Jefferson County Department of Public Works

Port Hadlock UGA Sewer System/
Water Reclamation Facility and
Influent Pipeline

Technical Specifications

Volume 4 - Divisions 35 – 46 and Appendix A

December 2013
PORT HADLOCK UGA SEWER SYSTEM / WATER RECLAMATION FACILITY AND INFLUENT PIPELINE DESIGN

TABLE OF CONTENTS

VOLUME 1 OF 5

**DIVISION 0 - BIDDING REQUIREMENTS, FORMS AND TERMS AND CONDITIONS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00110</td>
<td>Invitation to Bid</td>
</tr>
<tr>
<td>00200</td>
<td>Instruction to Bidders</td>
</tr>
<tr>
<td>00220</td>
<td>Non-Discrimination, Equal Employment Opportunity, EPA Fair Share Goals, Good Faith Effort Requirements, and Apprenticeship Requirements</td>
</tr>
<tr>
<td>00230</td>
<td>Davis Bacon Action Wage Determinations and Washington State Prevailing Wage Rates for Public Work Contracts</td>
</tr>
<tr>
<td>00410</td>
<td>Bid Proposal Forms</td>
</tr>
<tr>
<td>00430</td>
<td>Bid Proposal Bond</td>
</tr>
<tr>
<td>00440</td>
<td>Bidder’s Checklist</td>
</tr>
<tr>
<td>004510</td>
<td>Qualification Information – Project Specific Contracts</td>
</tr>
<tr>
<td>005200</td>
<td>Contract Documents and Contract Bond Forms</td>
</tr>
<tr>
<td>006100</td>
<td>Performance and Payment Bond</td>
</tr>
<tr>
<td></td>
<td>Maintenance Bond</td>
</tr>
<tr>
<td></td>
<td>Guarantee Form</td>
</tr>
<tr>
<td>007000</td>
<td>General Terms and Conditions</td>
</tr>
<tr>
<td>008000</td>
<td>Supplemental Terms and Conditions</td>
</tr>
</tbody>
</table>

VOLUME 2 OF 5

**DIVISION 01 - GENERAL REQUIREMENTS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>010140</td>
<td>Project Constraints</td>
</tr>
<tr>
<td>01100</td>
<td>Summary</td>
</tr>
<tr>
<td>01250</td>
<td>Substitution Procedures</td>
</tr>
<tr>
<td>012600</td>
<td>Contract Modification Procedures</td>
</tr>
<tr>
<td>012900</td>
<td>Payment Procedures</td>
</tr>
<tr>
<td>013100</td>
<td>Project Management and Coordination</td>
</tr>
<tr>
<td>013200</td>
<td>Construction Progress Documentation</td>
</tr>
<tr>
<td>013233</td>
<td>Photographic Documentation</td>
</tr>
<tr>
<td>013300</td>
<td>Submittal Procedures</td>
</tr>
<tr>
<td>014000</td>
<td>Quality Requirements</td>
</tr>
<tr>
<td>014200</td>
<td>References</td>
</tr>
<tr>
<td>015000</td>
<td>Temporary Facilities and Controls</td>
</tr>
<tr>
<td>015639</td>
<td>Temporary Tree and Plant Protection</td>
</tr>
<tr>
<td>016000</td>
<td>Product Requirements</td>
</tr>
<tr>
<td>Division 01 – Administration and Management</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>016200 Permits and Easements</td>
<td>017300 Execution</td>
</tr>
<tr>
<td>017700 Closeout Procedures</td>
<td>017823 Operation and Maintenance Data</td>
</tr>
<tr>
<td>017839 Project Record Documents</td>
<td>019150 System Startup, Testing, and Training</td>
</tr>
</tbody>
</table>

**DIVISION 02 – SITE CONSTRUCTION**

| 024119 Selective Demolition               |  |

**DIVISION 03 – CONCRETE**

| 033000 Cast-in-Place Concrete            |  |

**DIVISION 04 – MASONRY**

| 042000 Unit Masonry                       |  |

**DIVISION 05 - METALS**

| 051200 Structural Steel Framing          | 052100 Steel Joist Framing                |
| 053100 Steel Decking                     | 054000 Cold-Formed Metal Framing          |
| 055000 Metal Fabrications                | 055119 Metal Grating Stairs               |
| 055213 Aluminum Pipe and Tube Railings   | 055300 Metal Gratings                     |

**DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES**

| 061000 Rough Carpentry                    | 061600 Sheathing                           |
| 062023 Interior Finish Carpentry          | 064116 Plastic-Laminate-Faced Architectural Cabinets |

**DIVISION 07 - THERMAL AND MOISTURE PROTECTION**

| 071900 Water Repellents                   | 072100 Thermal Insulation                  |
| 072500 Weather Barriers                   | 074113.16 Standing-Seam Metal Roof Panels |
| 074213.13 Formed Metal Wall Panels        | 074213.53 Metal Soffit Panels             |
| 076200 Sheet Metal Flashing and Trim      | 078413 Penetration Firestopping            |
| 079200 Joint Sealants                     |  |

**DIVISION 08 - OPENINGS**

<p>| 081113 Hollow Metal Doors and Frames      | 081416 Flush Wood Doors                    |
| 083100 Access Hatches                     | 083323 Overhead Coiling Doors             |</p>
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>083613</td>
<td>Sectional Doors</td>
</tr>
<tr>
<td>085113</td>
<td>Aluminum Windows</td>
</tr>
<tr>
<td>086200</td>
<td>Unit Skylights</td>
</tr>
<tr>
<td>087100</td>
<td>Door Hardware</td>
</tr>
<tr>
<td>089119</td>
<td>Fixed Louvers</td>
</tr>
<tr>
<td></td>
<td><strong>DIVISION 09 - FINISHES</strong></td>
</tr>
<tr>
<td>092216</td>
<td>Non-Structural Metal Framing</td>
</tr>
<tr>
<td>092900</td>
<td>Gypsum Board</td>
</tr>
<tr>
<td>093013</td>
<td>Ceramic Tiling</td>
</tr>
<tr>
<td>095113</td>
<td>Acoustical Panel Ceilings</td>
</tr>
<tr>
<td>096513</td>
<td>Resilient Base and Accessories</td>
</tr>
<tr>
<td>096519</td>
<td>Resilient Tile Flooring</td>
</tr>
<tr>
<td>096543</td>
<td>Linoleum Flooring</td>
</tr>
<tr>
<td>096813</td>
<td>Tile Carpeting</td>
</tr>
<tr>
<td>099113</td>
<td>Exterior Painting</td>
</tr>
<tr>
<td>099123</td>
<td>Interior Painting</td>
</tr>
<tr>
<td>099600</td>
<td>High-Performance Coatings</td>
</tr>
<tr>
<td>099601</td>
<td>Coatings – Wetwell and Manholes</td>
</tr>
<tr>
<td></td>
<td><strong>DIVISION 10 – SPECIALTIES</strong></td>
</tr>
<tr>
<td>101423</td>
<td>Signage</td>
</tr>
<tr>
<td>102800</td>
<td>Toilet, Bath, and Laundry Accessories</td>
</tr>
<tr>
<td>104413</td>
<td>Fire Protection Cabinets</td>
</tr>
<tr>
<td>104416</td>
<td>Fire Extinguishers</td>
</tr>
<tr>
<td>105113</td>
<td>Metal Lockers</td>
</tr>
<tr>
<td>105613</td>
<td>Metal Storage Shelving and Workbenches</td>
</tr>
<tr>
<td></td>
<td><strong>DIVISION 11 - EQUIPMENT</strong></td>
</tr>
<tr>
<td>113100</td>
<td>Residential Appliances</td>
</tr>
<tr>
<td>115300</td>
<td>Laboratory Equipment</td>
</tr>
<tr>
<td></td>
<td><strong>DIVISION 12 - FURNISHINGS</strong></td>
</tr>
<tr>
<td>122113</td>
<td>Horizontal Louver Blinds</td>
</tr>
<tr>
<td>123450</td>
<td>Laboratory Casework and Furnishing</td>
</tr>
<tr>
<td>124813</td>
<td>Entrance Floor Mats and Frames</td>
</tr>
<tr>
<td>124816</td>
<td>Entrance Floor Grilles</td>
</tr>
<tr>
<td>125000</td>
<td>Freestanding Furniture</td>
</tr>
<tr>
<td></td>
<td><strong>DIVISION 22 - PLUMBING</strong></td>
</tr>
<tr>
<td>220548</td>
<td>Vibration and Seismic Controls</td>
</tr>
<tr>
<td>220553</td>
<td>Identification for Plumbing Piping and Equipment</td>
</tr>
<tr>
<td>221116</td>
<td>Domestic and Service Water Piping</td>
</tr>
<tr>
<td>221119</td>
<td>Domestic Water Piping Specialties</td>
</tr>
<tr>
<td>221316</td>
<td>Sanitary Waste and Vent Piping</td>
</tr>
<tr>
<td>224213</td>
<td>Plumbing Fixtures</td>
</tr>
</tbody>
</table>
DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING
230513 Common Motor Requirements for HVAC Equipment
230553 Identification for HVAC Piping and Equipment
230593 Testing, Adjusting and Balancing for HVAC
230713 Duct Insulation
230800 Commissioning of HVAC
230900 Instrumentation and Control for HVAC
231323 Fuel Oil Distribution System
233113 Metal Ducts
233300 Air Duct Accessories
233423 HVAC Power Ventilators
233713 Diffusers, Registers, and Grilles
238126 Split-System Air Conditioners
238239.19 Wall and Ceiling Unit Heaters

VOLUME 3 OF 5

DIVISION 26 - ELECTRICAL
260500 Common Work Results for Electrical
260519 Low-Voltage Electrical Power Conductors and Cables
260526 Grounding
260529 Hangers and Supports for Electrical Systems
260533 Raceway and Boxes for Electrical Systems
260548 Seismic Controls for Electrical Systems
260553 Identification for Electrical Systems
260800 Commissioning of Electrical Systems
260913 Power Monitoring and Control
260923 Lighting Control Devices
262200 Low Voltage Transformers
262413 Switchboards
262416 Panelboards
262419 Motor Control Centers
262713 Service and Metering
262726 Wiring Devices
262800 Low Voltage Circuit Protection Devices
262816 Enclosed Switches and Circuit Breakers
262923 Variable Frequency Drives
263213 Engine Generators
263526 Active Harmonic Filters (AHF)
264300 Surge Protection for Low Voltage Electrical Power Circuits
265000 Lighting
266013 Motors
## DIVISION 27 – COMMUNICATIONS
- 270513 Telephone Service
- 272100 Telecommunications Equipment
- 272200 Computer Equipment

## DIVISION 28 – ELECTRONIC SAFETY AND SECURITY
- 283100 Fire Alarm System (Addressable)

## DIVISION 31 – EARTHWORK
- 311000 Site Clearing
- 312000 Earth Moving
- 312319 Dewatering
- 312500 Erosion Control
- 315000 Excavation Support and Protection

## DIVISION 32 – EXTERIOR IMPROVEMENTS
- 321216 Asphalt Paving
- 323113 Chain Link Fences and Gates
- 328400 Planting Irrigation
- 329113 Soil Preparation
- 329200 Turf and Grasses
- 329300 Plants

## DIVISION 33 - UTILITIES
- 330513 Precast Concrete Manholes
- 330517 Precast Concrete Vaults
- 331213 Water Service Connections
- 331219 Fire Hydrants
- 331300 Disinfecting of Water Utility Distribution
- 333100 Sanitary Utility Sewerage Piping
- 334100 Storm Utility Drainage Piping

## VOLUME 4 OF 5

## DIVISION 35 – WATERWAY AND MARINE CONSTRUCTION
- 352016.26 Gates

## DIVISION 40 – PROCESS INTEGRATION
- 409000 Instrumentation and Control Systems
- 409001 Control Systems Supplied with Equipment and Packaged Systems
- 409002 Testing and Commissioning
- 409003 Division 40 Test Forms
- 409004 Schedules
- 409005 Influent Pump Station Control Strategy
- 409006 Headworks Control Strategy
- 409007 MBR System Control Strategy
- 409008 Waste Activated Sludge (WAS) Pump Control Strategy

---

**TABLE OF CONTENTS**

**TOC - 5**
409009 UV Disinfection Control Strategy
409010 C3 Water System Control Strategy
409011 Miscellaneous Control Strategy
409012 Flow Equalization Control Strategy
409100 Field Instruments General
409113 Analytical Instruments
409119.29 Pressure Transmitters
409119.43 Level Transmitters
409123 Packaged Metering Manhole
409123.33 Flow Transmitters
409124 Process Switches
409200 Process Taps and Primary Elements
409443 Programmable Logic Controllers
409513 Panels
409515 Power Supply and Conditioning Equipment
409517 Miscellaneous Panel Instruments
409543 Networking Equipment
409600 Supervisory Control and Data Acquisition (SCADA) System Software
409635 Programming
409715 Pressure Gages

DIVISION 41 – LIFTING EQUIPMENT
412223 Monorail and Davit Cranes

DIVISION 42 – PROCESS PIPING SYSTEMS
420520 Pipe Hangers and Supports
420520.1 Seismic Anchorage and Bracing
420553 Identification for Process Piping and Equipment
422700 Process Piping - General
422700.01 Steel Pipe
422700.02 Ductile Iron Pipe
422700.03 Plastic Pipe
422701 Process Valves and Operators
422701.01 Gate Valves
422701.02 Ball Valves
422701.03 Plug Valves
422701.04 Butterfly Valves
422701.05 Check Valves
422701.10 Specialty Valves
422702 Process Piping Specialties
422713 Process Piping Insulation
424214 Electric Heat Trace
DIVISION 43 – PROCESS GAS AND LIQUID HANDLING, PURIFICATION AND STORAGE EQUIPMENT
432113 Centrifugal Liquid Pumps
432113.16 Submersible Non-Clog Pumps
434200 Hydropneumatic Tank

DIVISION 44 – POLLUTION AND WASTE CONTROL SAMPLING SYSTEM
443119 Packaged Odor Control system
444225.02 Engineered Surface Mounted Aluminum Covers
444248 Sampling System

DIVISION 46 – WATER AND WASTEWATER EQUIPMENT
460500 Basic Mechanical Materials and Methods
460513 Common Motor Requirements for Water and Wastewater
462133 Rotary Drum Screens
463300 Chemical Feed Systems
464240 Membrane Bioreactor System
466616 Ultraviolet Disinfection

APPENDIX A – GEOTECHNICAL REPORT

VOLUME 5 OF 5 - DRAWINGS
SECTION 352016.26 – GATES

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers heavy-duty stainless steel slide gates. The self-contained slide gates shall be designed for continuous exposure to municipal wastewater. Slide gates will be installed outdoors and subject to full exposure to sunlight and inclement weather conditions.

1.2 SUBMITTALS

A. Procedures: Section 013300 “Submittal Procedures.”

B. Certifications: Submit a letter certifying the manufacturer, product designation and specification data of all shop paints to be used for equipment under this section.

C. Shop Drawings: Submit shop drawings of all equipment to be used for approval. Shop drawings shall include the following features:

1. Fabrication drawings with full dimensions.
2. Plan, cross section and details showing proposed mounting for each gate.
3. Product information, charts, or graphs to verify that the product provided meets the requirements set forth in the specification.
4. Mounting details and details of proposed seal configuration for each gate.
5. Shop primer and coating data.

D. Operation and maintenance information specified in Section 017300 “Execution.”

1.3 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, connections and dimensional requirements of gates. Contractor shall confirm field blockout size dimensions prior to ordering equipment.

B. Electrical components, devices and accessories: Listed and labeled by UL.

1.4 DELIVERY, STORAGE AND HANDLING

A. Retain protective covers and protective coatings during storage.

B. Comply with manufacturer’s rigging instructions for handling.
PART 2 - PRODUCTS

2.1 SLIDE GATES

2.2 ACCEPTABLE MANUFACTURER
A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Golden Harvest.
   2. Approved equal.

2.3 SLIDE GATE MATERIALS
A. Frames, guides, reinforcing member and operator support yoke: Type 316 stainless steel.
B. Gates: Type 316 stainless steel.
C. Stems: Type 316 stainless steel.
D. Closure Seals, hollow bulb P-seals and bottom wedge seal: Molded or extruded neoprene with vulcanized corners. ASTM D 2000, 50-60 durometer.
E. J-Seal clamping bars and fasteners: Type 316 stainless steel.
F. Wear strips: UHMW plastic.
G. Gate stem hardware: Type 316 stainless steel.
H. Anchor bolts: Adhesive Anchors as recommended by the manufacturer.

2.4 EQUIPMENT FEATURES
A. Equipment furnished and installed under this section shall be fabricated and assembled, erected and placed in proper operating condition in full conformity with drawings, specifications, Engineering data, instructions and recommendations of the equipment manufacturer unless exceptions are noted by the Engineer.
   1. Gate and operators shall be furnished with all necessary parts and accessories indicated on the drawings, specified, or otherwise required for a completely properly operated installation and shall be the latest product of a manufacturer regularly engaged in the production of equipment of this type.
   2. Gate shall comply with AWWA C513-97.
   3. Gate shall be designed to fit into the structures as indicated on the drawings.
   4. Maximum allowable leakage of slide gates shall not exceed 0.10 gallons per minute per foot of wetted perimeter at the maximum seating pressure of 6 feet.

B. Frames and Guides: The frame and guide shall be fabricated from Type T-316 stainless steel. The guide frame will have a slot suitable for mating with the gate cover.
1. Guides shall be bolted to the head wall with T-316 stainless steel epoxy anchors. When the guides are extended above the operating floor level to form the bench stand upon which the lift mechanism is fastened, they must be suitably straight and rigid without the use of additional stiffening members and shall have a maximum unsupported length of 3 feet 6 inches. They shall have a maximum deflection of 1/4-inch when subjected to a horizontal force of four times the 25 lb. maximum handwheel pull.

C. Gates: Slide gates shall be manufactured of ANSI 316 stainless steel.

1. Structural reinforcing shall be utilized to attain the necessary stiffness to meet the deflection requirements, and shall be not less than 1/4-inch thick.
2. All gates shall be flat and level. Warpage throughout the entire gate shall not produce a crown of more than 1/16 inch in any direction.

D. Operating Stems: The slide gates shall be equipped with a rising operating stem. The stem will be Type 316 stainless steel with Acme threads and shall be provided with adjustable stop collars to limit upward and downward travel. Stems shall have a maximum L/R of 200. Bronze bushings or ultra high molecular weight polyethylene stem guides shall be used when stem lengths exceed a L/R of 200. Threads shall be cold rolled. Machine cut threads will not be acceptable.

E. Stem Covers: Transparent plastic stem covers shall be provided on all rising gates stem with vent holes to minimize condensation. The stem covers shall be attached by a threaded connection and be marked with ‘Open’ and ‘Closed’ position indicators.

F. Seals: The gate shall be equipped with elastomeric seals to reduce leakage. At the maximum operating head, the leakage shall not exceed 0.1 gpm per foot of wetted perimeter.

1. Elastomeric P-seals shall be made of molded or extruded neoprene having a hardness range of 55 to 65 Shore A durometer and conforming to ASTM D 2000 having a maximum compression set of 25 percent, and low temperature brittleness to meet suffix F-16 (-40F). Seals, including bottom seals, shall be mounted on gate covers with T-316 stainless steel cap screws and T-316 stainless steel or FRP clamping bars thus providing a means of repair, and replacement without dewatering the channel. A 1/4-inch thick UHMW wear strip will be fastened to the opposite side of the gate from the P-seals along both sides.

G. Handwheels shall be sized large enough that a maximum of 25 pounds pull will start the gate from a static position in the closed mode with a maximum head of water.

2.5 SHEAR GATES

A. Shear gates shall be manufactured by Waterman Industries or approved equal.

B. Shear gates shall be designed to effectively control flows under seating head conditions. Frame shall be of cast iron with pads to receive the bolt on wedges and shall be of the flanged type drilled for mounting to an ANSI 125# flange or mounting to a wall. The seating surface shall be bronze machined to a smooth surface. The wedges shall be cast bronze and be securely attached to the frame utilizing two stainless steel bolts per wedge and shall be adjustable to ensure proper closure.
C. The cover shall be cast iron with machined bronze seat attached and incorporate cast wedge pads for mating with the wedges. The cover shall be mounted to the frame utilizing a stainless steel hinge bolt. A cast iron lifting lug shall be bolted to the cover in such a manner as to allow a swiveling action. The lug shall be made so that it accepts a pipe type lifting rod which is to be field cut to the desired length.

2.6 COATING SYSTEM

A. Coating systems shall be per Sections 099600 “High Performance Coatings.” Painting of aluminum and stainless steel is not required.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to ordering the gates the Contractor shall verify the field dimensions to ensure the proposed design will fit in the existing blockouts.

B. Gates shall be completely assembled and tested in the shop prior to shipping. All gates shall be fully assembled in their frame except for operators, guides, stem-extension, stem covers or concrete-mounted pedestals. Where shipping constraints require it, frame may be partially assembled such that the top may be easily mounted to the bottom containing the disc.

3.2 INSTALLATION

A. All above equipment shall be installed in accordance with the manufacturer’s recommendations, drawings, and/or specifications. Alignment and adjustments shall be verified after installation.

3.3 TESTING

A. In addition to testing that may be required by codes, the Contractor shall perform all tests specified in this section and shall furnish and pay for all material and labor required for tests. Prior to the plant start-up, the gate and actuator shall be tested in place with its own motor and drive unit. The tests shall duplicate all normal operating modes and all failure modes. The Contractor shall notify the Engineer a minimum of five (5) days in advance of running any tests unless otherwise specified and no tests shall be accepted unless the Engineer is present. Contractor shall include the services of a factory certified representative to inspect and test the gate operation. Should test indicate unsatisfactory operation or leaks occurring, conditions shall be corrected and test repeated at Contractor’s expense.
3.4 WARRANTY

A. The Contractor shall provide a 100 percent parts and labor warranty as required in Section 007000 EJCDC Standard General Conditions of the Contract.

END OF SECTION 352016.26
SECTION 409000 – INSTRUMENTATION AND CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Scope:

1. General: This section specifies general requirements applicable to process instrumentation systems consisting of process sensors, monitoring and control devices, and accessories required to provide a complete and fully functional monitoring and control system.

2. Responsibility: The Contractor shall provide, configure, calibrate, program, test, and commission all components of the instrumentation, control, communications, and network systems supplied (UNO). The Contractor shall place the completed systems in operation, including tuning loops and making final adjustments to instruments as required during plant start-up. The Contractor shall provide the services of instrument technicians for testing and adjustment activities.

3. Related Requirements: Division 40 is an extension of, and includes all of the requirements of Division 26, Electrical. All work performed under Division 40 shall also comply with the applicable sections of Division 26 as well as the general provisions of Divisions 00 & 01.

B. Contract Requirements:

1. General Conditions, Supplementary Conditions, and Division 01 apply to Work in this section.

C. Definitions:

1. General: The definitions of terminology used in these specifications shall be defined in ISA Standard S51.1, unless otherwise specified.

