog loop the CONTRACTOR shall also modify the 24 VDC to that loop so that the power supply source of that loop is part of the control panel and backed up by the UPS in it.
- C. Field Connection Panels and Interface Terminal Blocks: In cases where field I/O wiring has to be extended to the control panel from enclosures that are removed or modified, the CONTRACTOR shall provide separate enclosures/field connection panel (FCP), as required, to which field I/Os are wired, and from which the signals shall be wired to the control panel.

END OF SECTION