2. APPROVED EQUAL: Items that are accepted and approved by the owner, the owner’s designated project representative, or the engineer as being functionally equivalent for the application and acceptable substitutes for items specified in the contract documents.

3. Contractor: The general contractor is responsible for overall project construction. The party with whom the contract is executed.

4. CSI: Control System Integrator. An organization engaged in the business of detail design, component purchase, assembly, programming, and implementing process control and industrial electronic systems.

5. Data Sheets: Data sheets as used in this specification shall refer to ISA S20.

6. Galvanic Isolation: Pertaining to an electrical node having no direct current path to another electrical node. As used in this specification, galvanic isolation refers to a device with electrical inputs and/or outputs which are galvanically isolated from ground, the device case, the process fluid, and any separate power supply terminals, but such inputs and/or outputs are capable of being externally grounded without affecting the characteristics of the devices or providing path for circulation of ground currents.

7. GC: General Contractor
9. Integrated Circuit: A number of circuit elements inseparably associated on or within a continuous body to perform the function of a circuit.
10. NA: Not Applicable
11. Panel: An instrument support system which may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Panels may provide mechanical protection, electrical isolation, and protection from dust, dirt, and chemical contaminants which may be present in the atmosphere. "Panel" shall be understood to include consoles, cabinets, and racks.
13. PACKAGED SYSTEM: Integrated equipment systems that are specified in other divisions and sections of the specifications. These systems include process and mechanical equipment as well as electrical and controls equipment that conforms to the requirements of Division 26 and 40. These systems may include skid mounted and loose items. Some items provided with the equipment may require installation and connection by others. Some related items identified as "supplied by others" may not be supplied with the system but may nonetheless be required for some of the functions of the system.
14. SCADA: Supervisory Control and Data Acquisition.
15. Signal Types: The following types of signals are used in systems specified in this division.
   a. Low Level Analog: A signal that has a full output level of 100 millivolts or less. This group includes thermocouples and resistance temperature detectors.
   b. Digital Code: Coded information such as that derived from the output of an analog to digital converter or the coded output from a digital computer or other digital transmission terminal. This type includes those cases where direct line driving is utilized and not those cases where the signal is modulated.
   c. Pulse Frequency: Counting pulses such as those emitted from speed transmitters.
   d. High Level Analog: Signals with full output level greater than 100 millivolts but less than 30 volts, including 4-20 mA transmission.
   e. Modulated Signals: Signals emanating from modems or low level audio signals. Normal signal level is plus 4 dBm to minus 22 dBm. Frequency range is 300 to 10,000 hertz.
   f. Discrete Events: Dry contact closures monitored by solid-state equipment. If the conductors connecting to dry contacts enter enclosures containing power or control circuits and cannot be isolated from such circuits in accordance with NEC Article 725, this signal shall be treated as low voltage control.
   g. Low Voltage Control: Contact closures monitored by relays, or control circuits operating at less than 30 volts and 250 milliamperes.
   h. High Level Audio Signals: Audio signals exceeding plus 4 dBm, including loud speaker circuits.
   i. Radio Frequency Signals: Continuous wave, alternating current signals with fundamental frequency greater than 10 kilohertz.
   j. 120 VAC control: Contact closures monitored by relays, or control circuits operating at 120 volts AC.
16. Solid State: Circuitry or components of a type which convey electrons by means of solid material such as silicon or crystals, or which work on magnetic principles such as ferrite cores. Vacuum tubes, gas tubes, slide wires, stepping motors, or other devices are not acceptable substitutes for solid-state components or circuitry.
17. Two-wire Transmitter: A transducer which derives operating power supply from the signal transmission circuit and therefore requires no separate power supply connections. As used in this specification, two-wire transmitter refers to a transmitter which produces a 4 to 20-milliampere, current-regulated signal in a series circuit with a 24-volt direct current driving potential and a maximum circuit resistance of 600 ohms.

18. UNO: Unless specifically Noted Otherwise. All general requirements statements shall apply as stated except where specific exceptions are stated, in which case the general requirement shall be modified by the stated exception.

1.2 QUALITY ASSURANCE

A. Referenced Standards: The latest edition of the documents listed below are included in the Contract where referenced. The most stringent collective interpretation of the requirements shall govern where conflict or overlap exists between any of these documents and the Contract Documents.

1. American National Standards Institute (ANSI)
2. Institute of Electrical and Electronic Engineers (IEEE)
3. Underwriters' Laboratories (UL)
4. The Instrumentation, Systems, and Automation Society (ISA)
7. API RP 552: Transmission Systems - first Edition
8. ANSI/ISA S5.4: Instrument Loop Diagrams
9. ISA S20: Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
10. ANSI/ISA S5.1: Instrumentation symbols and Identification
11. ANSI/ISA S51.1: Process Instrumentation Terminology
12. ISA S5.3: Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer systems
13. ISA RP12.2.02: Recommendations for the Preparation, Content, and Organization of Intrinsic Safety Control Drawings
14. NFPA 70 National Electric Code (NEC)
15. NFPA 79 Electrical Standards for Industrial Machinery
16. NFPA 820 Fire Protection in Wastewater Treatment and Collection Facilities
17. IBC 1632 International Building Code
18. UL 508 Industrial Control Equipment

B. Listing:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment shall be listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the
field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. General: Submit information per Division 01.

B. Media: All submittals shall be provided in hard copy (paper) in accordance with Division 01 and electronic format. Electronic format shall be PDF format on CD. One CD shall be provided for each hard copy required per Division 01.

C. Organization and Format: Submittal organization shall be the same as the specifications. Provide submittals bound with section coversheets and tabbed dividers with specification section numbers for submittal organization. Bill of materials, cut sheets, shop drawings, schematics, panel layouts, schedules, etc., shall be cross-referenced, indexed, or otherwise related by unique identifier for each item. The project may reject improperly organized or notated submittals. Provide .pdf file page numbers in table of contents as well as bookmark links to section coversheets in pdf file.

D. Reviews and Re-Submittals: Suppliers shall provide re-submittals which include responses to all submittal review comments separately and at a level of detail commensurate with each comment. Supplier responses shall indicate how the supplier resolved the issue pertaining to each review comment. Responses that only indicate that the review comment was noted, will be looked into, etc., are not satisfactory. Re-submittals which do not comply with this requirement may be rejected and returned without review. Contractor shall be allowed no extensions of any kind to any part of their contract due to the rejection of non-compliant submittals. Submittal review comments not addressed by the contractor in re-submittals shall continue to apply whether restated or not in subsequent reviews until adequately addressed by the contractor to the satisfaction of the reviewing and approving authority.

E. Product Data: Submit catalog cut sheets for all products. Identify all cut sheets by unique bill of material item number, index, or key. Notate catalog cuts to indicate only those items, models, options, or series of equipment to be furnished. Cross out or otherwise obliterate all extraneous materials and information. Clearly identify all configuration options for the equipment to be furnished.

F. Bill of Materials: Submit bill of materials including all items, products, and assemblies supplied. Documents shall be updated following submittal review, factory test, and commissioning. Updates shall be provided to the Engineer in a timely manner. Bill of materials shall include the following information:

1. Item number, index, or key relating to submitted cut sheets, drawings, schedules, etc.
2. Item manufacturer's name, model, and part numbers. Supplier unique part numbers are not acceptable.
3. Description
4. Quantity supplied
5. Supplier contact information
G. Notated Specifications: Submit copies of all Division 40 specification sections with each paragraph notated to indicate compliance. A check mark shall indicate complete compliance. Explanations shall be provided for all non-compliant items in accordance with Division 01.

H. Notated P&ID Drawings: Submit copies of all project Process and Instrumentation drawings with each drawing element notated to indicate compliance. A check mark shall indicate complete compliance. Explanations and markups shall be provided for all non-compliant items and in accordance with Division 01.

I. Notated Electrical and Instrumentation Drawings: In the case of deviations from the contract documents, particularly related to the impact of the configuration of submitted packaged equipment supplied to the project, submit marked up copies of applicable Electrical and Instrumentation contract drawings notated to identify and explain all proposed deviations from the contract documents. Items not notated on the submitted marked up copies shall be assumed to be 100% compliant with the bid documents. This requirement applies to electrical one lines, MCCs, MCC control schematics, panel schedules, and control schematics. This requirement does not apply to plan drawings and conduit schedule which shall be marked up to reflect the as constructed project configuration and submitted as record drawings.

J. Seismic: Submit Seismic design information. Include a list of equipment weighing 200 pounds or more.

K. O&M: Submit operation and maintenance information as specified in any Division 40 specification section. O&M manuals shall include product data for all materials and items supplied in compliance with the submittal requirements of this section.

L. Div 40: Submit information as required by all Division 40 specification sections.

M. CSI: Submit information about proposed CSI including employee resumes, company information, etc, as required by any Division 40 specification sections.

N. Drawings: Submit all drawings described in this and other Division 40 sections including elementary, loop, schematic, fabrication, installation, field wiring, panel layout and assembly, etc., drawings. Drawings shall be updated following submittal review, factory test, and commissioning. Updates shall be provided to the Engineer in a timely manner. Cross reference drawing elements with BOM and catalog cut sheet unique references. Drawings shall use project tag formats and numbers. Unique and separate drawings shall be provided for each item supplied including but not limited to all panels and all MCC units. Typical drawings that apply to multiple panels or multiple MCC motor control units are not acceptable.

O. Packaged Equipment: All packaged equipment suppliers shall provide submittals in compliance with Division 40. This shall include packaged equipment purchased under the contract as well as any pre purchased packaged equipment assigned to the contractor.

P. Software and Programming: Per Section 409635 “Programming.”

Q. Component Drawings: Dimensional, installation, and wiring diagrams and drawings for all supplied components.
R. Testing And Calibration: Test plans, calibration forms, test forms, test results, and test reports required by any Division 40 specification section. Per Section 409002 “Testing and Commissioning.”

S. Spare Parts: Spare parts lists

1.4 SERVICE REQUIREMENTS

A. Environmental Conditions: All equipment shall be suitable for operation in the following ambient conditions. Modify equipment if necessary as required to function in the specified environment.

1. Atmospheric contaminants:
   - Hydrogen sulfide 0.1 mg/L
   - Chlorine 0.01 mg/L
   - Ammonia 0.5 mg/L
   - Dust 50.0 ug/m3

2. Electromagnetic radiation:
   - 27/500 MHz 10 volts/m

3. Control Rooms:
   - Temperature 60 to 95 degrees F
   - Humidity 20 to 80 percent

4. Pump Rooms
   - Temperature 40 to 120 degrees F
   - Humidity 10 to 100 percent

5. Outdoor Field Locations:
   - Temperature -10 to 120 degrees F
   - Humidity 10 to 100 percent

1.5 DESCRIPTION OF SYSTEM

A. General:

1. System Scope: The instrumentation and control system shall include the instruments, control devices, programmable controllers, input and output devices, sensors, interfacing devices, communications devices, cabinets, enclosures, and other components, as required to implement the functional requirements of the Contract.

2. Design and Assembly: The instrumentation and control system shall be designed and assembled by the CSI to be an integrated system composed completely of components that are specifically designed and intended to be used for and in conjunction with the control and operation of motor-driven pumps and process equipment. The control system shall be designed and assembled by the CSI to provide:
   a. Control of motor driven pumps, equipment, and processes
b. Monitoring of operation of motor driven pumps, equipment, and processes  
c. Indication of operating status of motor driven pumps, equipment, and processes  
d. The capabilities indicated and implied by Contract documents.  
e. Reliable communications with the plant SCADA system.  

3. Custom Parts: System components shall be commercial, off-the-shelf (COS) components. Custom designed or manufactured components shall require Engineer approval.

B. Functional Requirements:

1. Bid Documents: As defined in Division 40 specifications and the contract drawings.  
3. Fault Tolerance: The system shall be immune to single point failures to the maximum extent practical.  
4. Location of Functions: The system shall include manual, automatic, programmed, and hardwired functions. The devices that provide these functions shall be located at field mounted control stations, packaged system local control panels, motor control equipment, process area control panels, and plant SCADA equipment.

C. Hierarchical Monitoring and Control System Architecture:

1. All systems have been designed to be manually operable via discrete devices and via programmed Human Machine Interface devices. Systems have been designed to be monitored and controlled in a hierarchical manner. Basic functions have been designed to be provided at field stations, local panels, and MCC’s by discrete panel switches, indicator lights, and displays. The overall plant wide SCADA system has been designed to provide monitoring and control of all systems and equipment at the plant. All programmable devices and systems have been designed to, and shall communicate over a TCP/IP plant Ethernet network. The Contractor shall ensure that all components of supplied systems fully and seamlessly integrate into this system architecture.

1.6 CONTRACTOR AND SUBCONTRACTOR SCOPES OF WORK

A. Systems Responsibility:

1. With the exception of packaged systems and third party programming, all instrumentation and industrial electronic systems and functions shall be provided under the supervision of a single Control System Integrator, chosen by the Contractor, who is regularly engaged in the design, programming, configuration, and installation of similar systems of equal or greater scope and complexity. The Control System Integrator shall be enjoined by the Contractor as a Subcontractor. The assignment of specific responsibilities herein to the Control System Integrator shall not, in any way or under any conditions, diminish the Contractor's full and complete responsibility for all work performed and all materials installed under the contract. The contract between the Contractor and the Control System Integrator shall specifically require that the Control System Integrator conform to and meet all requirements specified in the contract documents. The assignment of the Control System Integrator as an equipment supplier shall not be acceptable.
B. Intent of Drawings And Specifications:

1. General: Due to the fact that the contract documents cannot dictate the use of specific brands or models of components and equipment unless there is a compelling reason to do so, the control system drawings are intended to primarily convey detailed functional and operational requirements of the control system rather than specific component selection, assembly, and interconnection information. The substantial interconnection information provided in the Contract Drawings is general in nature and is provided for the purpose of indicating the general scope of work and the aforementioned functional and operational requirements, and shall not be construed to represent detailed shop drawings or parts thereof.

2. Ancillary Components Required: Components not explicitly indicated in the Contract Documents but none-the-less implied, required for the environment or area classification indicated, or required for the proper functioning of the system as indicated shall be considered required just as though they had been explicitly indicated. The aforementioned components shall be considered incidental to the Contract and shall not constitute a basis for claim by the Bidder for additional compensation or time allowed to complete the Work.

C. Control System Integrator’s Responsibilities:

1. Sole Responsibility: In accordance with A and B above, the Control System Integrator (CSI) shall be solely and completely responsible for the detailed design, assembly, programming, and commissioning of the entire control system with the exception of control equipment provided as a part of packaged equipment systems or otherwise noted as exceptions.

2. Design and Performance: The control system hardware and assemblies shall be designed by the CSI to provide the control capabilities and functions indicated in and implied by the drawings and these specifications and to provide trouble-free operation with a minimum of maintenance.

3. Coordination and Integration: The CSI shall be directly responsible for the coordination and integration of the control system with motor controls, packaged equipment controls, and other related equipment. The CSI shall be responsible to obtain submittal information on equipment specified or provided by other suppliers or disciplines and to integrate all the equipment into the control system to form a complete working system as outlined by the Contract Documents.

4. Proactive Communication: The CSI shall communicate directly with the manufacturer(s) and supplier(s) of all related equipment to determine all details of the equipment that may influence or affect the control system. The CSI shall determine all requirements for and shall cause integration of the control system into a unified operating system. All correspondence shall include Carbon Copying (cc:) the General Contractor.

5. Itemized Responsibilities: The CSI shall be responsible for the following equipment and services:
   
a. Detailed Design of Control Panels: The drawings depict the functional and operational requirements of the control system and are at times diagrammatic. The CSI shall provide detailed, scaled design of all components on and in control panels and determine specific physical, thermal, and electrical requirements.
   
b. Detailed Design of Control Circuitry: The drawings depict the functional and operational requirements of the control system and are at times diagrammatic. The CSI shall be responsible for the final selection of all control system components,
except for components specified as “no equal”, and all detailed circuit design and component interconnection required to meet the general and functional requirements indicated in or implied by the Drawings and Specifications. Where components are specified as “no equal”, the CSI shall provide all detailed design, including specification of miscellaneous or interfacing components required to integrate the specified component into the CSI’s control system design. It is the responsibility of the CSI to ensure that all devices selected, and the proposed interconnection of those devices, perform as intended to provide a complete and operable system meeting the requirements of the anticipated environment and area classifications. The CSI shall define all requirements for all interfacing components and shall supply all appurtenances, accessories, and all such devices which may be required for proper functioning and interfacing of components as part of the control system. An example of such appurtenances would be interposing relays or analog isolators. All such aforementioned necessary ancillary components not specifically indicated in the Contract Documents shall be considered incidental to the contract and shall be required just as if they had been specifically indicated.

c. Interconnecting Wiring: The design of all interconnecting wiring of control equipment, including remote control panels, packaged equipment panels, mechanical equipment with control components, etc.

d. Equipment Testing: Testing of the Motor Control Equipment in the CSI’s shop. Testing of control panels in the CSI’s shop under simulated operating conditions per Section 409002 “Testing and Commissioning.”

e. Integration Testing: Integration testing of all system and related components simultaneously in the CSI’s facility. This testing shall include all panels, instruments, process switches, test fixtures, MCCs, motor controllers, available equipment packages, communications and networking equipment, SCADA system hardware and software (UNO), PLC system hardware and software (UNO), etc. per Section 409002 “Testing and Commissioning.”

f. Coordination with GC: Coordinate with the Contractor for specific requirements and locations of raceway penetrations and field wiring in control panels. The CSI shall supply the Contractor with all necessary detailed installation drawings and/or written instruction for installation of all control components and sensing devices as required for proper system operation.

g. Communications and Networks: Set up, configuration, test, and verification of all communications equipment, channels, and networks including new and reused telephone circuits.

h. Startup And Testing: Perform system start up, commissioning, functional testing activities following installation per Section 409002 “Testing and Commissioning.”

i. Instruments: Provide all instruments specified unless specifically noted otherwise. Some instruments shall be provided by packaged equipment vendors. The CSI shall integrate vendor provided instruments and equipment.

j. Configuration And Programming: Configure and program all supplied devices, equipment, and software unless specifically noted otherwise per Section 409635 “Programming.” Configuration and programming of devices and equipment supplied as a part of packaged systems shall be provided by the vendor of each packaged system per Section 409001 “Control Systems Supplied with Equipment and Packaged Systems.”

k. Application Software Development: Per Section 409635 “Programming.”

l. Equipment Submittal Review: Review all equipment and packaged system submittals which include Division 40 items. Notify the Contractor of any and all
needed modifications to submitted equipment, package system scope of services or supply, or CSI supplied equipment required to accommodate and integrate submitted equipment into the CSI’s work. Specifically note how submittals which include variances from the contract documents will impact CSI provided control panels and MCC’s if accepted by the contractor.

D. General And Electrical Contractor’s Responsibility: The General and Electrical Contractor shall be responsible for the following equipment and services:

1. CSI Submittal Review: Review of the CSI’s submittals and wiring diagrams for coordination with space requirements, raceway requirements of field wiring, etc.
2. Equipment Submittals: Supply the Integrator with information submittals on all equipment which impacts or connects to the control system, which the Integrator must incorporate into their shop drawings and integrate into the project. This includes items such as pumps, motors, packaged control panels, other equipment, valve actuators, etc.
3. Installation:
   a. Installation of control panels provided by the CSI.
   b. Installation of Motor Control Equipment (MCC).
   c. Installation of interconnecting wiring in accordance with the contract documents and the CSI’s wiring diagrams.
   d. Installation of Instrumentation and Control System components in accordance with the contract documents and instructions of the CSI.

1.7 SHOP DRAWINGS

A. General: The CSI, suppliers of packaged control systems, and suppliers of MCCs shall develop all shop drawings required for design, fabrication, assembly, installation, operation, and maintenance of the supplied control system components. Drawings shall be prepared utilizing a computer aided drafting program. CAD shop drawings shall be updated and provided to the Engineer prior to factory testing, prior to system installation, and with the O&M manuals. All drawings shall be supplied in hardcopy and electronic file formats per paragraph 1.3.B of this section.

1. Diagrams: Submit detailed interconnection diagrams, wiring diagrams, elementary diagrams, communications diagrams, and loop diagrams with all electrical and electronic components clearly identified by project tag number consistent with the contract drawings and schedules. Diagrams for each circuit or element shall be separate and unique. Typical diagrams are not allowed. Diagrams shall carry a date and brief description of the revisions. Diagrams shall carry a uniform and coordinated set of wire and terminal block numbers in compliance with panel work wiring.
2. Panel Layouts: Submit detailed construction drawings for panel layouts and equipment enclosures with dimensions in inches. Show both exterior and interior views.
3. Wire and TB Numbers: Wiring and loop diagrams shall carry a uniform and coordinated set of wire numbers and terminal block numbers in compliance with Division 26 and 40.
4. Unique Drawings: Each control circuit, control loop, control panel layout design, motor control schematic, etc., shall be presented on a unique drawing. Control circuits, loop diagrams, and panel layouts referenced to typical diagrams are not acceptable.
5. Symbols: Drawing symbol format shall comply with NFPA 79, ISA 5.1, ISA 5.3 and where appropriate, ISA RP 12.2.02.
6. **Record Drawings:** Provide record drawings.

7. **Format:** Drawings shall be prepared utilizing a computer based drafting program and shall be formatted as follows:
   a. **Size:** Hardcopy plots shall be 11-inch by 17-inch (half-size).
   b. **Text:** Minimum Text size: 0.125 inch for 22 x 34 inch drawings, 0.063 inch for 11 x 17 inch drawings.
   c. **Boarders:** Drawings shall have borders and title blocks identifying the Contract, facility, system, revisions to the drawing, and type of drawing.
   d. **Revisions:** Each release of a drawing shall carry a revision number, date, and a brief description of the changes. All changes associated with a given release shall be indicated on the drawing by a revision flag. Changes on the latest revision shall be indicated by clouding.
   e. **CAD:** Drafting software shall be AutoCAD 2010 or later. Bind all x-refs.

8. **Field Equipment Terminals:** All schematics, diagrams, and drawings showing connections to field equipment shall provide correct terminal block numbers for the connections at the field equipment. This includes packaged system control panels, MCCs, stand alone motor controls, valve actuators, instruments, switches, etc. The contractor, subcontractors, and suppliers shall coordinate as needed to accomplish this.

B. **Elementary and Loop Diagrams:** Provide elementary diagrams for all discrete loops. Loop diagrams shall be prepared in compliance with ISA S5.4 and shall be provided for all analog loops. Elementary diagrams and loop diagrams shall show circuits and devices of a system. These diagrams shall be arranged to emphasize device elements and their functions as an aid to understanding the operation of a system and maintaining or troubleshooting that system.

   1. **Provide complete elementary diagrams for equipment control.**
   2. **Comply with NFPA 79.**
   3. **Show wire numbers, color codes, signal polarities, and terminal block numbers. Tables for wire numbers, signal polarity, and terminal block numbers are not acceptable.**

C. **Schematic Diagrams:** Provide schematic drawings showing all control panel components, the interconnection of all control panel components, all field devices, and the connection of all field devices to control panels. Schematic diagrams shall also show all communications components, their interconnection, and their interface with other control panel components. Provide wire and terminal block numbers in compliance with panel work wiring.

D. **Panel Fabrication And Arrangements Drawings:** Provide arrangement drawings of all panel front and internal-mounted instruments, switches, devices, and equipment indicated. All panel mounting details shall be shown. Outer dimensions of all panels shall be included on the drawing. Deviations from approved arrangements shall require Engineers approval prior to installation. Arrangement drawings shall be drawn to scale using standard Architectural or Engineering scales.

E. **Record Drawings:**

   1. **Also referred to as as-built drawings.**
   2. **Shop Drawings:** All submitted drawings shall be updated over the course of the construction project to reflect the installations and equipment as-built. A full set of record drawings shall be provided to the Engineer upon completion of the project and
shall be included in the O&M manuals. Record drawing requirements shall be the same as submittal drawing requirements.

3. Contract Drawings: The contractor shall maintain a set of record plan and P&ID markup drawings on site during construction. The contractor shall mark up the record drawing set to indicate any and all deviations of the installed systems from the contract documents. The marked-up drawings shall be provided to the Engineer at project close out.

F. Wiring Diagrams:

1. Panels: comply with NFPA79.
2. Show components of a control panel in an arrangement similar to the actual layout of the panel.
3. Show internal wiring between devices within the panel.
4. Show all terminal blocks whether used for internal or field wiring. Those used for field wiring shall be clearly identified as such.
5. Wiring diagrams shall indicate insulation color code, signal polarities, wire numbers, and terminal block numbers.

G. Interconnection Diagrams:

1. Submit complete interconnection diagrams for field wiring.
2. Show each panel and field devices.
3. Show wire numbers, cable numbers, panel numbers, and field device tag numbers.

H. Certifications:

1. Temperature: Provide test data certified by the manufacturer to demonstrate that field electronic devices are suitable for the specified ambient temperatures.
2. Corrosion: Provide test data showing design features of the electronic equipment provided to protect against damage by the specified atmospheric contaminants and specific evidence that similarly protected electronic equipment has operated in similar environments for a period of not less than five years without failure due to corrosion.

1.8 SEISMIC DESIGN

A. Procedure and submittals: per Section 013300 “Submittal Procedures.”

B. Structures and equipment shall be braced to prevent damage from specified forces.

C. Equipment shall not be required to function properly during periods of seismic disturbance, but shall be capable of manual restart without repair or modification following a disturbance.

1.9 ACCEPTABLE CONTROL SYSTEM INTEGRATORS

A. System Execution Personnel: The Control System shall be designed, constructed, and commissioned by full time or contract employees with a minimum of 5 years of experience and a minimum of one year with Integrator. The CSI shall configure and program all devices and equipment supplied to perform the functions indicated in the contract documents unless
specifically noted otherwise. Engineering and programming services shall only be provided by staff members directly employed by the CSI. Contract labor is not acceptable for engineering and programming services.

B. Recommended Integrators: CSI’s recommended for this project include the following companies.

1. Technical Systems, Inc. – Lynnwood, Washington
2. Quality Controls, Inc. – Lynnwood, Washington

C. Approval of Personnel And Alternates:

1. Withholding Of Approval: The Contractor and the proposed CSI shall anticipate that the Engineer may withhold approval of a proposed CSI or employee if, in the opinion of the Engineer, the CSI or employee does not have the experience, capability, or an acceptable performance and execution record of similar projects in the past. No Contractor, CSI, or employee denied approval by the Engineer shall be entitled to any extension of time or to any claim for damages related to any consequences resulting from the withholding of approval for any reason whatsoever. Applicable consequences may include but are not limited to associated extra or unanticipated costs, hindrances, delays, or complications of any kind.

D. Requirements For Alternates: The acceptability of a proposed alternate CSI will be determined solely by the Engineer. The CSI shall be an instrument and control system manufacturing company that conforms to the following requirements:

1. Location: The CSI’s manufacturing and assembly facility shall be located within a 100 mile drive from the Owner’s offices and the job site.
2. Specialty: The CSI shall be specialized in the design, assembly, testing, installation, programming, commissioning, and service of municipal control and communication systems in the Pacific Northwest for at least five years.
3. Employee Experience: The CSI shall employ technicians and engineers with documented experience in the design, assembly, testing, installation, operation, calibration, troubleshooting, service, and repair of control and communication systems for municipal waterworks and sewerage facilities.
4. Similar Experience: The CSI shall have completed the design, assembly, testing, installation, and commissioning of control systems which include the instruments, components, equipment, and devices cited on the Plans by specific manufacturer's name.
5. Spare Parts Stock: The CSI shall maintain a stock of spare parts for the instruments and devices cited on the Plans by specific manufacturer's name.
6. Alternate Supplier Info: Prior to placement of purchase orders for services and equipment, the Contractor shall provide the following information about a proposed alternate CSI:

a. Company Info: Description of ownership and organization of Integrator.

b. Resumes: Resumes of principals and/or key employees who will be working directly in the engineering, design, assembly, testing, and commissioning of the system for this project.

c. Expertise: Description of expertise in design, assembly, testing, and installation of control systems for municipal waterworks and sewerage facilities.
d. Project Resume: Description of municipal control systems designed, assembled, and installed in the last five (5) years. Description shall include:

1) Names of employees involved in each system.
2) Detailed description and drawings of each system.
3) Cost of each system.
4) Names and telephone numbers of persons involved in operation and maintenance of each system.

e. Service: Description of the service capabilities normally provided by the company including resumes of employees assigned to field service and listing of service equipment.

f. Spare Parts: Description of spare parts normally stocked and of restocking procedures.

g. Additional Info: Additional information that may assist the Engineer in ascertaining the company’s general ability to perform the work.

h. Warranty: Written agreement to the warrantee service terms of the contract documents.

1.10 PRECEDENCE OF REQUIREMENTS

A. The Contractor, Sub Contractors and equipment suppliers shall comply with all requirements specified in the contract documents, individually and in combination. In the case of redundant, overlapping, or conflicting requirements, the most stringent and demanding interpretation of the requirements statements collectively shall govern unless specifically clarified by the project. The Contractor and equipment suppliers shall request needed clarification of requirements during bid, otherwise the project’s interpretation shall govern. The System Supplier shall diligently scrutinize all parts of all bid documents prior to bid.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Products: All products provided by the CSI shall be manufactured to comply with the listing requirements identified in Part 1 and other requirements as indicated in the Contract. System components shall be commercial, off-the-shelf components to the maximum extent possible. Custom designed or manufactured components shall require Engineer’s approval.

2.2 MATERIALS

A. General: Material shall be new, free from defects, and of the quality specified. All equipment and materials utilized in the system shall be the products of Manufacturers with at least five (5) years’ experience in the manufacture of similar equipment. Similar items in the system shall be the products of the same Manufacturer. All equipment shall be of industrial grade and of standard construction, shall be capable of long, reliable, trouble-free service, and shall be specifically intended for control and monitoring of operation of motor-driven pumps and
process equipment. All equipment shall be of modular design to facilitate interchangeability of parts and to assure ease of servicing.

B. Electronic Components: Unless otherwise specified, electronic equipment shall be of solid-state construction. Components of standard electronic assemblies shall not be replaced with components of different characteristics in order to meet the performance requirements of the specification. Parts shall be as shown in the instruction manuals and shall be replaceable with standard commercial components of the same description without degrading the performance of the completed assembly.

2.3 INSTRUMENTS

A. Instrument Schedule: Application requirements are specified in the Instrumentation Schedule, individual specification sections, and/or on the drawings. The Instrumentation Schedule lists major instruments required to implement the process instrumentation and control systems. Instruments listed with equipment specification number references other than Division 40 shall be supplied by equipment suppliers. All instrument functions specified on this list with Division 40 specification references shall be provided by the CSI. Any additional instruments or devices required to complete the instrument loops because of unique characteristics of the particular equipment selected by the CSI (such as isolation I/Is) shall be provided. Such additional instruments shall be considered incidental to the contract and shall be provided and included in the original contract price even when not specified in the instrument index or on the contract drawings.

2.4 SPARE PARTS

A. In addition to spare parts mentioned elsewhere in Division 26 & 40 specification sections, the CSI shall supply the following spare parts for use by the Owner:

1. Qty 1 Relay of each type used or 10%, whichever is the greater amount
2. Qty 10 lamps of each type used or 100%, whichever is the greater amount.
3. Qty 10 spare fuses for each type of fuse supplied minimum

PART 3 - EXECUTION

3.1 DESIGN AND ASSEMBLY

A. General: With the exception of any packaged equipment control systems, the supplied control systems shall be designed by the CSI. The supplied control system shall be completely assembled in the shop of and by the CSI. All components and equipment shall be prewired to the maximum extent possible.

B. Integration: The CSI shall determine all requirements for and shall cause integration of the supplied control systems, MCCs, and any supplied packaged equipment control systems into a complete and unified system. The CSI shall be responsible for the coordination and integration of the supplied control system with motor controls and other related equipment.
C. Review of Submittals: The CSI shall be directly responsible to obtain submittal information on related equipment supplied by others and to integrate this information as required with the overall control system to form a complete working package.

D. Coordination: The CSI shall communicate directly with the Manufacturer(s) and Supplier(s) of all related equipment to determine all details of the equipment that may influence or affect the supplied control system components. The CSI shall make any and all adjustments or revisions required to integrate the submitted equipment into the job at no additional expense to the owner and with no extension of the schedule.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Shipping:
   1. Anchor, brace, and protect equipment during shipping handling.
   2. No internal wiring shall be disconnected for transportation.

B. Delivery Inspection: Notify the Engineer and provide access for inspection upon arrival of any material or equipment to be incorporated into the work. Remove protective covers when required.

C. Supplied Control Panels:
   1. Completely wired and tested in the factory prior to being shipped to the job site.
   2. Shipped as a single unit to job site after testing is complete.
   3. No internal wiring shall be disconnected for transportation.

3.3 INSTALLATION

A. GENERAL
   1. Installation by Contractor: The control system and associated instruments and connections shall be installed by the contractor.
   2. Installation Instructions: The control system shall be installed in accordance with the installation drawings and instructions provided by the CSI, packaged system suppliers, and other equipment suppliers.
   3. Supervision: The CSI's instrumentation and controls project engineer shall supervise and coordinate all activities related to the installation of Division 40 requirements.
   4. Expertise of Installer: Installation shall be performed by the workers who are skilled and experienced in the installation of electrical instrumentation and control systems. Installation shall include all elements and components of the control systems and all conduit and interconnecting wiring between all elements, components, sensors, valve operators, etc.
   5. Location: Equipment shall be located so that it is readily accessible for operation and maintenance.
   6. Instrument Technician: The CSI shall provide the services of skilled instrument technicians for testing, calibration, and adjustment activities.
B. Signal Connection And Transmission:

1. Unless otherwise specified, analog signal transmission between electric or electronic instruments not located within a common panel shall be 4 to 20 milliamperes and shall have a loop compliance of at least 500 ohms.
2. Two-wire loop transmitters shall operate at 24 VDC.
3. Unless otherwise shown, milliampere signals from the field shall be converted to 1 to 5 VDC signals at the field terminal block of each panel. Conversion error shall not exceed 0.1%. All instruments within a panel shall be parallel wired with 1-5 VDC signals.
4. Loops shall be grounded at the field terminal block by bonding to the instrument panel signal ground bus. Separate grounded conductors shall be provided for each loop. Daisy chaining of grounded conductors from one loop to another is not allowed.
5. Provide isolating amplifiers for field equipment possessing a grounded input or output, or having a common mode voltage other than system ground.
6. Convert high frequency (greater than 50 Hz) pulse rate signals from field transmitters to analog 1-5 VDC signals at the panel.
7. Convert platinum resistance temperature detector (RTD) outputs to 4-20 milliampere signals at the RTD, or where shown on the Drawings. The temperature milliampere signal may be brought from the field to the panel and converted to a 1-5 Volt DC signal.
8. All other transmission systems, such as impulse duration, low frequency pulse rate, and voltage regulated, will not be permitted. When transmitters with non-standard outputs are specified, their output shall be converted to 4 to 20 milliamperes at the field instrument.
9. Equipment located in classified areas shall be explosion-proof or intrinsically safe. Provide intrinsic safety barriers approved by UL, CSA, or FM.

C. Tagging: All field devices shall be labeled with tag number indicated in the bid documents or consistent with project tagging conventions when not shown in the bid documents. Comply with project naming and numbering conventions. Tag shall be 10ga, 316 stainless steel with stamped letters and numbers attached to device with 12ga, 316 stainless steel wire.

D. Field Equipment:

1. Installation: Equipment shall be provided as specified on the drawings such that ports and adjustments are accessible for in-place testing and calibration. Where possible, equipment shall be located between 48 inches and 60 inches above the floor or a permanent work platform. Instrumentation equipment shall be mounted for unobstructed access, but mounting shall not obstruct walkways. Equipment shall be mounted where shock or vibration will not impair its operation. Support systems shall not be attached to handrails, process piping or mechanical equipment except for measuring elements and valve positioners. Instruments and cabinets supported directly by concrete or concrete block walls shall be spaced out not less than 5/8 inch by framing channel between instrument and wall.
2. Support Systems: Steel used for support of equipment shall be hot-dip galvanized after fabrication. Support systems including panels shall be designed in accordance with the applicable building code and seismic zone and shall prevent deformation greater than 1/8 inch under the attached equipment load and an external load of 200 pounds in any direction.
E. Electrical Power Connections:

1. Electric power wiring and equipment shall be in compliance with Division 26.
2. Disconnect Switches: Power disconnect switches shall be provided within sight of equipment and shall be labeled to indicate opened and closed positions and specific equipment served. "Within sight of" is defined as having a clear unobstructed view from the equipment served and within 50 feet of the equipment served. Disconnect switches shall be mounted between 36 inches and 72 inches above the floor or permanent work platform. Where equipment location is such that the above requirements cannot be met by a single disconnect switch, two switches, one at the equipment and one at the work platform, shall be provided.
3. Surge Arrestors: Each disconnect switch serving equipment located outdoors shall be provided with a surge arrester, General Electric 9L15CCB001, or equal. The surge arrester shall be bonded to the plant ground grid with a No. 8 AWG bare copper conductor.
4. Control Panels: All control panels shall be provided with a main power disconnect equipped with auxiliary contacts as required to disconnect all power sources to the panel or shall be labeled to indicate the multiple power sources not disconnected by the main disconnect. Field wiring for all power sources not disconnected by the main disconnect shall land on fused disconnect type terminal blocks.

3.4 TESTS AND INSPECTIONS:

A. Per Section 409002 “Testing and Commissioning.”

3.5 CALIBRATION, START-UP, AND COMMISSIONING:

A. Per Section 409002 “Testing and Commissioning.”

3.6 SYSTEM MAINTENANCE AND WARRANTY

A. CSI Solely Responsible: The CSI shall be solely and completely responsible for all maintenance of control systems they supply from time of installation to the date of substantial completion of all work under the contract. The CSI shall correct all deficiencies and defects and make any and all repairs, replacements, modifications, and adjustments as malfunctions or failures occur. The CSI shall perform all such work required or considered to be required by the owner to properly maintain the system.

B. Defects and Repairs: The CSI shall make any and all repairs, replacements, modifications, and adjustments required to eliminate any and all defects in design, materials, and workmanship which are discovered within the one year guarantee period. The CSI shall begin all repairs, replacements, modifications and adjustments within twenty-four (24) hours of notification by telephone by the owner and shall complete such repairs, replacements, modifications and adjustments within forty-eight (48) hours of notification.

C. Acceptance of Work: The CSI shall anticipate that the Owner may delay acceptance of all work under the contract if, in the judgment of the Owner, malfunctions or failures in operation of the supplied control system repeatedly occur after start-up to an unacceptable extent. The CSI shall
not be entitled to an extension of time or to any claim for damages because of hindrances,
delays, or complications caused by or resulting from delay by the owner in accepting the work
because of malfunctions or failures in operation of the supplied control system.

D. Packaged Systems: Packaged system suppliers shall provide warranty support meeting the
above stated requirements for their supplied systems.

3.7 OPERATION AND MAINTENANCE DATA

A. O&M Manuals: The CSI shall prepare and assemble six (6) sets of operation and maintenance
(O&M) manuals in accordance with the project general requirements and this section. These
manuals shall be submitted two weeks prior to training. O&M manuals shall include, but not be
limited to, the following:

1. Trouble-shooting procedures
2. Calibration procedures
3. Testing procedures
4. Component replacement procedures
5. Preventative maintenance procedures
6. Listing of recommended spare parts
7. Listing of recommended maintenance tools and equipment
8. Catalog data for all equipment and devices supplied, organized per submittal
requirements
9. Configuration, setup, and programming manuals for all programmable devices supplied
including PLC, VFD, instruments, etc.
10. Communication channel test forms
11. Calibration and test forms for all field switches, instruments, PLC IO, VFD IO, etc.
12. Configuration files for all configurable or programmable electronic devices and
equipment supplied for this project
13. Application software program documentation for all programs and configurations
developed or supplied by the contractor for this project
14. System user's manual covering all functions supplied by the contractor for this project as
described below

B. Record Documents: All contract P&ID drawings and control strategy specification sections and
all submittal drawings shall be revised to reflect as-built conditions at the end of the project.
Record drawings and documents shall be submitted in accordance with the project general
requirements and this section. Record drawings and documents shall be submitted with the
O&M manuals. Record drawings and documents shall include the following:

1. Shop drawings per this section.
2. Wiring diagrams of cabinet and enclosure contained assemblies
3. Wiring diagrams of all system connections and interconnections including all loops, field
equipment, communications interfaces, networks, etc.
4. All other submitted shop and installation drawings and details not listed
5. Bill of Material
6. Contract P&ID drawings
7. Contract control strategy specification sections
3.8 SYSTEM USERS MANUAL

A. Scope: The CSI shall develop and submit a detailed user manual covering all aspects of the operation and use of the components and systems they supply. The manual shall cover the following:

1. Overview: An overview of the architecture of the control system including control panels, MCC’s, field devices, PLC, OIT, SCADA, data historian, remote alarm notification, communications, networks, remote access, etc.
2. Functions: All hardware/hardwired, programmed, manual, automatic, display, control, alarming, communications, networking, etc. features and functions of the systems and components they supply.
3. Hardwired Elements: Descriptions of the meaning and function of all hardwired panel, MCC, and field mounted discrete operator interface monitoring and control devices. Correlate functions to the control strategies.
4. Programmed Elements: The presentation and use of all elements of all OIT and SCADA HMI screens provided by the contractor for this project. Relate to control strategies. Include screen shots of all screens provided by the contractor with narrative descriptions of use, function, meaning, color conventions, animation, etc., of all screen elements.
5. Tag Lists: PLC, OIT, SCADA, remote alarm notification system, and process data historian tag data base lists.
6. Configuration Setup: Configuration screens for all PLC, OIT, SCADA, historian, remote alarm notification, communications, and network system components.
7. Network schema: Provide IP address listing
8. Security: System, application, data base, remote access, etc., security. Provide all configured user and administrator user names and passwords.
9. Start Up: System start up procedures for SCADA systems supplied and configured by the contractor for the project.

B. Used in Training: The system user’s manual shall be completed prior to and shall be used for required training. The manual shall be updated to incorporate comments received during training and re submitted for inclusion in the O&M manual. Submit 2 weeks prior to training.

C. Packaged Equipment: Packaged equipment suppliers shall supply user's manuals per the above requirements for the systems they supply.

D. Third Party Programming: Third parties other than the contractor or packaged equipment suppliers who provide PLC, OIT, SCADA, or other programming shall provide users manuals for the programming they provide.

3.9 TRAINING

A. General: The CSI shall conduct specifically organized training sessions to educate and train the owner's personnel in the maintenance and operation of all aspects and components of the control system they supply. Training on all system components shall include, but not be limited to, the following subjects:

1. All O&M manual items
2. All system users’ manual items
B. Training Sessions: The CSI shall provide a minimum of 16 hours of on-site instruction to the owner's employees after start-up and commissioning of the system. The owner shall be allowed to video tape all or any part of the training sessions. The CSI shall prepare and assemble specific instruction materials for each training session and shall supply such materials to the Engineer at least two (2) weeks prior to the time of the training. The O&M manuals and the system users’ manual shall be complete and shall be used in the training sessions.

C. VFD Training: Training shall cover details of operation of VFD's from the HIM (Human Interface Module). Training shall provide detailed instructions on the modification of VFD operating parameters typically requiring adjustment by operators. The contractor shall develop and provide "cheat sheets" which provide step by step instructions required to accomplish the following:

1. Copy VFD configuration to HIM
2. Copy HIM configuration to VFD
3. Switch between auto and manual modes
4. Manually adjust speed
5. Adjust minimum and maximum speed limits
6. Adjust acceleration and deceleration ramp times
7. Access parameters and fault codes

END OF SECTION 409000
SECTION 409001 – CONTROL SYSTEMS SUPPLIED WITH EQUIPMENT AND PACKAGED SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: This section specifies requirements for packaged control systems supplied with vendor provided packaged equipment. Control systems provided with packaged equipment shall include all components required to provide complete and fully operational equipment control systems. Systems shall be supplied pre-assembled, pre-connected, and pre-configured to the maximum extent practical. Systems shall be supplied with complete design, component, assembly, programming, installation, operation, troubleshooting, and maintenance documentation. Packaged control systems shall comply with the requirements of all applicable sections of Divisions 26 and 40 and the Contract Drawings.

B. Application Of Division 40 Requirements: Packaged control systems shall conform to all system design, fabrication, programming, testing, training, documentation, etc. requirements specified in Division 40. Where referenced specification sections refer to the CSI as the responsible party, the packaged system supplier shall conform to the stated requirements for their scope of work and supply.

C. Services: The packaged system Vendor shall provide the following services:

1. Design, fabricate, program, factory test, deliver, install, calibrate, site test, commission, provide training for, etc., all control system components and assemblies as required to provide a fully functional packaged control system acceptable to the Project Representative.
2. Provide programming per 409635.
3. Provide testing and commissioning per 409002.
4. Provide training to Owner staff per contract requirements and 409000.
5. Provide O&M manual per contract requirements and 409000.
6. Provide detailed system users manual per contract requirements and 409000.
7. Provide on-site assistance, direction, and coordination during installation, functional check-out, startup, and commissioning of systems, and as needed through project closeout.
8. Coordinate with the Engineer, the contractor, sub contractors, and suppliers of other equipment as required to assure seamless integration of provided systems, signals, and IO into the overall plant SCADA system where and as required by the control strategy specification sections and the contract drawings.

D. Pre purchased Systems: The RFP purchase process and the resulting system documentation and equipment purchase contract shall govern requirements for system features and functionality, in lieu of references to the contract documents, for pre purchased systems. Pre purchased systems are those packaged systems for which an RFP is issued and a purchase contract is executed prior to project bid. The contractor shall ensure that pre selected and assigned suppliers of packaged equipment provide complete Division 26 and 40 submittals per the requirements stated in the contract documents of those divisions during the submittal phase of the project. The contractor
shall include this scope and deliverable in their bid if it is not included in the equipment purchase agreement.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This section incorporates by reference the latest revisions of the listed documents. In case of conflict between the requirements of this Section and those of the listed documents, the more stringent requirements shall prevail.

1. NFPA 70 National Electric Code (NEC)
2. IBC 2003 International Building Code
3. UL 508 Industrial Control Equipment

B. Listing

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

C. Packaged System Vendor Qualifications

1. The packaged control system shall be provided by the manufacturer of the overall packaged equipment system.
2. The vendor shall employ and provide a qualified on-site specialist experienced in the design, programming, installation, and operation of the supplied control equipment for either a minimum of five years or five separate projects. This experience shall include managing programming, testing, commissioning, and training tasks for the packaged control system.
3. Provide the names and qualifications for three full time employees qualified to support the installed packaged control system after formal acceptance by the Engineer.
4. Provide experienced training personal for the required operations and maintenance training courses.

1.3 SUBMITTALS

A. General: Per 409000

B. Detailed Drawings and Schedules:

1. Provide system plan drawings showing all electrical and instrumentation and control devices.
2. Provide connection diagrams showing all required connections between system components and between system components and other plant equipment and systems. Identify all terminals for field connections on both ends of all connecting cable or wire.
3. Provide a list of all related electrical and instrumentation and control items assumed to be supplied by others.
4. Provide a list of all electrical and instrumentation and control items supplied which require installation and/or connection by others.
5. Submit Instrument schedule including all process switches, instruments, transmitters, and sensors supplied.
6. Submit shop drawings per 409000.
7. Drawings and schedules shall use project tag formats and numbers.

C. Qualifications: Submit qualifications of vendor firm and personnel.

D. Control Strategy: Submit detailed control logic description.

E. SCADA Interface: Where interface to the facility SCADA system is required include a complete I/O list with addresses, field terminal numbers, and SCADA data communications interface address.

F. Programming Submittals: Provide programming submittals per 409635.

G. Test Plans, Procedures, Results: Submit test plan, procedures, and results documents per 409002.

H. Operation and Maintenance Manuals: Submit O&M manuals per 409000.

I. Mark Up All Applicable Contract Documents
   1. Submit copies of all applicable Division 40 specification sections with each paragraph notated to indicate compliance. A check mark shall indicate complete compliance. Explanations shall be provided for all non-compliant items in accordance with Division 01.
   2. Submit copies of all applicable project approved Process and Instrumentation drawings with each drawing element notated to indicate compliance. A check mark shall indicate complete compliance. Explanations and markups shall be provided for all non-compliant items in accordance with Division 01.
   3. Submit copies of all applicable Electrical and Instrumentation drawings notated with markups to indicate and explain any proposed deviations from the contract documents. Explanations and markups shall be provided for all non-compliant items in accordance with Division 01. Electrical plan drawings and conduit schedules shall be exempt from this submittal requirement and shall be submitted with the record drawings at the end of the project.

1.4 SERVICE REQUIREMENTS

A. Environmental conditions are specified in Sections 409000 “Instrumentation and Control Systems.”
1.5 WORK BY OTHERS

A. Plant network, SCADA system, data historian.

B. Division 26 work required for the installation and connection of field equipment and devices supplied loose by the vendor.

C. Installation materials for instrumentation and automatic valves including but not limited to sample line tubing, fittings, mountings, etc.

D. Power, signal, and communications interconnections between packaged control system components and facility network, power, and SCADA systems.

PART 2 - PRODUCTS

2.1 General:

A. Control systems shall conform to the requirements of Section 409000 “Instrumentation and Control Systems” and all other applicable Division 40 specification sections.

B. Similar Packages: Provide identical packaged control system control logic for parallel equipment within a process or equipment of the same type distributed over multiple processes.

C. Fault Tolerance: Packaged control system hardware shall be designed for immunity to single point of failure. The hardware and wiring shall be arranged so that the equipment associated with one process train can be removed from service without affecting any other process train.

D. Tag Numbers: All equipment, valves, and instruments shall be provided with a unique tag as indicated on the contract drawings or that is consistent with the project’s tag naming convention if the tag is not indicated on the drawings. The Contractors shop drawings shall reflect these tag numbers.

E. Electrical: The complete electrical assembly shall meet all requirements of the National Electrical Code, National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), all applicable state and local codes, and the requirements of Divisions 26 and 40.

F. Programmable Logic Controllers: For systems which include a PLC, PLCs shall comply with Section 409443 “Programmable Logic Controllers.” All PLCs shall communicate peer to peer and with the plant SCADA system over Ethernet.

G. Hard Wired Interface to Plant Systems: The supplied equipment shall provide hardwired interfaces to plant systems as indicated in the applicable control strategy specification section, the contract drawings, or as required by the system supplier.
2.2 FUNCTIONAL REQUIREMENTS

A. General: Functional requirements for packaged control systems are specified in the applicable control strategy specification section, other Division 40 specification sections, and the contract drawings.

B. Manual Control: Sufficient interface components shall be provided to facilitate convenient manual operation and monitoring of all supplied equipment without reliance on any programmable device.

C. Vendor Design: Packaged systems shall be designed by the manufacturers. Control system functions and components indicated on the drawings shall be provided, as well as any ancillary or incidental equipment or devices that are required for the operation of vendor-furnished equipment. Vendors shall provide programming as required by the process and the vendor's equipment to safeguard the equipment and operators, and as required to provide complete and convenient functionality and trouble-free operation.

D. Equipment and Control Strategy Modification Request: The manufacturer shall inform the Engineer of functions and features not specified in the contract documents that are required by the manufacturer for the operation of their system. The manufacturer shall coordinate all differences between their proposed system and the contract documents with the Engineer and shall provide a full accounting, with documentation, of these differences and the impacts these differences will have on other aspects of the project. The vendor shall coordinate any requested deviations, modifications, or revisions to the applicable Division 40 control strategy and contract drawings with the Engineer. Revisions approval shall be at the discretion of the Engineer. If approved, the vendor shall document and implement the resultant revised control strategy. The revised control strategy shall be used in any testing that follows.

E. Systems Integration: Packaged control systems shall provide specified hardwired interfaces and preconfigured fully documented data interfaces with the plant SCADA system as indicated in the Contract Drawings and the applicable control strategy specification section. The lists shall include all data required by the contract documents to be logged to the facility data historian.

2.3 INSTRUMENT AIR

A. Instrument air systems required to operate vendor provided pneumatic devices shall be included in the vendor package.

2.4 FIELD INSTRUMENTS

A. Field instrumentation shall be provided per the contract documents to measure process parameters in compliance with Division 40.

B. Field instrumentation shall be selected and calibrated to operate at 40 to 60 percent range during normal process conditions or as defined by the process parameters indicated in Section 409004 “Schedules.”

C. All field mounted powered instruments shall be powered from the panel receiving its signal.
2.5 PROCESS SWITCHES
A. Process switches shall comply with Division 40 specifications.
B. Each field mounted powered process switch shall be powered from the panel receiving its signal.

2.6 CONTROL VALVES
A. Control valves shall comply with Division 42. Throttling valves shall be sized to operate in the linear control range of the valve, generally not less than 20 percent open for minimum conditions and no greater than 80 percent open for maximum conditions.

2.7 ACTUATORS
A. Control valve actuators shall comply with Division 42. Local valve actuation controls shall be mounted remotely from the actuator if needed to provide easy operator access.
B. The valve and actuator assembly shall be fully bench tested for break-away seat torque requirements plus a 150 percent service factor, full stroke operation, limit and torque switch settings, and full stroke run time. The owner may choose to witness factory testing of the valve operation at their discretion.
C. Actuators shall provide the instrumentation indicated on the drawings and in the applicable Division 40 control strategy specification sections.
D. All field mounted 120 VAC or 24 VDC powered actuators shall be powered from the controlling panel. A separate dedicated 120 VAC panel board fed separately from the same source powering the control panel and mounted next to the control panel may be provided to power 120 VAC actuators where the actuator load exceeds the control panel load.

2.8 ELECTRICAL
A. All electrical work shall comply with Division 26.
B. 480 VAC Motors: All 480 VAC motor starters and variable frequency drives shall be provided by others and shall be located in MCCs in electrical rooms UNO. Equipment supplier shall coordinate their equipment requirements with suppliers of MCC's.
C. Equipment Power: 480 VAC three phase and 120 VAC single phase power shall be available for system equipment. System power and MCC space requirements shall be submitted with the proposal. Power connection to vendor-supplied control panels shall be 120 VAC. Each 480 VAC motor shall have a separate branch circuit connection. A local 480 VAC power distribution panel shall not be required at the equipment.
D. Local Control Panel: Skid-mounted components shall be pre-wired to a single local control panel (LCP) located in the proximity of the equipment. The LCP shall enclose terminal blocks for field connections of control power or I/O as well as PLCs and required communications devices. The local control panel shall provide all termination points for signal connections to the
plant SCADA system (if connection is required), field instruments and process switches, valve actuators, MCCs, etc. Panels shall provide a minimum of 25 percent excess power supply capacity and 25 percent empty panel space.

E. Selective Coordination: All circuit breakers at the plant must be selectively coordinated. Any and all contractor provided equipment circuit breakers must meet NEC 701.18 selective coordination requirements for the entire plant. Contractor shall coordinate the application of selective coordination requirements and the integration of all equipment into the overall plant. Any rework of contractor supplied equipment needed to meet selective coordination requirements shall be performed by the contractor at no additional expense and with no extension to the project schedule.

2.9 MOTORS AND VFD’s

A. Motors and drives shall be as specified in Divisions 46 and 26.

2.10 SPARE PARTS

A. Provide a spare parts list associated with the packaged control system for the equipment listed in the proposal. Include unit prices for all replaceable parts. Provide the following items:

1. One set of new and unused special tools required for installation, operation, and maintenance.
2. Spare parts for electrical components, instruments, control system hardware, and control devices as specified in Division 26 and 40 specification sections.
3. Recommendations for spare parts and materials for the first 12 months of system operation. Provide a total cost for all recommended spare parts.

2.11 UPS

A. All vendor provided local control panels which include electronic equipment shall be provided with an uninterruptible power supply. The UPS shall comply with section 409515 “Power Supply and Conditioning Equipment.”

PART 3 - EXECUTION

3.1 ASSEMBLY

A. Assembly shall comply with all applicable sections of Division 26 and 40 specifications.

3.2 SYSTEM PROGRAMMING

A. All Program development activities and all programs supplied shall comply with 409635, the applicable control strategy specifications section, and the contract drawings.
3.3 FACTORY TEST:
   A. Factory testing shall comply with Section 409002 “Testing and Commissioning”. Section 409002 “Testing and Commissioning” requirements referenced to the CSI shall also apply to the packaged equipment supplier for their scope of supply.
   B. The owner and/ or project representative may elect to witness factory testing.

3.4 SHIPPING
   A. Packaged equipment shall be factory assembled and tested to the maximum extent practical. Parts and assemblies that must be shipped unassembled shall be packaged and tagged in a manner that will provide easy identification in the field, protect the equipment from damage, and facilitate the final assembly in the field. All hardware items shall be shipped to the job site in a timely manner as required to meet the established construction schedule. Packaged equipment control system equipment and instrumentation shall be shipped and stored per the requirements of Division 01. The Contractor shall direct work during unloading of control system equipment and components on-site.

3.5 INSTALLATION, CALLIBRATION, CHECKOUT
   A. Supervision: The Contractor shall provide vendor-authorized, factory-trained personnel to furnish technical direction for on-site labor associated with equipment installation, wiring and cabling, power wiring, grounding, field I/O wiring, etc., for packaged control systems. Contractor shall install the control system in accordance with vendor’s instructions and recommendations.
   B. Checkout: The vendor shall inspect the control system installation, including field instrument installation, field wiring, etc., and shall certify the completed installation meets the vendor’s packaged control system installation requirements.
   C. Calibration: The system supplier shall configure and calibrate all supplied components including instruments, process switches, communications and network devices, programmable control and display devices, etc.
   D. Acceptance Criteria: The Contractor and the system supplier shall monitor all system diagnostic indicators and certify that system performance meets or exceeds the vendor’s published performance specifications.
   E. Problem Resolution: All malfunctions, faults, or abnormal operating conditions shall be investigated, documented, and resolved by the Contractor and vendor to the satisfaction of the Owner.

3.6 SITE TESTING (START UP AND COMMISSIONING)
   A. Per 409002.
   B. Un Witnessed Site Testing (Start Up): Testing of packaged equipment shall be conducted in conjunction with preliminary site testing of other process equipment per the approved
construction schedule. The system shall be fully checked out as a stand alone system. The Contractor shall complete all control system functional testing and documentation to the satisfaction of the Engineer prior to commissioning activities. The vendor shall provide assistance to suppliers of other equipment which interface with the vendor's system to test and verify correct system interface wiring and functionality.

C. Witnessed Site Testing (Commissioning): The system shall be fully integrated with other systems on site as specified in the contract documents. Following completion of start up functional test and the correction of any deficiencies or problems discovered, the Contractor and the system supplier shall conduct system commissioning tests and shall demonstrate system performance and compliance to the Engineer.

D. Supervision: Qualified Contractor’s personnel shall be provided to supervise and perform these tasks.

3.7 TRAINING

A. General: Training shall comply with section 409000 “Instrumentation and Control Systems” and Division 01.

B. Course Schedule: Provide a minimum of 16 hours of formal operations and maintenance training for each packaged control system. Training schedule shall meet the needs of the owners operations and maintenance staff and shall be submitted for approval 4 weeks prior to scheduled training. Training shall be presented in four 4-hour sessions, two sessions per day, each covering the same material, in two separate weeks. Provide each course participant with O&M manual, system users manual, and other training material based on each packaged control system supplied.

C. Instructors: The system supplier shall provide qualified personnel to train the Owner’s staff.

3.8 SUPPORT SERVICES

A. The vendor shall provide telephone support as required by the owner for the duration of the warranty period.

B. Vendor shall attend a full day review of the packaged control system’s actual performance and operation 9 months after the packaged system has been formally accepted by the Engineer. Problems shall be identified for correction and desired modifications shall be identified to fully optimize system performance. The vendor shall perform the requested corrections and modifications within the warranty period. Service time spent remedying miscellaneous control system equipment deficiencies and problems shall not contribute towards the satisfaction of this requirement.

3.9 WARRANTY

A. In addition to the warranty requirements listed elsewhere in the specifications, all necessary packaged control system devices, components, parts, and vendor service support shall be
provided for a minimum of one year after the issuance of approval of completion of the performance test by the Engineer.

END OF SECTION 409001
SECTION 409002 – TESTING AND COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: The Contractor shall test, verify, document, and demonstrate each and every aspect of the functionality and characteristics of all of the devices, equipment, and systems they supply, individually and as an interconnected system. The overriding purpose of required testing is to ensure and convince the Engineer that the supplied equipment, systems, and programs are 100% functional and in full compliance with the contract and the needs of the process prior to being put into operational service. The items listed below as well as other items required by this section shall be tested in accordance with the requirements of this Section:

1. All control system hardware, components, assemblies, wiring, interconnections, cabling, etc.
2. PLC’s
3. OIT’s
4. SCADA HMI including data acquisition servers
5. Data historian
6. Remote alarm notification system
7. Communications apparatus and channels
8. Network devices and media
9. All programming
10. All configurations
11. Control panels
12. MCC’s
13. Packaged equipment control systems

B. Tests and Witnessing: A comprehensive series of Contractor conducted tests shall be performed and documented as specified. Tests shall be witnessed by the project at the projects discretion. The Contractor shall test and verify the performance of all equipment, software, and integrated systems supplied. If equipment or software does not have specific tests defined in the contract documents, then the Contractor shall develop testing procedures and submit to the project for approval.

C. Programs not provided by the CSI: All programming on the project will be provided by the CSI, the design consultant, or packaged equipment suppliers. Programs shall be tested by those who provide the programs. The contractor and CSI shall provide integration and testing support for hardware and non programmed system functions as required to support third party programmers in the installation, testing, commissioning, and demonstration of programming not provided by the CSI to the extent that the programming provided by others interfaces with or otherwise interacts with contractor and CSI provided systems.

D. Packaged equipment control systems: Suppliers of packaged equipment control systems shall comply with all requirements stated in this section for CSI supplied control systems and components for their scope of work and supply. The CSI shall not be responsible for the application of this section’s requirements to equipment supplied by others. The CSI shall be
required to provide integration and testing support to packaged equipment suppliers to the extent that CSI supplied systems interface with or otherwise interact with packaged control systems. Packaged equipment suppliers shall, for their scope of work and supply, rigorously verify all control, monitoring, communications, and interface functionality required between vendor systems and plant systems and equipment, including MCC’s and plant SCADA system application software and equipment.

E. Test and Document all Data Points and Functions End to End: All process data points connected to the control systems shall be tested, verified, and documented by the contractor, end to end, to produce the required result from signal origin, thru logical processing and calculation functions, to signal and data destinations and process equipment responses. The test and verification of the correct reception, transmission, processing, and storage of all process data input and output points shall be individually and collectively documented in appropriate test forms, test logs, test reports, etc. All functions and logical processing of all process data input and output points shall be tested, verified, and documented individually and collectively. The generation of all data calculated from process input and output data shall be tested and verified individually and collectively.

1. Signal origins include, but are not limited to the following:
   a. Process switches
   b. Field instruments
   c. MCC control circuitry
   d. Packaged equipment control panels
   e. Valve actuators

2. Signal processing functions include but are not limited to the following:
   a. Control sequence functions per control strategy documents
      1) Relay logic
      2) PLC programming
   b. Alarm generation and signal trip
   c. Calculations such as counters, timers, and totalizers
   d. Data logging
   e. Automatic remote alarm annunciation functions
   f. Report generation
   g. Network communications

3. Signal and data destinations and results include but are not limited to the following:
   a. Display devices of any kind
   b. SCADA, Historian, PLC, Auto dialer data bases
   c. Data reports and Historian queries
   d. MCC control circuitry
   e. Packaged equipment control panels
   f. Valve actuators
   g. Stand alone motor controls
   h. Remote access devices
1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more stringent requirements shall govern.

1.3 SUBMITTALS

A. General: Per 409000

B. Test Plans and Documentation: Provide complete documentation of all test schedules, plans, procedures, and results. Test results documentation shall utilize a tracking process for each component of the system and the system as a whole. The tracking process shall document all tests, the outcome of each test, shall record failures, the reasons for failures, and the remedies used to correct the failures. Test schedules, plans, procedures, forms, formats, etc., shall be submitted the project for review and approval before the start of factory tests and site tests. Provide the documents listed below as well as any other documents required by this section:

1. Factory test schedule, plan, procedures, forms, logs, reports, etc., as specified in Part 2.
2. Site test schedule, plan, procedures, forms, logs, reports, etc., as specified in Part 2.

C. Submittal Format: All documentation shall be submitted in hard copy and electronic file format.

PART 2 - PRODUCTS

2.1 TEST PLANS

A. General: Prepare separate test plans for the Factory Tests and Site Tests (start up and commissioning).

B. Factory Test Plan: Test plan shall include the items listed below.

1. Test Schedule
2. Test procedures
3. Test report format
4. Test log format
5. Door mounted discrete interface and display device test form
6. PLC and MCC discrete and analog I/O test forms
7. Instrument calibration form
8. Loop test form
9. Non programmed function test form
10. Programmed function test form
11. Test instrument list including calibration data
12. Test fixture information, for simulating field wiring connections
13. Integration Test Diagram: For factory test provide a test setup diagram showing all hardware and interconnections planned to accomplish factory integration testing of the supplied system. The diagram should include the following components:
a. Control panels  
b. MCC's  
c. OIT's  
d. SCADA components  
e. Cabling and wiring  
f. Network devices and media  
g. Communication devices and media  
h. Test fixture

C. Site Test Plan: All system components must be recheck after installation on site. Test plan shall include the items listed below.

1. Test Schedule  
2. Test procedures  
3. Test report format  
4. Test log format  
5. Door mounted discrete interface and display device test form  
6. PLC and MCC discrete and analog I/O test forms  
7. Instrument calibration form  
8. Loop test form  
9. Non programmed function test form  
10. Programmed function test form  
11. Test instrument list including calibration data

2.2 TEST SCHEDULE

A. Provide test schedule to Project Representative 30 days prior to planned testing activities. Indicate itinerary for each planned day of testing. Indicate planned witnessed test dates. Indicate expected test report transmittal dates.

2.3 TEST PROCEDURES

A. General: Structure test procedures in a step-by-step manner. Provide separate procedures for separate function and test types. The procedures shall facilitate the generation and reporting of test results and the re-creation of error conditions. Procedures shall provide methods to test and document all required system functions, sequences, and responses to field conditions. Provide test procedures for the following types of tests as well as any others required by this section:

1. Discrete input and output loop tests, PLC and MCC  
2. Analog input and output loop tests, PLC and MCC  
3. Panel front and MCC unit door device tests  
4. Non programmed function tests  
5. Programmed function tests  
6. Programmed display device tests  
7. Data bases, Historian, and reporting function tests  
8. Software alarm dialer tests
2.4 TEST REPORTS

A. General: Compile and prepare reports for documenting un witnessed portions of Factory and Site Tests (start up and commissioning). Develop test report formats to record test results and conditions. Reports shall be completed and submitted for review and approval prior to witnessed portions of factory and site tests. Test reports shall include the items listed below.

   Complete and submit the following for review and approval:

   1. Test summary
      a. Summary description of tests being conducted
      b. Test dates
      c. Tester names
      d. Witness names
      e. Prerequisite tests and status
      f. Test objectives and methods summary
      g. Test and monitoring equipment lists
      h. Test results summary

   2. Test log
   3. Test procedures
   4. Test forms listed below, completed
   5. Test check off documents listed below, completed
   6. Listing of all configurable device parameters and settings for all configurable equipment

2.5 TEST LOG

A. The CSI shall keep a test log that shall be developed during un witnessed portions of factory and site testing which documents the performance of each device, loop, circuit, function, feature, etc., of the system. Failures shall be noted in the test log and corrected prior to witnessed portions of factory and site testing. Log format may be somewhat informal. Logs shall be kept for each day of testing. Logs shall be signed and dated by all testers.

2.6 TEST CHECK OFF DOCUMENTS

A. Approved, as-built process and instrumentation drawings, contract or shop schematic drawings (factory test only), and control strategy documents shall be used as check lists during testing to ensure all items and functions are tested. All items on applicable documents shall be tested, verified to provide the required result, and checked off to indicate completion of testing for each element, feature, and function. All sheets of these documents shall be signed and dated by the tester and included in test report submittals.

B. Conformance of contract documents prior to testing: Applicable contract and shop documents and control strategies shall be revised by the contractor as needed to conform to the actual systems, equipment, and control strategies submitted and installed by the contractor or supplier prior to use in testing.

C. Screen shots of all OIT and SCADA HMI screens with all elements check marked to indicate successful testing of required functionality and characteristics. Correct and retest until all
elements test successfully for inclusion, color usage, animation, and read-write functionality. Testers shall sign and date sheets and include with test report submittal.

2.7 TEST FORMS

A. Form Types: Form types may be combined where appropriate. Provide appropriate forms for the following types of tests:

1. Door mounted discrete interface and display device test form for control panels and MCCs
2. PLC and VFD discrete and analog I/O test and calibration forms
3. Instrument calibration form
4. Field Loop test form
5. Programmed and non programmed function test forms
6. PID loop tuning form
7. Programmable and non programmable display device test forms
8. Data base, Historian, and reporting function test forms
9. Software alarm dialer test form
10. Communications channel test form
11. Network connectivity test form

B. General Information on Forms: Forms shall include appropriate general information such as the following:

1. Point or loop identification for all analog, discrete, or communications signals.
2. Applicable drawing and control strategy document numbers
3. Logical function of signal or complex function
4. Test Procedure text or reference to typical procedure
5. Test equipment used
6. Signal stimulus method if signal is forced. Provide all thresholds and ranges in process engineering units.
7. Process manipulation method if process variation is used to test the signal. Provide all thresholds and ranges in process engineering units.
8. Expected result, allowable limits, success criteria
9. Actual result
10. Accuracy calculation
11. Conclusion (successful or description of corrective action)
12. Tester name, test date

C. Loop and Function Test Forms: The contractor or packaged system supplier, as applicable, shall test, verify, and document that all signal interfaces between provided control system components and plant equipment, MCC’s, devices, and other control systems correctly transmit and receive and produce the required results. The contractor and system supplier shall provide a separate test and verification form for each discrete, analog, and digital data connection to the provided systems as well as for all required system functions. The forms shall include the information listed above as well as any additional information needed to clearly demonstrate that each interface data communications signal functions as required and produces the desired result:

1. Provide for all discrete and analog input and output data points
2. Provide for all hardwired and programmed functions.
3. Provide for control panel signal loops and motor control equipment signal loops.
4. Provide for digital data exchange between software components

D. Calibration and Test Forms Provided with Specifications

1. Sample calibration and test forms are included with these specifications. Appropriate forms shall be used as needed and wherever calibration and test forms are referenced by Division 40 specifications. The CSI shall submit additional forms as needed where a suitable form is not included in the provided set of forms. Test forms shall be completed for all devices and subsystems as required by Division 40 specifications for all required test phases. Completed forms shall be submitted with test reports following witnessed portions of factory and site tests. Provide a final set of calibration and test forms with the O&M manual submittal.
2. Any testing, calibrations, and report forms provided in these documents are provided to the contractor as is and for use and modification, if needed, by the contractor. The provided forms do not necessarily provide all needed forms or data fields and do not necessarily support all required testing, documentation, and report formats. The contractor shall provide any additional forms or shall modify the provided forms as needed to meet the testing and reporting documentation requirements. Simply filling out the provided forms will not necessarily satisfy the requirements of this section. The specified testing and documentation requirements do not necessarily require all of the provided forms.

PART 3 - EXECUTION

3.1 TESTS AND INSPECTIONS GENERAL REQUIREMENTS

A. Inspection: Materials, equipment, and construction included under this Specification shall be inspected in accordance with the contract plans, specifications, and the approved shop drawings. Any and all substitutions will require re submittal and rigorous quality control.

B. Notification and Schedule: No required test shall be performed without prior verifiable notice to the Engineer. The Contractor shall provide test plans, schedules, and procedures per Sections 2.1, 2.2, and 2.3, 30 days prior to the planned beginning of each test phase.

C. Scope: The CSI shall provide all programming and associated testing, documentation, and commissioning services specified UNO. The Contractor and the CSI shall provide all personnel, facilities, utilities, labor, tools, material, equipment, etc., required to accomplish the testing and documentation requirements.

D. Commissioning Support: The CSI and packaged system suppliers shall continuously support the Contractor during witnessed site testing (commissioning) of the completed project. The CSI and packaged equipment suppliers shall be required to provide this support to the extent and on the schedule requested by the Engineer. Typically the CSI, packaged equipment suppliers, and the Contractor will be asked to have one qualified tradesman each onsite and available for the duration of testing tasks.
E. Packaged Equipment: Packaged system vendors shall perform factory testing of packaged control systems in vendor facilities and site testing on site. Packaged equipment vendors shall comply with all of the submittal, testing, and documentation requirements of this section applied to their scopes of supply. Packaged equipment test schedules shall parallel and integrate with contractor test schedules. The Engineer may elect to or decline to witness packaged equipment factory tests at their discretion. The Contractor shall inform the Engineer of the vendor's factory test schedule 30 days in advance of the planned start date.

F. Witnessed Testing Prerequisites: All systems shall be tested and tests documented by suppliers of all control systems prior to any scheduled witnessed testing. The un witnessed factory and site test reports shall be provided to the project at least one week prior to planned witnessed testing. The project may request complete testing to be witnessed, may request to witness some but not all of the tests, or may waive the witnessed testing.

G. Duration: Test duration shall be per the contract documents and project schedule. The contractor, sub contractor, and equipment suppliers shall be sufficiently organized and have accomplished sufficient progress such that no witnessed test phase shall take more than 5 working days.

3.2 FACTORY TESTING

A. General: Factory acceptance test and verification for all deliverable equipment, programs, and associated documentation shall be performed prior to shipment of the system to the site. The tests shall verify that all equipment including control panels, PLC, OIT, SCADA equipment, MCC’s, etc., are manufactured, configured, and assembled correctly, and are operating as required. The tests shall verify that the software and hardware meet the quality, functional, and performance requirements of the project.

B. Un Witnessed tests shall be documented: All test documents shall be completed and submitted to the Engineer prior to witnessed testing.

C. Device and Assembly Verification (Un Witnessed): The completed control systems assemblies shall be thoroughly verified in the shop of and by the supplier prior to witnessed factory testing. Testing shall verify the functionality of all supplied devices, the correctness of all panel wiring, and shall verify all required system functions and features including non programmable control logic, annunciation, alarming, networking, communications, etc. The CSI shall verify the proper operation of all system devices and circuits, including but not limited to all inputs, outputs, loops, circuits, control devices, etc. The CSI shall configure and verify the functionality of all supplied communications and network devices. Testing of the supplied control system shall include energizing each discrete input and output and simulating each analog input and output using a loop simulator and calibrator or other appropriate device. All circuits shall be energized simultaneously or as expected in maximum power supply loading operation during testing. Un witnessed testing of the supplied control system shall be conducted continuously, 24 hours per day, for at least seven (7) days without a failure or interruption. Provide the documents listed below as well as others required by this specification section:

1. PLC IO Wiring: Test and verify the correctness of all wiring of PLC discrete and analog input and output modules to the correct field terminals. Provide completed PLC IO verification forms to document this test. Include description of test methods.
2. PLC Analog IO Calibration: Test the accuracy of all PLC analog input and analog output points to the field terminals. Provide PLC analog IO calibration forms to document this test. Include description of test methods.

3. VFD Analog IO: Configure supplied VFD's per the requirements and specifications. Test and verify the accuracy and response of VFD analog IO. Provide MCC analog IO calibration forms to document this test. Include description of test methods.

4. Discrete Interface and Display: Test and verify all discrete field located and control panel or MCC door mounted display and operator interface devices. Document these function tests individually or in logical groups on appropriate forms. Include description of test methods.

5. Non Programmed Functions: Test and verify the responses of all non programmed hardware driven logical functions at control panels and MCC's. Functions include signal trip, alarm generation, relay logic, interlocks, etc. Document these tests individually or in logical groups on appropriate forms. Include description of test methods.

D. Factory Integration Testing (un witnessed): All packaged equipment supplier or CSI provided programs including PLC, OIT, SCADA components, historian, alarm dialer, etc., programs shall be 100% complete, installed, and functioning prior to factory integration testing. All programs shall be thoroughly tested and verified prior to factory test witnessing. This requirement applies to all programs within the scope of services of the contractor or packaged system supplier. The CSI or system supplier shall verify all required functions and features of the system. Testing shall verify all instrumentation, display, communications, network, automatic control, manual control, annunciator, alarming, OIT (UNO), SCADA HMI (UNO), etc., functions of the control system. For CSI or packaged equipment supplier provided programming, provide the following documentation as well as other documentation required by this section:

1. Programmed Functions: Test and verify all programmed control strategy functions. Specified input conditions shall produce all specified output and operational results. Document these tests individually or in logical groups on appropriate forms. Include description of test methods.

2. Programmable Displays: Test and verify the correct display, read-write functionality, and animation of all specified data points on programmable display devices. Document these tests by providing complete sets of contract P&ID drawings and display screen print outs with each item check marked to indicate compliance or other equivalent and appropriate means. Include description of test methods.

3. Data Historian: Test and verify the correct logging of process data to the data historian and the correct rendering of required data reports from the process data historian. Document this test by providing tag lists and report formats with each item check marked to indicate compliance or other appropriate and equivalent means. Include description of test methods.

4. Remote Alarm Notification: Test and verify the correct configuration and callout functionality of all specified remote alarm notification system points. Document this test by providing the call out tag list with each tag check marked to indicate compliance. Include description of test methods. Coordinate with the provided owner staff call list during the un witnessed site test phase.

E. Field Wiring and Test Fixture: The electrical interfaces of all system equipment not present for factory testing shall be simulated with a test fixture provided by the CSI. The test fixture shall provide switches, indicator lights, digital signal displays, labeling, etc., as required to simulate field devices. All supplied control system I/O not connected to actual system equipment shall be
connected to interface or indication devices on the test fixture. The test fixture devices connected to control system I/O shall be labeled to indicate the control system function being performed or indicated. Sufficient loop simulators (or other appropriate device) needed to satisfy all analog programming conditions simultaneously shall be provided by the CSI. Digital panel meters shall be provided for analog outputs not connected to actual system devices. It is essential that all I/O be simultaneously connected to actual project equipment or the simulation devices on the test fixture.

F. A PLC and OIT based test fixture of equivalent functionality and convenience may be used in lieu of the test box described above.

G. Test Log: A factory test log shall be kept per Part 2.5 of this section.

H. Factory Test Report: A test report shall be prepared to demonstrate thoroughness of testing and to document and communicate factory testing results. The report shall contain data and documentation as indicated in Part 2 of this document. The test report documentation shall be provided to the Engineer prior to witnessed factory testing. The acceptability of the test results and report shall be determined by the Engineer. Witnessed factory testing shall not be scheduled prior to verifiable receipt of acceptance of the test results and report by the Engineer. Prior to witnessed testing all aspects of the control system should be fully checked out and verified. All that should remain to be done is for the supplier to demonstrate this to the witness.

I. Witnessed Factory Testing: Following acceptance of un-witnessed factory test report documents the CSI shall demonstrate system compliance to the Engineer. The project shall not be expected to orchestrate or lead the testing. The CSI shall demonstrate all required functions and features of the system, or requested subset thereof, including but not specifically limited to control, indication, alarming, monitoring, data logging (UNO), network, communications, PLC (UNO), OIT (UNO), SCADA HMI (UNO), etc functions to the Engineer. The CSI shall revise, correct, modify, calibrate, and adjust the system as required by the Engineer during witnessed testing to achieve and successfully demonstrate all required functions and features. All deficiencies discovered shall be corrected by the CSI. Testing shall continue until the system is approved by the Engineer. Upon approval, the Engineer shall provide verifiable notice of factory test approval to indicate the completion of factory testing. The panels shall not be shipped prior to receipt of the Engineer’s notice of acceptance of factory testing.

J. Update Shop Drawings: All shop drawings shall be corrected and updated following factory testing. All corrections and revisions made to the system or the drawings shall be incorporated by CAD into the shop drawings and provided to the Engineer and the contractor prior to installation of the equipment by the contractor.

K. Third Party Programmers: Third party programmers will provide, install, test, and demonstrate programming they provide. The CSI shall provide integration testing support as needed and as requested by the Engineer. The CSI shall support the third party programmer throughout the programmers testing activities as required to verify that contractor provided equipment responds and reports to third party provided programs as specified by the contract documents. The CSI shall support testing activities of the third party programmer on all issues concerning interface of contractor provided equipment and functions with third party provided programming.

L. Packaged Equipment: Suppliers of packaged control systems shall provide and accomplish factory testing and documentation equivalent to that described above for their systems.
3.3 CONTROL SYSTEM INSTALLATION AND CALIBRATION

A. General: Supplied control systems shall be installed and all field wiring and interconnections verified. When the installation of the supplied control system is substantially complete, the CSI shall calibrate all components of the supplied control system including but not limited to all instruments, indicators, recorders, loops, etc. The CSI shall configure all communications and network devices and shall verify proper communications of devices across all network and communications channels and media. Each component shall be adjusted to be within the Manufacturer's required performance range for the specific application. Components supplied by the CSI that do not function properly, that cannot be properly calibrated, or that are found to not meet the Manufacturer's performance specifications shall be removed and replaced at no additional cost to the owner.

B. Documentation: The CSI shall complete device calibration forms and network and communications channel test forms. Calibration forms identifying each process switch, instrument, final elements such as actuators and VFD's, and test forms for each network and communications device and channel tested shall be completed and included in the un witnessed site test report. Provide the following calibration documentation as well as other documentation required by this section:

1. Test and calibrate all devices which provide an analog input to control system equipment. Test and calibrate all analog instruments, VFD analog outputs, valve actuator analog outputs, packaged control system analog outputs, etc. Document these tests on appropriate calibration forms, one each per device. Describe test procedure. All field wiring shall be included in the test procedure. Provide correlation of process parameter value to analog signal and PLC register value at 0, 25, 50, 75, and 100 percent of range. Compare to expected values and calculate accuracy. Include all display device calibration.

2. Test and calibrate all analog outputs from control systems to other equipment. Test and calibrate all VFD analog inputs, valve actuator analog inputs, packaged control system analog inputs, etc. Document these tests on appropriate calibration forms, one each per device. Describe test procedure. All field wiring shall be included in the test procedure. Provide correlation of PLC register and analog signal value at 0, 25, 50, 75, and 100 percent of range to process and equipment parameter or response. Compare to expected values and calculate accuracy. Include display device calibration.

3. Test and calibrate all devices which provide discrete input to the control system. Document these tests on appropriate test forms. Describe test procedures. All field wiring shall be included in the tests. Record increasing and decreasing trip points and correlate to process parameter values. Compare with expected values and calculate accuracy.

4. Test and calibrate all devices which receive discrete outputs from the control system. Verify the correct response occurs. Document these tests on appropriate test forms. Describe test procedures. All field wiring shall be included in the tests.

5. Configure and verify the functionality of all communications, networks, and connected devices. Document these tests on appropriate test forms. Describe test procedures. Provide all device configuration settings.

6. Analytical Instruments: Provide test gasses, buffer solutions, and reference fluids for tests and calibration of all analytical instruments. Test per manufacturer's instructions.

C. Third Party Programmers: The Contractor shall complete all calibration documents and provide to third party programmers prior program installation and system site testing.
D. Packaged Systems: Packaged system suppliers shall perform and document the calibration tasks described above for their scopes of supply.

E. Field Wiring: All field wiring shall be included and verified in calibration and site testing tasks.

3.4 UN WITNESSED SITE TESTING (START-UP)

A. General: Control systems shall be fully tested prior to any witnessed site testing. Control systems shall be put into operation by the CSI or the packaged system supplier. The functionality of all aspects of the system shall be verified by the CSI or packaged system supplier. All aspects of the control systems, including but not limited to all inputs, outputs, circuits, loops, instruments, annunciation, display, alarming, automatic control, manual control, PLC (UNO), OIT (UNO), SCADA (UNO), data logging, reporting, remote alarm notification, PID loops, etc shall be verified to be working correctly. A test log shall be kept per Part 2 of this document. A Test Report shall be prepared by the CSI for this phase per Part 2 of this document. All deficiencies shall be corrected and the test report provided to the Engineer prior to scheduling of witnessed site testing (commissioning) with the Engineer present. The acceptability of the calibration and un witnessed site test results and report shall be determined by the Engineer. All plant systems shall be complete, integrated, fully tested, fully verified, and all tests fully documented by the contractor prior to witnessed site testing (commissioning). All that should remain to be done is to demonstrate system compliance to the Engineer. The system shall be complete, fully integrated, fully tested; all tests and operational data documented, and ready to be put into continuous production operation at this point in the process. The system capabilities listed below and all other capabilities specified shall be tested, verified, and documented in the un-witnessed site test report:

1. All automatic and manual control functions specified
2. All programmed and non programmed functions specified
3. All programmed and non programmed display and annunciation functions specified
4. All operator interface and monitoring functions specified
5. All communications functions specified
6. All network functions specified
7. All SCADA functions specified
8. All data historian functions specified
9. All motor control and MCC functions specified
10. All control panel functions specified
11. All packaged equipment control system functions specified
12. All Remote alarm notification and auto dialer functions specified
13. Provide all PID loop tuning parameters

B. Packaged Control Systems: Package equipment vendors shall install, calibrate, startup, test, and verify their supplied systems as described above for CSI supplied systems per the project site test schedule. Packaged equipment suppliers shall document testing of their systems as described above. Communications and interface functionality required between vendor systems and plant systems and equipment, including MCC’s and plant SCADA system application software and equipment shall be tested, verified, and documented during this test phase.

C. Third Party Programmers: Where specifically noted, the programmer shall install, test, and verify programs provided for the Contractor supplied PLC’s, OIT’s, and SCADA components.
The contractor shall provide support as needed and as requested by the Engineer to support testing of these programs and to verify the proper responses of related equipment.

D. Process Conditions: The contractor shall provide conditions at the facility which fully exercise process equipment to enable realistic testing and verification of the control system and associated equipment. This includes but is not limited to adequate flow quantities and flow rates of water required to simulate operational process conditions.

3.5 WITNESSED SITE TESTING (COMMISSIONING)

A. General: After un-witnessed site testing (start-up) is completed by the CSI, packaged system suppliers, third party programmers, and the contractor, and the required test report approved by the Engineer, commissioning demonstrations shall be presented to and witnessed by the Engineer and the Owner. The contractor shall lead and orchestrate commissioning demonstrations of the complete and integrated systems. Commissioning shall include demonstration of all instruments, components, features, and functions of the entire control and communication system and all sub systems. Commissioning shall be considered complete when the Engineer has determined that all of the system requirements have been met.

B. Scope: The Engineer may request the rerun of all un-witnessed site tests or a subset thereof. The required un-witnessed site test report and associated documentation may be verified in whole or in part during commissioning at the Engineers discretion.

C. Support: During the commissioning phase, the CSI, the Electrical Contractor, and packaged equipment suppliers shall revise, correct, modify, and make adjustments as required by the Engineer to achieve the operation required. The CSI, packaged equipment suppliers, and the Contractor shall be continuously present during commissioning to exercise all aspects of the control system and associated process equipment and to correct deficiencies as they are found.

D. Third Party Programmers: When a third party programmer is used to program contractor supplied PLC’s, OIT’s, and SCADA components, the programmer shall conduct the commissioning for the programs provided and the contractor shall provide support as requested by the Engineer.

3.6 LOOP TEST STAGES:

A. General: Test and document each instrument loop in the following sequence:

<table>
<thead>
<tr>
<th>Testing sequence</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wiring</td>
<td>409003-A</td>
</tr>
<tr>
<td>2. Piping</td>
<td>409003-B</td>
</tr>
<tr>
<td>3. Individual components</td>
<td>409003-C through I</td>
</tr>
<tr>
<td>4. Individual loops</td>
<td>409003-J</td>
</tr>
<tr>
<td>5. Loop commissioning</td>
<td>409003-K</td>
</tr>
</tbody>
</table>

B. Testing of piping, wiring, and individual components: Shall be completed with certified test reports completed which shall be provided to the Engineer prior to commencement of individual loop testing.
C. Individual component calibration and test:

1. Each instrument and final element shall be field calibrated in accordance with the manufacturer’s recommended procedure. Instruments shall then be tested in compliance with ISA S51.1 and the data entered on the applicable test form.
2. The Engineer may elect to witness these tests.
3. Alarm trips, control trips, and switches shall be set to initial values specified in the Instrument Schedule in Section 409004 “Schedules.”
4. Final elements shall be checked for range, dead-band, and speed of response.
5. Any component that fails to meet the required tolerances shall be repaired by the manufacturer or replaced.
6. Repeat above tests until the component is within tolerance.
7. Record all threshold, range, and dead band data in engineering units appropriate to the process on test forms.

D. Loop Test:

1. Test each instrument loop as an integrated system. This test shall check operation from transmitter to signal receiving components, and from the supplied control panels to final control elements.
2. The Engineer may elect to witness these tests.
3. Manipulate the process or inject signals at the field terminations to simulate primary measuring elements. Record method of signal stimulus on test forms.
4. Output of each auto/manual control function shall be manually varied from 0 to 100 percent, and correct operation of final control element verified.
5. Each process switch and alarm circuit shall be manually actuated at the field sensor.
6. Verify correct operation of all annunciator windows, indicator lights, or OIT/HMI screen elements as applicable.
7. Record all threshold, range, and dead band data in engineering units appropriate to the process on test forms.

E. Closed-loop test:

1. Engineer may elect to witness these tests.
2. Test shall demonstrate stable operation of each loop under actual process operating conditions. This test includes adjustment of loop tuning parameters. Loops shall be tuned and documented prior to witnessing by the project. Record all loop parameters on test forms for each loop test.
3. Unless otherwise specified, adjust tuning parameters (proportional gain, integral time constant, and derivative time constant) for each control loop to provide ¼-amplitude damping.
4. Prepare a chart recording showing loop response to a step disturbance for each loop.
5. Make two charts for cascade loops if applicable, one showing the secondary loop response with its set point on manual, and the second showing overall loop response.
6. Chart recordings shall be made at sufficient speed and amplitude to clearly show specified amplitude damping and shall be annotated to show loop number and title, and settings of parameters and set points.

F. Programmers other than the CSI: Third party programmers and packaged system suppliers shall tune and commission all loops controlled by supplied programs. The contractor and subcontractors shall provide integration support as requested by the Engineer.
3.7 OIT, HMI, SCADA TEST

A. Test and verify all required read and write functionality. Verify correct addressing to the correct PLC registers.

B. Test and verify correct presentation and function of all display elements on all display screens.

C. Provide the services of a qualified technician for the needed duration to assist in this test.

D. Test and verify all process data communications between PLC’s, OIT’s, packaged equipment HMI, plant SCADA system, data historian, and remote alarm annunciation software.

E. Test and verify all displayed historical and real time trends are functioning correctly.

F. Test and verify the process data historian is configured and logging required data correctly.

G. Test and verify that all parts of the process network are functioning correctly.

H. Provide screen shots of all OIT and SCADA HMI screens. Notate screen shots to indicate the test status of each screen element. A check mark shall indicate that the element was fully and successfully tested. Make corrections until all elements test successfully. Tester shall sign and date each screen shot and shall provide the documents with other test reports and forms to the project.

I. Test and verify all required historical data reports are configured and functioning correctly.

J. Programmers Other than the CSI: Third party programmers and packaged system suppliers shall test and commission all programs they supply. The contractor and sub contractors shall provide integration support as requested by the Engineer.

3.8 CALIBRATION EQUIPMENT AND TESTING APPARATUS

A. The Contractor shall have available test and calibration equipment for factory panel tests, installation, start-up, service contract, and maintenance or troubleshooting purposes. The equipment required for these tests is as follows:

B. Digital Multimeter with an accuracy of plus or minus 0.1 percent - sufficient number to satisfy simultaneous field signal requirements.

C. Signal calibrator for analog signals - sufficient number to satisfy simultaneous field signal requirements.

D. One - 60-inch Water Manometer with 0.1-inch graduations. Include accessories of floor stand, pipe clamp, tubing, air bulb with shutoff and fittings for 0.25 inch and 0.375 inch threaded taps for "Tee" fittings to connect manometer.

E. One - 20-inch Mercury Manometer graduated in inches of water. Include accessories of floor stand, pipe clamp, tubing, air bulb with shutoff and fittings for 0.25 inch and 0.375 inch threaded taps and "Tee" fittings to connect manometer.
F. One - 0 to 100 psi, 6-inch-diameter pressure gauge with 1 psi graduations and plus or minus 1 percent accuracy. Include "Tee" fittings and fittings for 0.25 inch through 1 inch threaded taps to connect gauge.

G. One - Air tank pressurized to 150 psi with 2 regulators. One regulator for the 0 to 30 psi range, and one regulator for the 30 to 100 psi range. Include accessories of fittings for 0.25 inch through 1 inch threaded taps to connect air tank.

H. One - 30-foot supply of 0.375-inch PVC clear plastic tubing with fittings for 0.25 inch and 0.375 inch threaded taps to make manometers for Venturi tubes, orifice plates, etc., for calibration checks.

I. One - Decibel meter for telemetry work capable of reading minus 40 db to plus 10 db over frequency range of 300 to 2,500 hertz with a selective narrow band filter.

J. One - High-impedance earplug speaker with alligator clips for telemetry monitoring of transmitter keying.

K. One - Signal generator for telemetry adjustable over 300 to 2,500 hertz with 1 milliwatt output into 600 ohm line.

L. One - Set of portable radios capable of operating within buildings at one location and 5 miles outside of buildings in hilly terrain.

M. One - Programming terminal with software to configure programmable equipment.

N. Modify and add to the list as required to fully and efficiently start up, calibrate, test, and commission all supplied equipment.

END OF SECTION 409002
SECTION 409003 – DIVISION 40 TEST FORMS

PART 1 - GENERAL

1.1 SUMMARY

A. The forms listed below may be referenced from other Sections of the Contract Document and may be used to document required contract work.

- 409000-A  Loop Wiring and Insulation Resistance Test Data Form
- 409000-B  Control Circuit Piping Leak Test Form
- 409000-C  Controller Calibration Test Data Form
- 409000-D  Panel Indicator Calibration Test Data Form
- 409000-E  Recorder Calibration Test Data Form
- 409000-F  Signal Trip Calibration Test Data Form
- 409000-G  Field Switch Calibration Test Data Form
- 409000-H  Transmitter Calibration Test Data Form
- 409000-I  Miscellaneous Instrument Calibration Test Data Form
- 409000-J  Individual Loop Test Data Form
- 409000-K  Loop Commissioning Test Data Form
- 409000-L  PLC Analog Input Calibration form
- 409000-M  PLC Analog Output Calibration form
- 409000-N  Discrete Input Loop Test Form
- 409000-O  Discrete Output Loop Test Form
- 409000-P  Analog Input Loop Test Form
- 409000-Q  Analog Output Loop Test Form
- 409000-R  Fiber Optic Cable Network Test Form
- 409000-S  Radio Network Test Form
- 409000-T  Calibration Certificate

1.2 SCOPE

A. The Contractor shall be responsible for all required documentation of tests and evaluations required by the Contract.

B. Contractor shall modify provided forms or shall generated additional forms as required to document the work as required by the contract documents.

C. Some of the provided forms may not be needed to meet testing documentation requirements. The contractor shall determine forms required.
PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PROVIDED FORMS

A. Calibration and test forms are included with this specification section. Appropriate forms shall be provided by the contractor and used where calibration test forms are referenced by Division 40 specifications. Contractor shall submit additional forms as needed where a suitable form is not included in the provided set of forms. Test forms shall be completed for all devices and subsystems as required by Division 40 specifications for all required test phases. Completed forms shall be submitted following all required test phases and a final set shall be included in the O&M manuals.

B. Any testing and report forms provided in these documents are provided to the contractor as is and for use and modification, if needed, by the contractor. The provided forms do not necessarily provide all needed forms or data fields and do not necessarily support all required testing, documentation, and report formats. The contractor shall provide any additional forms and shall modify the provided forms as needed to meet the testing and reporting documentation requirements. Simply filling out the provided forms will not necessarily satisfy all of the documentation requirements.
409003-A LOOP WIRING AND INSULATION RESISTANCE TEST DATA FORM

Contract Name: _________________________________

Contract No.: _________________________________

Loop No.: _

List all wiring associated with a loop in table below. Make applicable measurements as indicated after disconnecting wiring.

<table>
<thead>
<tr>
<th>Wire No.</th>
<th>Panel Tie</th>
<th>Continuity Resistance</th>
<th>Insulation Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field Cond. / Cond. / Shield / Shield / Cond. / Shield /</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cond. / Shield / Gnd. / Cond. / Gnd. / Shield /</td>
<td></td>
</tr>
</tbody>
</table>

A — (A/SH)

B (A/B) —

C (A/C) —

D (A/D) —

etc.

A. **Continuity Test.** Connect ohmmeter leads between wires A and B and jumper opposite ends together. Record resistance in table. Repeat procedure between A and C, A and D, etc. Any deviation of ±2 ohms between any reading and the average of a particular run indicates a poor conductor, and corrective action shall be taken before continuing with the loop test.

B. **Insulation Test.** Connect one end of a 500V meter to the panel ground bus and the other sequentially to each completely disconnected wire and shield. Test the insulation resistance and record each reading.

CERTIFIED ____________________________________________
Signature of Contractor Representative Date

WITNESSED ____________________________________________
Signature of Engineer Date
**409003-B  CONTROL CIRCUIT PIPING LEAK TEST FORM**

Contract Name: 

Contract No.: 

Loop No.: 

List tubing associated with loop in table below. Make applicable measurements after isolating any air consuming pilots from circuit.

<table>
<thead>
<tr>
<th>Tube No.</th>
<th>Permitted Equivalent Length of 1/4-Inch Copper$^a$</th>
<th>Measured Test Period (seconds)</th>
<th>Pressure Drop (psi)$^b$</th>
<th>Pressure Drop (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. Convert actual tubing and air motor volume to equivalent 1/4-inch copper tubing.

B. Pressure drop shall not exceed 1 psi per hundred feet of 1/4-inch copper tubing per 5 seconds.

CERTIFIED

Signature of Contractor Representative Date

WITNESSED

Signature of Engineer Date
### 409003-C  CONTROLLER CALIBRATION TEST DATA FORM

Contract Name: __________________________________________

Contract No.: __________________________________________

Tag No. and Description: __________________________________

Make and Model No.: ___________________________ Serial No.: ____________

Input: ______ Process Variable (PV) Scale: ______

Output: ______ Output Scale: ______________

#### PV Scale Calibration

<table>
<thead>
<tr>
<th>Percent of Range</th>
<th>Expected</th>
<th>Actual</th>
<th>% Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Reading</td>
<td>Reading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percent Deviation Allowed: __________________

Connect output to PV for following tests:

<table>
<thead>
<tr>
<th>Set Point (SP) Indicator Accuracy</th>
<th>Output Meter Accuracy</th>
<th>Controller Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV Expected</td>
<td>Actual</td>
<td>% Dev.</td>
</tr>
<tr>
<td>(0%)</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>(50%)</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>(100%)</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>


CERTIFIED __________________________

Signature of Contractor Representative Date____________________

WITNESSED __________________________

Signature of Engineer Date____________________
409003-D PANEL INDICATOR CALIBRATION TEST DATA FORM

Contract Name: ________________________________

Contract No.: ________________________________

Tag No. and Description: ________________________________

Make and Model No.: _____________________ Serial No.: ______________

Input: _

Scale: _ Range: ______________

PV Scale Calibration

<table>
<thead>
<tr>
<th>Percent of Range</th>
<th>Expected Input</th>
<th>Actual Reading</th>
<th>% Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

Percent Deviation Allowed: ______________

CERTIFIED __________________________________
  Signature of Contractor Representative Date

WITNESSED __________________________________
  Signature of Engineer Date
**409003-E  RECORDER CALIBRATION TEST DATA FORM**

Contract Name: 

Contract No.: 

Tag No. and Description: 

Make and Model No.: 

Serial No.: 

Input:  

Chart:  

Scale:  

Range:  

<table>
<thead>
<tr>
<th>Percent of Range</th>
<th>Expected Input</th>
<th>Expected Reading</th>
<th>Actual Reading</th>
<th>% Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percent Deviation Allowed: 

CERTIFIED  

Signature of Contractor Representative  

Date  

WITNESSED  

Signature of Engineer  

Date
409003-F  SIGNAL TRIP CALIBRATION TEST DATA FORM

Contract Name:  

Contract No.:  

Tag No. and Description:  

Make and Model No.:  Serial No.:  

Input:  

Scale:  Range:  

Set Point(s):  

After setting set point(s), run signal input through entire range and calculate deadband.

<table>
<thead>
<tr>
<th>Increasing</th>
<th>Decreasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>Input</td>
</tr>
<tr>
<td>Set Point</td>
<td>Trip Point</td>
</tr>
<tr>
<td></td>
<td>Calculated</td>
</tr>
<tr>
<td>Trip Point</td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>Deadband</td>
</tr>
<tr>
<td></td>
<td>Deadband</td>
</tr>
</tbody>
</table>

CERTIFIED  
Signature of Contractor Representative  Date  

WITNESSED  
Signature of Engineer  Date
**409003-G   FIELD SWITCH CALIBRATION TEST DATA FORM**

Contract Name: ________________________________________________

Contract No.: ________________________________________________

Tag No. and Description: _______________________________________

Make and Model No.: ___________________________ Serial No.: __________

Input: _

Range: ___________________________

Set Point(s): ___________________________

Simulate process variable (flow, pressure, temperature, etc.) and set desired set point(s). Run through entire range of switch and calculate deadband.

<table>
<thead>
<tr>
<th>Increasing</th>
<th>Decreasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>Input</td>
</tr>
<tr>
<td>Set Point</td>
<td>Trip Point</td>
</tr>
</tbody>
</table>

CERTIFIED  ________________________________________________

Signature of Contractor RepresentativeDate

WITNESSED  ________________________________________________

Signature of Engineer Date
409003-H  TRANSMITTER CALIBRATION TEST DATA FORM

Contract Name: 

Contract No.: 

Tag No. and Description: 

Make and Model No.:  Serial No.:  

Input:  

Output:  

Scale:  Range:  

Simulate process variable (flow, pressure, temperature, etc.) and measure output with appropriate meter.

<table>
<thead>
<tr>
<th>Percent of Range</th>
<th>Expected Input</th>
<th>Actual Output</th>
<th>Output</th>
<th>% Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percent Deviation Allowed:

CERTIFIED
  Signature of Contractor Representative
  Date

WITNESSED
  Signature of Engineer
  Date
409003-I MISCELLANEOUS INSTRUMENT CALIBRATION TEST DATA FORM

Contract Name: __________________________________________

Contract No.: __________________________________________

(For instruments not covered by any of the preceding test forms, the Contractor shall create a form containing all necessary information and calibration procedures.)

CERTIFIED

Signature of Contractor RepresentativeDate

WITNESSED

Signature of Engineer Date
409003-J  INDIVIDUAL LOOP TEST DATA FORM

Contract Name: ____________________________________________________________

Contract No.:  ____________________________________________________________

Loop No.:  

Description:
(Give complete description of loop's function using tag numbers where appropriate.)

P&ID No.: (Attach copy of P&ID.)

A. Wiring tested:
(Attach test form 409003-A)

B. Instrumentation tubing/piping tested:
(Attach test form 409003-B)

C. Instruments calibrated:
(Attach test forms 409003-C through I)

D. List step-by-step procedures for testing loop parameters. Test loop with instruments, including
transmitters and control valves, connected and functioning. If it is not possible to produce a real
process variable, then a simulated signal may be used with the Engineer's approval.

CERTIFIED

Signature of Contractor Representative  Date

WITNESSED

Signature of Engineer  Date
409003-K  LOOPS COMMISSIONING TEST DATA FORM

Contract Name: ____________________________________________

Contract No.: ____________________________________________

Loop No.: ________________________________________________

A. Loop tested:
   (Attach test form 409003-J)

B. Controlled or connected equipment tests confirmed:

C. Give complete description of loop's interface with process.

D. With associated equipment and process in operation, provide annotated chart trace of loop response to changes in set points for verification of performance. This chart should demonstrate 1/4-amplitude damping as output adjusts to set point change. Show set points, starting and finishing times on chart, as well as any other pertinent data.

   Connect 2-pen recorder to process variable (PV) and to controller output. Use 1-inch/second chart speed.

   Pen 1 - PV - Connections:

   Pen 2 - Output - Connections:

CERTIFIED  ________________________________________________
   Signature of Contractor Representative Date

WITNESSED  ______________________________________________
   Signature of Engineer        Date
# 409003-L   PLC ANALOG INPUT CALIBRATION TEST FORM

<table>
<thead>
<tr>
<th>Panel No.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rack No. and Slot No.:</td>
</tr>
<tr>
<td>Make and Model No.:</td>
</tr>
<tr>
<td>Input:</td>
</tr>
</tbody>
</table>

Simulate input and measure output with appropriate meter.

<table>
<thead>
<tr>
<th>Percent of Range</th>
<th>Input</th>
<th>Expected Register Reading</th>
<th>Actual Register Reading</th>
<th>Percent Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>50</td>
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</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Percent Deviation Allowed:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Input 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Percent Deviation Allowed:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Input 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Percent Deviation Allowed:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Input 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
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<td></td>
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</tr>
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<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Percent Deviation Allowed:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Input 5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Percent Deviation Allowed:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CERTIFIED ___________________ DATE: ___________________
<table>
<thead>
<tr>
<th>Percent of Range</th>
<th>Input</th>
<th>Expected Register Reading</th>
<th>Actual Register Reading</th>
<th>Percent Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input 6</td>
<td>0</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>50</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Percent Deviation Allowed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 7</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Percent Deviation Allowed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 8</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Percent Deviation Allowed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 9</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Deviation Allowed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 10</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Percent Deviation Allowed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 11</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>100</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Percent Deviation Allowed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input 12</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>50</td>
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</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Deviation Allowed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CERTIFIED ___________________________ DATE: ___________________________
<table>
<thead>
<tr>
<th>Percent of Range</th>
<th>Input</th>
<th>Expected Register Reading</th>
<th>Actual Register Reading</th>
<th>Percent Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input 13</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percent Deviation Allowed:

| Input 14         | 0     |                           |                         |                   |
|                  | 50    |                           |                         |                   |
|                  | 100   |                           |                         |                   |

Percent Deviation Allowed:

| Input 15         | 0     |                           |                         |                   |
|                  | 50    |                           |                         |                   |
|                  | 100   |                           |                         |                   |

Percent Deviation Allowed:

| Input 16         | 0     |                           |                         |                   |
|                  | 50    |                           |                         |                   |
|                  | 100   |                           |                         |                   |

Percent Deviation Allowed:

| Comments: __     |
|                 |
|                 |
|                 |
|                 |
|                 |
|                 |

CERTIFIED ____________________________ DATE: ____________________________
# PLC ANALOG OUTPUT CALIBRATION TEST FORM

**FORM 409003-M**  
**ANALOG OUTPUT MODULE**

**Panel No.:**  
**Rack No. and Slot No.:**  
**Make and Model No.:**

**Input:**

Force output point and measure output with appropriate meter.

<table>
<thead>
<tr>
<th>Percent of Range</th>
<th>Input</th>
<th>Expected Register Reading</th>
<th>Actual Register Reading</th>
<th>Percent Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Deviation Allowed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Output 2         |       |                           |                         |                   |
| 0                |       |                           |                         |                   |
| 50               |       |                           |                         |                   |
| 100              |       |                           |                         |                   |
| Percent Deviation Allowed: | | | | |

| Output 3         |       |                           |                         |                   |
| 0                |       |                           |                         |                   |
| 50               |       |                           |                         |                   |
| 100              |       |                           |                         |                   |
| Percent Deviation Allowed: | | | | |

| Output 4         |       |                           |                         |                   |
| 0                |       |                           |                         |                   |
| 50               |       |                           |                         |                   |
| 100              |       |                           |                         |                   |
| Percent Deviation Allowed: | | | | |

**Comments:** ___

___

CERTIFIED ___________________ DATE: ___________________
## FORM 409003-N

<table>
<thead>
<tr>
<th>Discrete Input Loop Test Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tag/Device:</td>
</tr>
<tr>
<td>Serial Number:</td>
</tr>
<tr>
<td>Description:</td>
</tr>
<tr>
<td>Process:</td>
</tr>
<tr>
<td>Process Range:</td>
</tr>
<tr>
<td>Signal Range:</td>
</tr>
<tr>
<td>Panel Input:</td>
</tr>
<tr>
<td>PLC Input:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLC Input:</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;Setpoint</td>
</tr>
<tr>
<td>&lt;Setpoint</td>
</tr>
</tbody>
</table>

Hardwired functions:

Test Method:

Comments:

CERTIFIED __________________________ DATE: __________________________
**FORM 409003-O**

<table>
<thead>
<tr>
<th>Discrete Output Loop Test Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tag/Device:</td>
</tr>
<tr>
<td>Serial Number:</td>
</tr>
<tr>
<td>Description:</td>
</tr>
<tr>
<td>Process:</td>
</tr>
<tr>
<td>Process Range:</td>
</tr>
<tr>
<td>Signal Range:</td>
</tr>
<tr>
<td>Panel Output:</td>
</tr>
<tr>
<td>PLC Output:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLC data reg</th>
<th>Panel terminals</th>
<th>Device State</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>.</td>
</tr>
</tbody>
</table>

Hardwired Function:

Test Method:

Comments:

CERTIFIED ___________________________   DATE: ___________________________
## Analog Input Loop Test Data

| Tag/Device: |  |
| Serial Number: |  |
| Description: |  |
| Process: |  |
| Process Range: |  |
| Signal Range: |  |
| Panel Input: |  |
| PLC Input: |  |
| Process Range | Process Value | Signal | PLC data expected | PLC data actual | Display data |
| 0% |  |  |  |  |  |
| 50% |  |  |  |  |  |
| 100% |  |  |  |  |  |

Hardwired functions:

Test Method:

Comments:

CERTIFIED ___________________________ DATE: ___________________________
FORM 409003-Q

Analog Output Loop Test Data

Tag/Device:

Serial Number:

Description:

Process:

Process Range:

Signal Range:

Panel Output:

PLC Output:

<table>
<thead>
<tr>
<th>Process Range</th>
<th>PLC register value</th>
<th>Signal</th>
<th>Process Value expected</th>
<th>Process Value actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td></td>
<td></td>
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<tr>
<td>50%</td>
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<td></td>
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<tr>
<td>100%</td>
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</tbody>
</table>

Hardwired functions:

Test Method:

Comments:

CERTIFIED ___________________________  DATE: ___________________________________
FORM 409003-R  Fiber Optic Cable Network Test Form

Cable Manufacturer:  
Cable Type:  
Cable Connector Type:  
Network or Segment ID:

<table>
<thead>
<tr>
<th># Fibers and Bundle or Tube ID.</th>
<th>Strand Color</th>
<th>Fiber-Optic Test Result Strand ID</th>
<th>Term. Device D=Distribution Pnl. H=Hub R=Router T=Transceiver</th>
<th>Term. Function RCV, XMT, Other</th>
<th>Splices</th>
<th>Length</th>
<th>Data Rate of Term. Equip.</th>
<th>Data Xfer Rate or Ping Time (ms)</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

CERTIFIED ___________________________ DATE: ___________________________

DIVISON 40 TEST FORMS 409003 - 22
FORM 409003-S  Radio Network Test Form

Radio Manufacturer:
Radio Network
Address:

<table>
<thead>
<tr>
<th>Radio Call or SN#</th>
<th>Comm. Node</th>
<th>Node Name</th>
<th>Function</th>
<th>Subnet ID</th>
<th>Antenna</th>
<th>Signal Strength</th>
<th>Noise</th>
<th>% Signal to Noise</th>
<th>Data Rate Set</th>
<th>Data Xfer Rate or Ping Time (ms)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>M=Master</td>
<td>RCV=XX</td>
<td>Y=Yagi</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S=Slave</td>
<td>XMT=XX</td>
<td>O=Omni</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>R=Repeater</td>
<td></td>
<td>Height=XX’</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>SR=SRapeater</td>
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</tr>
</tbody>
</table>

CERTIFIED ___________________________   DATE: ___________________________
FORM 409003-T  CALIBRATION CERTIFICATE

Tag Number/Loop Number:
Loop Description:
Instrument Location:
Manufacturer:
Model Number:
Adjustable Range:
Calibrated Range:
Remarks:

Installation Per Manufacturer's Requirements?  Yes  No
If "No", explain:

Installation Per Contract Documents?  Yes  No
If "No", explain:

Analog Signal Calibration:

<table>
<thead>
<tr>
<th>Units</th>
<th>0%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Input</td>
<td>Output</td>
<td>PLC Register</td>
<td>Accuracy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Actual</td>
<td>Expected</td>
<td>Actual</td>
<td>Expected</td>
<td>Actual</td>
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</tbody>
</table>

Discrete Device Calibration

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>Switch Point Setting</th>
<th>Switch Point Actual</th>
<th>Switch Point Expected</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Setting</td>
<td>Dead Band</td>
<td>Upscale</td>
<td>Down Scale</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<td>3</td>
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<tr>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

I hereby certify that the above information is correct and accurate, to the best of my knowledge, and that the instrument indicated above has been supplied, installed, calibrated, and tested in accordance with the manufacturer's recommendations and the Contract Documents, unless otherwise noted.

Receipt of this Calibration Certification shall in no way imply final acceptance of any work or instrument supplied as a part of this Contract.

CONTRACTOR's Signature: .................................................. Date: __________________________

END OF SECTION 409003
SECTION 409004 - SCHEDULES

PART 1 - GENERAL

1.1 SUMMARY

A. The following schedules are provided:

1. Instrument Schedule

B. Contract Requirements: General Conditions, Supplementary Conditions, and Division 01 apply to Work in this section.

C. Schedule fields and schedules are included in Part 3.

1.2 REFERENCES

A. References to drawing numbers provided in these schedules are provided as a convenience only. An incorrect drawing number or the omission of an appropriate drawing number shall have no impact on the scope of work required under this contract.

PART 2 - PRODUCTS

2.1 SCHEDULES

A. Schedules shall provide the data columns indicated.

B. Instrument Schedule General:

1. This schedule briefly describes major discrete devices required by the control system. Scheduled devices shall be provided as described in the schedules and in the referenced specification paragraph. Each instrument is located by a panel reference or electrical or mechanical plan drawing reference (if field mounted).

2. These schedules shall not be interpreted as a set of complete data sheets for the devices but only as a listing of instruments with certain salient features described. Additional elements such as power supplies, current repeaters or isolators, mounting hardware, cord sets, and other such elements as may be required by a particular vendor in order to complete the system shall be provided even though not listed. The Contractor shall create complete ordering information for all instruments and shall submit this information to the Owner’s Representative for review prior to manufacture.

C. Instrument Schedule column descriptions:

1. Tag number: These are instrument tag numbers which include the instrument loop (IL) numbers and individual instrument prefixes and suffixes, or component name or circuit designation.
2. Description: Defines application of the loop or identifies the type of individual instrument within the loop.
3. Specification number: Numbers refer to specification requirements for new instruments which shall be provided.
4. Process drawing number: Numbers refer to basic process flow drawings showing the schematic locations of primary measuring elements and final control devices within the process.
5. Mechanical drawing number: Numbers refer to mechanical drawings showing locations or installation details for individual field mounted instruments.
6. Electrical drawing number: Numbers refer to electrical drawings showing field instrument locations.
7. Instrument drawing: The numbers refer to instrument drawings showing circuit diagrams.

PART 3 - EXECUTION

3.1 INSTRUMENT SCHEDULE FIELDS

A. Column Headings To Include:

1.01 TAG NUMBER
1.02 DESCRIPTION
1.03 P&ID DRAWING NUMBER
1.04 INSTRUMENT DRAWING NUMBER
1.05 PHYSICAL LOCATION
1.06 FIELD POWER VIA
1.07 SPECIFICATION NUMBER
1.09 CALIBRATION RANGE
1.12 APPLICATION NOTES

END OF SECTION 409004
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FE 31 00 17</td>
<td>Pump Station Discharge Flow Element</td>
<td>I-100</td>
<td>I-027</td>
<td>E-102</td>
<td>PNL-340014</td>
<td>409123.33-FM1</td>
<td>8 inch diameter pipe</td>
<td></td>
</tr>
<tr>
<td>FIT 31 00 17</td>
<td>Pump Station Discharge Flow Transmitter</td>
<td>I-100</td>
<td>I-027</td>
<td>E-102</td>
<td>PNL-340014</td>
<td>409123.33-FM1</td>
<td>0-2000 GPM</td>
<td></td>
</tr>
<tr>
<td>FE 31 00 11</td>
<td>Influent Parshall Flume Flow Element</td>
<td>I-100</td>
<td>I-027</td>
<td>E-102</td>
<td>PNL-340014</td>
<td>409123.33-FM4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIT 31 00 11</td>
<td>Influent Parshall Flume Flow Transmitter</td>
<td>I-100</td>
<td>I-027</td>
<td>E-102</td>
<td>PNL-340014</td>
<td>409123.33-FM4</td>
<td>0-2000 GPM</td>
<td>Metering manholes per Section 409123</td>
</tr>
<tr>
<td>FE 31 00 12</td>
<td>Drain Parshall Flume Flow Element</td>
<td>I-100</td>
<td>I-027</td>
<td>E-102</td>
<td>PNL-340014</td>
<td>409123.33-FM4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIT 31 00 12</td>
<td>Drain Parshall Flume Flow Transmitter</td>
<td>I-100</td>
<td>I-027</td>
<td>E-102</td>
<td>PNL-340014</td>
<td>409123.33-FM4</td>
<td>0-1000 GPM</td>
<td>Metering manholes per Section 409123</td>
</tr>
<tr>
<td>LSL 31 00 13</td>
<td>Wet Well Low Level Switch</td>
<td>I-100</td>
<td>I-017</td>
<td>E-102</td>
<td>PNL-340014</td>
<td>409124-LS1</td>
<td>Install at El. 77.5 FT, adjust as necessary during testing.</td>
<td></td>
</tr>
<tr>
<td>LSH 31 00 14</td>
<td>Wet Well High Level Switch</td>
<td>I-100</td>
<td>I-017</td>
<td>E-102</td>
<td>PNL-340014</td>
<td>409124-LS1</td>
<td>Install at El. 81.00 FT, adjust as necessary during testing.</td>
<td></td>
</tr>
<tr>
<td>LS 31 00 01</td>
<td>Pump 1 Hand-Off-Remote Switch</td>
<td>I-100</td>
<td>I-008</td>
<td>E-102</td>
<td>MCC</td>
<td>MCC-340005</td>
<td>262419</td>
<td></td>
</tr>
<tr>
<td>TSH 31 00 01</td>
<td>Pump 1 High Temperature Switch</td>
<td>I-100</td>
<td>I-008</td>
<td>E-102</td>
<td>MCC</td>
<td>MCC-340005</td>
<td>432113.16</td>
<td></td>
</tr>
<tr>
<td>MS 31 00 01</td>
<td>Pump 1 Moisture Switch</td>
<td>I-100</td>
<td>I-008</td>
<td>E-102</td>
<td>MCC</td>
<td>MCC-340005</td>
<td>432113.16</td>
<td></td>
</tr>
<tr>
<td>HS 31 00 02</td>
<td>Pump 2 Hand-Off-Remote Switch</td>
<td>I-100</td>
<td>I-008</td>
<td>E-102</td>
<td>MCC</td>
<td>MCC-340005</td>
<td>262419</td>
<td></td>
</tr>
<tr>
<td>TSH 31 00 02</td>
<td>Pump 2 High Temperature Switch</td>
<td>I-100</td>
<td>I-008</td>
<td>E-102</td>
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**PRE-AERATION BASIN 1**

**PRE-AERATION BASIN 2**

**POST ANOXIC BASIN 1**

**POST ANOXIC BASIN 2**

**MEMBRANE BIOREACTOR BASIN 1**
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**MEMBRANE THICKENER BASIN 1**
- HS 21 01 01 Valve Open-Close-Remote Switch I-409 NA NA XV-210101 464240 Provided by MBR Supplier
- ZSO 21 01 01 Valve Opened Position Switch I-409 NA E-402 PNL-340013 464240 Provided by MBR Supplier
- ZSC 21 01 01 Valve Closed Position Switch I-409 NA E-402 PNL-340013 464240 Provided by MBR Supplier
- LSL 21 01 02 Basin Low Level Switch I-409 NA E-402 PNL-340013 464240 Provided by MBR Supplier
- LSH 21 01 02 Basin High Level Switch I-409 NA E-402 PNL-340013 464240 Provided by MBR Supplier

**MEMBRANE BIOREACTOR BASIN 2**
- HS 07 02 01 Valve Open-Close-Remote Switch I-410 NA NA XV-070201 464240 Provided by MBR Supplier
- ZSO 07 02 01 Valve Opened Position Switch I-410 NA E-402 PNL-340013 464240 Provided by MBR Supplier
- ZSC 07 02 01 Valve Closed Position Switch I-410 NA E-402 PNL-340013 464240 Provided by MBR Supplier
- LSL 07 02 02 Basin Low Level Switch I-410 NA E-402 PNL-340013 464240 Provided by MBR Supplier
- LSH 07 02 02 Basin High Level Switch I-410 NA E-402 PNL-340013 464240 Provided by MBR Supplier

**PERMEATE SYSTEM**
- PT 08 00 02 MBR Permeate Pump (MBT 1) Suction Pressure I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- PT 08 01 02 MBR Permeate Pump (MBR 1) Suction Pressure I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- PT 08 02 02 MBR Permeate Pump (MBR 2) Suction Pressure I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- HS 08 00 01 MBR Permeate Pump (MBT 1) Hand-Off-Remote Switch I-411 I-009 MCC MCC-340005 262419
- HS 08 01 01 MBR Permeate Pump (MBR 1) Hand-Off-Remote Switch I-411 I-009 MCC MCC-340005 262419
- FE 08 00 03 MBR Permeate (MBT 1) Flow Element I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FIT 08 00 03 MBR Permeate (MBR 1) Flow Element I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FE 08 01 03 MBR Permeate (MBT 1) Flow Element I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FIT 08 01 03 MBR Permeate (MBR 1) Flow Element I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FE 08 02 03 MBR Permeate (MBR 2) Flow Element I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FIT 08 02 03 MBR Permeate (MBR 2) Flow Element I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- ZSC 08 00 05 MBR Permeate (MBT 1) Control Valve Closed I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- ZSC 08 01 05 MBR Permeate (MBR 1) Control Valve Closed I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- ZSC 08 02 05 MBR Permeate (MBR 2) Control Valve Closed I-411 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- PT 01 01 06 MBT Permeate Pump Suction Pressure I-412 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- HS 21 01 05 MBT Permeate Pump Hand-Off-Remote Switch I-412 I-013 MCC MCC-340005 262419
- FE 21 01 07 MBT Permeate Flow Element I-412 NA MCC PNL-340013 464240 Provided by MBR Supplier
- FIT 21 01 07 MBT Permeate Flow Transmitter I-412 NA MCC PNL-340013 464240 Provided by MBR Supplier
- AE 08 00 06 Permeate Turbidity Analyzer I-500 I-027 E-408 PNL-340014 464240 Provided by MBR Supplier
- AIT 08 00 06 Permeate Turbidity Transmitter I-500 I-027 E-408 PNL-340014 464240 Provided by MBR Supplier
- XV 18 00 20 UV Cooling Water Solenoid Valve I-500 I-026 E-407 PNL-340014 422701.01
- AIT 18 00 20 UV Transmittance Meter I-500 I-026 E-407 PNL-340014 409113
- AE 18 00 20 UV Transmittance Element I-500 I-026 E-407 PNL-340014 409113

**BLOWERS**
- HS 09 01 01 MBR Blower 1 Hand-Off-Remote Switch I-413 I-014 MCC MCC-340005 262419
- TSH 09 01 01 MBR Blower 1 Temperature Switch I-413 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FE 09 01 02 MBR Blower 1 Flow Element I-413 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FIT 09 01 02 MBR Blower 1 Flow Transmitter I-413 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- HS 09 00 01 MBR Blower 2 Hand-Off-Remote Switch I-413 I-014 MCC MCC-340005 262419
- TSH 09 00 01 MBR Blower 2 Temperature Switch I-413 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FE 09 00 02 MBR Blower 2 Flow Element I-413 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- FIT 09 00 02 MBR Blower 2 Flow Transmitter I-413 NA E-407 PNL-340013 464240 Provided by MBR Supplier
- HS 09 02 01 MBR Blower 2 Hand-Off-Remote Switch I-413 I-014 MCC MCC-340005 262419

12/31/2013
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<td>HS 19 01 01</td>
<td>WAS Pump High Temperature Switch</td>
<td>I-417</td>
<td>I-007</td>
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<tr>
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<td>I-007</td>
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<td>MCC-340005</td>
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<tr>
<td>FE 19 01 02</td>
<td>CIP Flow Element</td>
<td>I-417</td>
<td>I-027</td>
<td>E-408</td>
<td>PNL-340014</td>
<td>409123.33-FM1</td>
<td>6 inch diameter pipe</td>
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<tr>
<td>FIT 19 01 02</td>
<td>CIP Flow Transmitter</td>
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<td>I-027</td>
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<tr>
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<td>I-020</td>
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<td>422701.05</td>
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<tr>
<td>LSH 24 00 07</td>
<td>Standpipe High Level Switch</td>
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<td>I-020</td>
<td>E-408</td>
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<td>409124-LS1</td>
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<td>Standpipe Low Level Switch</td>
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<td>I-020</td>
<td>E-408</td>
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<td>409124-LS1</td>
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<td>WIT 24 00 05</td>
<td>NaCl Tank Load Cell</td>
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<td>I-027</td>
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<td>409119.43-LT11</td>
<td>0-700 LBS</td>
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<tr>
<td>HS 24 00 02</td>
<td>Pump 2 Hand-Off-Remote Switch</td>
<td>I-501</td>
<td>I-012</td>
<td>MCC</td>
<td>MCC-340005</td>
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<td>FIT 24 00 09</td>
<td>Plant Water Flow Transmitter</td>
<td>I-501</td>
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<td>E-408</td>
<td>PNL-340014</td>
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<td>0-150 GPM</td>
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<td>Permeate pH Analyzer</td>
<td>I-500</td>
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<td>AIT 24 00 12</td>
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<td>PNL-340014</td>
<td>409113-AIT3</td>
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<td>Provided by MBR Supplier</td>
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SECTION 409005 – INFLUENT PUMP STATION CONTROL STRATEGY

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the operation of the influent pump station, which receives process drain water from the treatment plant and sanitary wastewater from the sewer collection system. The pump station features a 12-foot diameter wet well, two submersible constant speed sewage pumps, a 3-inch metering Parshall flume in the plant drain pipe with portable sampler, and a 9x3-inch metering Parshall flume in the influent sewer line with a permanent automated sampler. The wet well has room for a 3rd pump in the future. The pumps discharge through a valve vault and a pump discharge flow meter vault.

B. The pump station is operated on a fill-draw control scheme with level element control and backup float switch control.

C. At start-up the pumps operate with a lead pump and a lag pump. The pump station can be expanded to a 3-pump operation with a lead pump, a 1st lag pump, and a 2nd lag pump. The level control scheme will need to be modified in the future to include control of the additional pump.

1.2 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
<th>Title</th>
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<tr>
<td>I-100</td>
<td>Influent Pump Station</td>
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</table>

1.3 ABBREVIATIONS

A. The following abbreviations are used in this section:

1. HMI: Human Machine Interface
2. HOR: Hand-Off-Remote
3. PLC: Programmable Logic Controller
4. SCADA: Supervisory Control And Data Acquisition system

1.4 SYSTEM OVERVIEW

A. The metering Parshall flumes shall measure the flow rate and total accumulated flow from the influent sewer and the plant drain, respectively.
B. Influent sewer for the pump station shall be sampled by an automated sampler. Sampling shall only be activated by the Plant PLC when flow is above an operator-adjustable but preset flow rate to collect a flow-weighted composite sample.

C. Plant drain shall be sampled as flow proportional composite sample by a portable sampler when necessary.

D. The pumps are equipped with winding temperature and moisture sensors. Primary automatic operation of the pumps shall be controlled by the PLC based on water level measured by the level element and operator adjustable setpoints. Secondary operation of the pumps shall be controlled by the PLC based on the high and low level switches if the level element fails.

E. Pump discharge flow meter shall monitor the flow of liquids pumped by the influent pump station to the facility headworks. Discharge flow rate and total accumulated flow shall be indicated on SCADA.

1.5 EQUIPMENT

A. Process Equipment:

<table>
<thead>
<tr>
<th>Equipment No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>PF-310011</td>
<td>9 inch Parshall Flume on Influent Sewer</td>
</tr>
<tr>
<td>PF-310012</td>
<td>3 inch Parshall Flume on Plant Drain</td>
</tr>
<tr>
<td>PMP-310001</td>
<td>Influent Pump 1</td>
</tr>
<tr>
<td>PMP-310002</td>
<td>Influent Pump 2</td>
</tr>
<tr>
<td>PMP-310003</td>
<td>Influent pump 3 (Future)</td>
</tr>
<tr>
<td>SAM-310019</td>
<td>Influent Sewer Sampler</td>
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<tr>
<td>SAM-310020</td>
<td>Plant Drain Sampler</td>
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B. Field Instruments and Panel Devices:

<table>
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<td>Pumps and Metering</td>
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<tr>
<td>LE-310015</td>
<td>Level Sensor</td>
</tr>
<tr>
<td>LSH-310014</td>
<td>Float Switch High</td>
</tr>
<tr>
<td>LSL-310013</td>
<td>Float Switch Low</td>
</tr>
<tr>
<td>TSH-310001</td>
<td>Pump 1 Winding Temp</td>
</tr>
<tr>
<td>MS-310001</td>
<td>Pump 1 Seal Fail</td>
</tr>
<tr>
<td>HS-310001</td>
<td>Pump 1 HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>TSH-310002</td>
<td>Pump 2 Winding Temp</td>
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<tr>
<td>HS-310002</td>
<td>Pump 2 HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>FIT-310017</td>
<td>Pump Discharge Flow Indicator Transmitter</td>
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<tr>
<td>FE-310017</td>
<td>Pump Discharge Flow Sensor</td>
</tr>
<tr>
<td>Parshall Flume and Sampler</td>
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</table>
### 1.6 SCADA / HMI DISPLAYS:

A. HMI screens shall be provided at SCADA locations. The HMI screen displays shall include the data indicated on the P&ID drawings as well as data included in this section.

### 1.7 ALARMS

A. Alarms shall be generated by the local PLC and shall be displayed on the SCADA. Alarms shall include process and equipment operating parameters outside of normal operating range, etc. All alarms shall have adjustable time delays accessible to the operator.

B. The following alarms shall be displayed on the local and SCADA HMI:

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<th>Description</th>
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<tbody>
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<td>High Level (Float Switch)</td>
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<tr>
<td>LAL-310013</td>
<td>Low Level (Float Switch)</td>
</tr>
<tr>
<td>LAH-310015</td>
<td>High Level (Transmitter)</td>
</tr>
<tr>
<td>LAL-310015</td>
<td>Low Level (Transmitter)</td>
</tr>
<tr>
<td>TAH-310001</td>
<td>Pump 1 High Winding Temperature</td>
</tr>
<tr>
<td>MAH-310001</td>
<td>Pump 1 Seal Fail</td>
</tr>
<tr>
<td>YA-310001</td>
<td>Pump 1 Fail to Start</td>
</tr>
<tr>
<td>TAH-310002</td>
<td>Pump 2 High Winding Temperature</td>
</tr>
<tr>
<td>MAH-310002</td>
<td>Pump 2 Seal Fail</td>
</tr>
<tr>
<td>YA-310002</td>
<td>Pump 2 Fail to Start</td>
</tr>
<tr>
<td>FAH-310011</td>
<td>Influent Sewer Parshall Flume Flow Alarm High</td>
</tr>
<tr>
<td>FAH-310012</td>
<td>Plant Drain Parshall Flume Flow Alarm High</td>
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<tr>
<td>YA-310019A</td>
<td>Influent Sewer Sampler Power On/Off Position Alarm</td>
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<tr>
<td>YA-310019B</td>
<td>Influent Sewer Sampler Time/Flow Control Position Alarm</td>
</tr>
<tr>
<td>YA-310019C</td>
<td>Influent Sewer Sampler Time Control Interval Selector Position Alarm</td>
</tr>
<tr>
<td>YA-310019D</td>
<td>Influent Sewer Sampler Manual Purge/Sample Cycle Position Alarm</td>
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<td>AAH-310018</td>
<td>High LEL Alarm</td>
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### 1.8 REMOTE ALARM NOTIFICATION SYSTEM

A. The following data points shall be configured in the remote alarm notification system software:
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<th>Description</th>
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<td>High Level (Float Switch)</td>
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<tr>
<td>LAL-310013</td>
<td>Low Level (Float Switch)</td>
</tr>
<tr>
<td>LAH-310015</td>
<td>High Level (Transmitter)</td>
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<tr>
<td>LAL-310015</td>
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<tr>
<td>YA-310001</td>
<td>Pump 1 Fail to Start</td>
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<tr>
<td>YA-310002</td>
<td>Pump 2 Fail to Start</td>
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<tr>
<td>FAH-310011</td>
<td>Influent Sewer Parshall Flume Flow Alarm High</td>
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<tr>
<td>FAH-310012</td>
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<tr>
<td>AAH-310018</td>
<td>High LEL Alarm</td>
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1.9 PROCESS DATA HISTORIAN:

A. In addition to the alarms listed above, the following data shall be generated by the local SCADA PLC and logged by the process data historian:

<table>
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<td>KQI-310002</td>
<td>Pump 2 Runtime</td>
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<td>YQI-310001</td>
<td>Pump 1 Starts</td>
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<td>Pump 2 Starts</td>
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<td>LI-310015</td>
<td>Wet Well Level</td>
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<tr>
<td>FI-310011</td>
<td>Influent Sewer Flow Rate</td>
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<td>FI-310012</td>
<td>Plant Drain Flow Rate</td>
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<td>FI-310017</td>
<td>Discharge Flow Rate</td>
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<td>FQI-310011</td>
<td>Influent Sewer Flow Total</td>
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<td>FQI-310012</td>
<td>Plant Drain Flow Total</td>
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<tr>
<td>FQI-310017</td>
<td>Discharge Flow Total</td>
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1.10 OPERATION

A. Manual Control:

1. An HOR switch shall be provided at the MCC for each pump. The pumps shall run with the switch in HAND and stop with the switch in OFF.
2. Automatic starts or shut downs due to wet well level will not occur.
3. Pump high temperature alarm and corresponding automatic shutdowns occur to maintain warranty status.

B. Automatic Control:

1. The pumps shall respond to the local PLC when the switch is in REMOTE. The HOR switch must be set to REMOTE for automatic operation.
2. Pumping control level set points shall be adjustable at SCADA HMI screens.
3. A PUMP1/PUMP2/ALTERNATE control element shall be provided on the SCADA HMI allowing selection of lead pump or alternation. When set to a fixed duty pump the selected pump shall remain the lead pump until the setting is changed or the lead pump fails or is turned off. The unselected pump shall be set as the lag pump. When set to...
ALTERNATE the lead pump shall switch after each cycle. If the lead pump fails, is
turned off, or is otherwise unavailable, the lag pump shall be promoted to lead pump.

4. Pump start, stop, and alarm level set points shall be adjustable at the SCADA HMI. The
table below shows default level set points. PLC logic shall verify LTL < LTH < LTHH.
Inputs shall be accepted if the criteria is met and remain unchanged otherwise.

<table>
<thead>
<tr>
<th>Tag</th>
<th>Sump Level (ft)</th>
<th>Control Action</th>
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<tbody>
<tr>
<td>LSH</td>
<td>See DWG. M101</td>
<td>High level switch/ Start both pumps</td>
</tr>
<tr>
<td>LAH</td>
<td>See DWG. M101</td>
<td>High level alarm</td>
</tr>
<tr>
<td>LTHH</td>
<td>See DWG. M101</td>
<td>Start lag pump</td>
</tr>
<tr>
<td>LTH</td>
<td>See DWG. M101</td>
<td>Start lead pump</td>
</tr>
<tr>
<td>LTL</td>
<td>See DWG. M101</td>
<td>Stop all pumps</td>
</tr>
<tr>
<td>LSL</td>
<td>See DWG. M101</td>
<td>Float switch stop</td>
</tr>
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</table>

5. Float switches shall be provided to back up the level instrument. If the level reaches the
high level float switch both pumps shall turn on and run until the level reaches the low
level float switch. Pumps shall always stop when the low level float switch is reached.

6. If the level transmitter signal is lost or out of range an alarm shall be activated. The
pumps shall operate on float switches until the level transmitter is repaired.

7. If the tank level is at or above the LAH set point for an adjustable time delay (default is
30 seconds), the high level alarm shall be activated.

8. Lead Pump starts when water reaches specified “Start lead pump” elevation (LTH) or
when the high level switch is activated, subject to interlocks.

9. Lead pump stops when any of the following conditions are met:
   a. Water surface elevation reaches specified “Stop all pumps” elevation (LTL).
   b. Water surface elevation falls below the low level float switch (LSL).
   c. Winding temperature: High temperature triggers alarm and pump shutdown.
      Current pump status changes to “unavailable” and Lag Pump becomes Lead Pump.
   d. Flow meter registers unusually low flow after a set period of time.

10. The lag pump starts if the lead pump is called to run and fails to start, when the water
    level reaches the specified “on” elevation (LTHH), or when the high level switch is
    activated, subject to interlocks.

11. When the high level float switch is activated Pump No. 1 will start immediately and
    Pump No. 2 will start after a short time delay (operator adjustable).

12. The lag pump stops when any of the following conditions are met:
    a. Water surface elevation reaches specified “Stop all pumps” elevation (LTL).
    b. Water surface elevation falls below the low level float switch (LSL).
    c. Winding temperature: High temperature triggers alarm and pump shutdown.
       Current pump status changes to “unavailable” and Lag Pump becomes Lead Pump.
    d. Flow meter registers unusually low flow after a set period of time.

13. The discharge flow meter will be used to confirm that a pump is operating. When a pump
    is running the PLC will confirm that water is flowing at an expected flow rate.

C. Interlocks: All fault related shutdowns shall require manual reset at the HMI.
1. Programmed:
   a. Pump failure alarm shall be activated after time delay if the flow meter reads an unusually low flow rate for greater than 30 seconds.
   b. The PLC shall remove the Start command when a fault occurs.
   c. The PLC shall remove the Start command when there is a loss of utility power. This interlock does not require a manual reset. The pumps will be free to start again as needed when generator power or utility power is restored.

2. Hardwired:
   a. Pumps shall be shut down on detection of overload, phase fail, or sequence failure.
   b. A protection module shall be provided for the pumps to monitor for high winding temperature and seal failure. The pumps shall be shut down on detection of high winding temperature. These faults shall be reset at the local control panel.

D. Sampler Operation:
   1. The permanent sampler shall receive a pulse. The sampler shall take a sample upon receiving each pulse. The sampler pulse signal shall be based on the flow total from the Influent Parshall Flume flow meter (FIT-310011) equaling 1000 gallons. The Sample Interval shall be operator adjustable from 0 to 10000 gallons.
   2. The sampler will be configured to send 4 alarm signals to the Plant PLC. Coordinate with supplier for the alarm descriptions.
   3. The Portable Sampler sampling interval shall be flow proportional based on the Drain Parshall Flume flow signal. The Portable Sampler shall accept 4-20mA flow signal per Section 444248.

PART 2 - MATERIALS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 409005
SECTION 409006 – HEADWORKS CONTROL STRATEGY

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the integration and operation of the various systems located at the headworks area. These include the headworks channels, the fine screen, and the odor control system.

1.2 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-300</td>
<td>Headworks Facility</td>
</tr>
<tr>
<td>I-301</td>
<td>Odor Control</td>
</tr>
<tr>
<td>I-400</td>
<td>Splitter Box</td>
</tr>
</tbody>
</table>

1.3 ABBREVIATIONS

A. The following abbreviations are used in this section:

1. PLC: Programmable Logic Controller
2. SCADA: Supervisory Control And Data Acquisition system

1.4 SYSTEM OVERVIEW

A. Headworks Channels

1. Raw sewage from Influent pump station is pumped to the headworks through a 12-inch force main. The headworks consist of an upstream channel, two screen channels and a downstream channel. Each channel consists of two manual stop gates with hand wheels for isolation. The stop gates will act both as a stop gate and a weir for emergency flow bypass. Under normal operating conditions, raw sewage enters in the upstream channel and then flows through either the screening channel #1 or channel #2 to the Influent Splitter Box. In the event when the fine screen in operation reaches the maximum permissible water level upstream of the screen, the flow backs up and overflows the stop gate in the adjacent channel and the other screen will be activated. The elevation for stop gates upstream of the screen are set at 118.75 feet and the elevation for the stop gates downstream of the screens are set at 118.25.

2. The Plant SCADA system will monitor various instruments in and around the headworks channel.
B. Fine Screen

1. The wastewater flows into the perforated plate drum through the open front side. The solids contained blind the screen surface producing a mat of screenings that has the effect of a filter and retain smaller solids. The perforated plate ensures that screenings adhere only to the drum and do not clog the screen surface.

2. The screenings are transported upwards by drum rotation and dropped into the centrally arranged collecting trough by means of a brush and spray nozzle bar. While the screw, that is connected with the screen basket, conveys the screenings from the collecting trough into the closed rising pipe, the integrated screenings washing system washes out the soluble particles, which are then returned into the wastewater flow. During their transport through the screw the screenings are compacted, washed and dewatered. The dewatered screenings are discharged into a dumpster located beneath the discharge chute. The press liquor collects in the press liquor collection chamber and flows back through the transparent press liquor return hose into the screen basket.

3. Each fine screen is provided with a control panel that contains all equipment necessary for the fully automatic operation of the screen as specified in section 462133 “Rotary Drum Screens.” The control panel will interface with the Plant SCADA system for equipment monitoring and alarming.

C. Odor Control System

1. The odor control system consists of a mist eliminator, fan and odor control vessel. The odor control system will be located adjacent to the headworks as shown on the drawings. The headworks channels are closed to contain odors produced from the discharge of raw sewage. Foul air is collected through a 10” FRP duct as shown on the drawings.

2. The foul air will first pass through the mist eliminator where any moisture or grease present in the air will be removed. The air then travels through the duct piping and is then pushed through the vertical carbon bed through the fan blower. The carbon media removes contaminants such as ammonia, hydrogen sulfide and mercaptans from the foul air and treated air is discharged through the weather hood to the atmosphere. The odor control system will operate continuously, 24 hours a day and seven days a week.

3. The fan motor is powered by a variable frequency drive (VFD) which can control the amount of air being pulled from the headworks. The Plant PLC will monitor the VFD speed as well as other instruments in the odor control system.

1.5 EQUIPMENT

A. Process Equipment:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG-010101</td>
<td>Channel #1 Stop Gate 1</td>
</tr>
<tr>
<td>SG-010102</td>
<td>Channel #1 Stop Gate 2</td>
</tr>
<tr>
<td>SG-010201</td>
<td>Channel #2 Stop Gate 1</td>
</tr>
<tr>
<td>SG-010202</td>
<td>Channel #2 Stop Gate 2</td>
</tr>
<tr>
<td>FS-010100</td>
<td>Fine Screen #1</td>
</tr>
<tr>
<td>FS-010200</td>
<td>Fine Screen #2</td>
</tr>
<tr>
<td>ME-010404</td>
<td>Odor Control Mist Eliminator</td>
</tr>
<tr>
<td>T-010403</td>
<td>Odor Control Vessel</td>
</tr>
</tbody>
</table>
B. Field Instruments and Panel Devices:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE-010107</td>
<td>Influent Channel pH Element</td>
</tr>
<tr>
<td>AIT-010107</td>
<td>Influent Channel pH Analyzer</td>
</tr>
<tr>
<td>AE-010108</td>
<td>Influent Channel Conductivity Element</td>
</tr>
<tr>
<td>AIT-010108</td>
<td>Influent Channel Conductivity Analyzer</td>
</tr>
<tr>
<td>AIT-010109</td>
<td>Influent Channel Combustible Analyzer</td>
</tr>
<tr>
<td>AE-010109</td>
<td>Influent Channel Combustible Gas Detector</td>
</tr>
<tr>
<td>TSH-010401</td>
<td>Odor Control Fan High Temperature Switch</td>
</tr>
<tr>
<td>SIC-010401</td>
<td>Odor Control Fan Speed Setting</td>
</tr>
<tr>
<td>VFD-010401</td>
<td>Odor Control Fan VFD</td>
</tr>
</tbody>
</table>

1.6 SCADA / HMI DISPLAYS:

A. SCADA HMI display screens shall be provided at the SCADA workstations. The HMI screen displays shall include the data indicated on the P&ID drawings as well as data included in this section.

1.7 ALARMS

A. Alarms shall be generated by the PLC and shall be displayed on SCADA HMI. Alarms shall include process and equipment operating parameters outside of normal operating range, discrepancies between command and status signals (Sequence Fault), etc. The following alarms shall be configured:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAH-010107</td>
<td>High Influent pH</td>
</tr>
<tr>
<td>AAL-010107</td>
<td>Low Influent pH</td>
</tr>
<tr>
<td>AAH-010108</td>
<td>High Influent Conductivity</td>
</tr>
<tr>
<td>AAL-010108</td>
<td>Low Influent Conductivity</td>
</tr>
<tr>
<td>AAH-010109</td>
<td>High Combustible Gas Level</td>
</tr>
<tr>
<td>YI-010101</td>
<td>Screen Running</td>
</tr>
<tr>
<td>YA-010101A</td>
<td>Screen Overload</td>
</tr>
<tr>
<td>YA-010101B</td>
<td>Channel High Level</td>
</tr>
<tr>
<td>YA-010401</td>
<td>Odor Control Fan VFD Fault</td>
</tr>
<tr>
<td>YI-010401B</td>
<td>Odor Control Fan Running</td>
</tr>
<tr>
<td>TAH-010401</td>
<td>Odor Control Fan High Temperature</td>
</tr>
<tr>
<td>FAL-010402</td>
<td>Odor Control Low Air Flow</td>
</tr>
</tbody>
</table>
1.8 REMOTE ALARM NOTIFICATION SYSTEM

A. The following data points shall be configured in the remote alarm notification system software:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAH-010107</td>
<td>High Influent pH</td>
</tr>
<tr>
<td>AAL-010107</td>
<td>Low Influent pH</td>
</tr>
<tr>
<td>AAH-010108</td>
<td>High Influent Conductivity</td>
</tr>
<tr>
<td>AAL-010108</td>
<td>Low Influent Conductivity</td>
</tr>
<tr>
<td>AAH-010109</td>
<td>High Combustible Gas Level</td>
</tr>
</tbody>
</table>

1.9 PROCESS DATA HISTORIAN:

A. In addition to the alarms listed above, the following data shall be generated by the local SCADA PLC and shall be logged by the process data historian:

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI-010107</td>
<td>Influent pH</td>
</tr>
<tr>
<td>AI-010108</td>
<td>Influent Conductivity</td>
</tr>
<tr>
<td>AI-010104</td>
<td>Headworks Channel Level</td>
</tr>
<tr>
<td>YI-010101</td>
<td>Screen 1 Running</td>
</tr>
<tr>
<td>KQI-010101</td>
<td>Screen 1 Elapsed Run Time</td>
</tr>
<tr>
<td>AI-010201</td>
<td>Screen 2 Running</td>
</tr>
<tr>
<td>KQI-010201</td>
<td>Screen 2 Elapsed Run Time</td>
</tr>
</tbody>
</table>

1.10 OPERATION

A. Fine Screen

1. Each of the fine screens are provided with a local control panel which contains all equipment necessary for the fully automatic operation of the screen as specified in section 462133 “Rotary Drum Screens.”

B. Odor Control System:

1. The odor control system will operate continuously, 24 hours a day and seven days a week. The operator will manually start the fan using the ON-OFF switch located at the MCC. The PLC does not have any automatic control over the odor control fan.

2. The fan speed will be manually adjustable using a potentiometer located at the headworks.

C. Portable Headworks Sampler

Sampler shall be flow paced based on FI-310017 and accept a 4-20mA flow signal per Section 444248.

D. Interlocks:

1. Programmed:
a.  None

2.  Hardwired:
   a.  Stop on VFD fault.
   b.  Stop on fan high temperature.

PART 2 - MATERIALS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 409006
SECTION 409007 – MBR SYSTEM CONTROL STRATEGY

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the integration of the MBR SCADA system with the Plant SCADA system. The entire MBR system is provided fully programmed and tested by the MBR vendor. The Contractor is responsible for connecting the Plant SCADA system to the MBR SCADA system for monitoring, recording, and alarming purposes.

B. A copy of the Ovivo control strategy is attached at the end of this section.

1.2 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
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<tbody>
<tr>
<td>I-401</td>
<td>Pre-Anoxic Basin 1</td>
</tr>
<tr>
<td>I-402</td>
<td>Pre-Anoxic Basin 2</td>
</tr>
<tr>
<td>I-403</td>
<td>Pre-Aeration Basin 1</td>
</tr>
<tr>
<td>I-404</td>
<td>Pre-Aeration Basin 2</td>
</tr>
<tr>
<td>I-405</td>
<td>Post-Anoxic Basin 1</td>
</tr>
<tr>
<td>I-406</td>
<td>Post-Anoxic Basin 2</td>
</tr>
<tr>
<td>I-407</td>
<td>Membrane Feed Channel</td>
</tr>
<tr>
<td>I-408</td>
<td>Membrane Bioreactor 1</td>
</tr>
<tr>
<td>I-409</td>
<td>Membrane Thickener 1</td>
</tr>
<tr>
<td>I-410</td>
<td>Membrane Bioreactor 2</td>
</tr>
<tr>
<td>I-411</td>
<td>MBR Permeate System</td>
</tr>
<tr>
<td>I-412</td>
<td>MBT Permeate System</td>
</tr>
<tr>
<td>I-413</td>
<td>Membrane Bioreactor Blowers</td>
</tr>
<tr>
<td>I-414</td>
<td>Pre-Aeration Blowers</td>
</tr>
<tr>
<td>I-415</td>
<td>CIP System</td>
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<td>I-416</td>
<td>pH CDS System</td>
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</tbody>
</table>

1.3 ABBREVIATIONS

A. The following abbreviations are used in this section:

1. PLC: Programmable Logic Controller
2. SCADA: Supervisory Control And Data Acquisition system
1.4 SYSTEM OVERVIEW

A. The Ovivo MBR process differs from traditional municipal treatment systems in that membranes are used to separate solids from treated water. The membranes are submerged in a basin downstream of the traditional processes (anoxic, pre-aeration, etc.). Here the filter media separate the solids in the mixed liquor from the water, producing permeate.

B. To prevent solids accumulation on the outside of the filter surface from slowing the filtration process, air scouring (bubbling air across the surface of the filters) is used to keep the surface free solids. Efficient and equal air scouring is critical to operation. Therefore, air scour flow rates are monitored, recorded and controlled.

1.5 SCADA / HMI DISPLAYS

A. In order to create a single SCADA system that will encompass the entire treatment plant, the MBR SCADA screens and databases shall be provided to the Plant SCADA programmer for integration into the Plant SCADA system. The Plant SCADA programmer will provide the Plant SCADA screens and database to the MBR supplier.

1.6 ALARMS

A. Alarms shall be generated by the MBR PLC and shall be displayed on the SCADA HMI. Alarm points shall be identified by the MBR supplier.

1.7 REMOTE ALARM NOTIFICATION SYSTEM

A. The alarm points shall be configured in the remote alarm notification system software as directed by the MBR supplier.

1.8 PROCESS DATA HISTORIAN

A. The Plant SCADA programmer shall coordinate with the MBR system programmer to determine what data points require historical logging.

PART 2 - MATERIALS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 409007
Control Strategy

Port Hadlock, WA
MBR Waste Treatment Plant

Prepared By: Hyperion International for Ovivo
Document Number: Rev. 1
Revision Date: November 25, 2013
Reference Documents: NA

2404 Rutland Drive
Austin, Texas 78758
(512) 834-6000
## Revision History

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<td>7/15/2013</td>
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<tr>
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<td>11/25/2013</td>
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Contents

1 Purpose ....................................................................................................................................... 1-1
2 MBR System Description ............................................................................................................... 2-1
  2.1. Overview .......................................................................................................................... 2-1
  2.2. System Description ........................................................................................................... 2-2
  2.3. Simplified Hydraulic Profile and Plant Layout ................................................................. 2-2
  2.4. MBR PLC System Equipment ............................................................................................ 2-3
  2.5. Pre-Anoxic Basins (PAX 01 and 02) .............................................................................. 2-5
  2.6. Pre-Aeration Basins (PA-01 and 02) ................................................................................ 2-6
  2.7. Post-anoxic Basins (AXP-01 and 02) ............................................................................. 2-7
  2.8. Membrane Bioreactors (MB-01 / 02) ............................................................................. 2-7
  2.9. Membrane Thickener Basin (MBT-01) .......................................................................... 2-8
  2.10. MBR Permeate Collection ............................................................................................... 2-9
    2.10.1. Permeate Flow Control Valve ................................................................................ 2-9
  2.11. MBT Permeate Collection ............................................................................................... 2-10
    2.11.1. MBT Permeate Collection Instrumentation I/O .................................................. 2-10
    2.11.2. MBT Permeate Pump ........................................................................................... 2-10
  2.12. Aeration .......................................................................................................................... 2-10
    2.12.1. MBR / MBT Basin Aeration ................................................................................. 2-10
    2.12.2. Pre-Aeration (PA) Blowers ................................................................................ 2-11
  2.13. Chemical Addition ............................................................................................................ 2-11
  2.14. Membrane Clean-in-Place System ................................................................................. 2-11

3 MBR Operations ......................................................................................................................... 3-14
  3.1. Mode & State Descriptions ............................................................................................... 3-14
  3.2. Plant Modes ..................................................................................................................... 3-14
  3.3. Process Train Modes ........................................................................................................ 3-15
  3.4. MBR Modes ..................................................................................................................... 3-15
  3.5. Permeate Header States .................................................................................................... 3-15
  3.6. MBR Permeate Flow Control ............................................................................................ 3-16
    3.6.1. Level Based Permeate Control ................................................................................ 3-16
    3.6.2. Level Based Control Transition ............................................................................. 3-16
    3.6.3. Transmembrane Pressure (TMP) Flux .................................................................. 3-19
    Permeability Control ........................................................................................................ 3-20
    Permeability Control Example ....................................................................................... 3-21
  3.7. MBR Aeration Header Status ............................................................................................ 3-23
    3.7.1. MBR Basin Air Flow Calculation ............................................................................ 3-23
  3.8. MBR Mode Selection ........................................................................................................ 3-24
  3.9. Main Interlocks ................................................................................................................ 3-26
  3.10. MBT Permeate Flow Control .......................................................................................... 3-26
    Permeate Flow Rate Calculator ...................................................................................... 3-26

4 Function Specific Controls ........................................................................................................ 4-1
  4.1. Level Calibration ................................................................................................................ 4-1
  4.2. Analog Input Overrides ..................................................................................................... 4-1
  4.3. Discrete Input Overrides ................................................................................................... 4-2
  4.4. Speed/Position Automatic Overrides .............................................................................. 4-3
  4.5. Equipment Control ........................................................................................................... 4-4
    Motor status ..................................................................................................................... 4-5
    Valve Status ..................................................................................................................... 4-6
  4.6. Local Control ..................................................................................................................... 4-6

5 Alarm Listing ............................................................................................................................. 5-1
  5.1. Critical Alarms .................................................................................................................. 5-1

Tables

Control Strategy, Page ii
Table 1-1 Terms and Definitions .................................................................................................................. 1-1
Table 2-1 Plant Subsystems .......................................................................................................................... 2-2
Table 2-2 MBR PLC System Equipment and Instrumentation ......................................................................... 2-3
Table 2-3 Pre-anoxic Basin Level Instrument I/O .......................................................................................... 2-5
Table 2-4 Feed-forward Pump I/O ............................................................................................................... 2-5
Table 2-5 Pre-anoxic Basin Mixer I/O ........................................................................................................... 2-6
Table 2-6 Pre-Aeration Basin Dissolved Oxygen / Temperature and pH Analyzer I/O .................................. 2-6
Table 2-7 Pre-aeration Basin Mixer I/O ......................................................................................................... 2-6
Table 2-8 Post-anoxic Basin Mixer I/O .......................................................................................................... 2-7
Table 2-9 MBR Diffuser Cleaning Valve I/O .................................................................................................. 2-7
Table 2-10 MBR Basin Level Instrument I/O ............................................................................................... 2-8
Table 2-11 MBR Diffuser Cleaning Valve I/O ............................................................................................... 2-8
Table 2-12 MBT Basin Level Instrument I/O .................................................................................................. 2-8
Table 2-13 Permeate Collection Instrumentation I/O .................................................................................. 2-9
Table 2-14 Permeate Pump I/O ..................................................................................................................... 2-9
Table 2-15 Permeate Turbidimeter I/O ......................................................................................................... 2-10
Table 2-16 MBT Permeate Collection Instrumentation I/O ........................................................................ 2-10
Table 2-17 MBT Permeate Collection Instrumentation I/O ........................................................................ 2-10
Table 2-18 MBR / MBT Air Flow I/O ........................................................................................................... 2-11
Table 2-19 MBR / MBT Blower System I/O .................................................................................................. 2-11
Table 2-20 Pre-aeration Blower I/O ............................................................................................................. 2-11
Table 2-21 Chemical Addition System I/O .................................................................................................. 2-11
Table 2-22 CIP System I/O .......................................................................................................................... 2-12
Table 2-23 CIP Components ......................................................................................................................... 2-13
Table 3-2 Sample Level Based Flow Control Matrix ................................................................................... 3-16
Table 3-3 Variables for Level Based Mode and State Transitions with One Controlling Level .................. 3-17
Table 3-4 Level Based Control State Transition Logic (Averaged Level) .................................................... 3-17
Table 3-5 Permeability Control Example State Transitions ....................................................................... 3-22
Table 3-6 MBR Modes and Related Parameters (Logic Diagram Only) ....................................................... 3-25
Table 4-1 Motor Status Display .................................................................................................................... 4-5
Table 4-2 Valve Status Display .................................................................................................................... 4-6
Table 5-1 Alarm Tags and Messages ............................................................................................................. 5-1

Figures
Figure 2-1 Simplified Hydraulic Profile ....................................................................................................... 2-2
Figure 2-2 Simplified Plant Layout and Flow Diagram ............................................................................... 2-2
Figure 2-3 Membrane CIP System ................................................................................................................. 2-3
Figure 3-1 Modes and States .......................................................................................................................... 3-14
Figure 3-2 Flow State Transition Sequence for Two MBRs ...................................................................... 3-19
Figure 3-3 Permeability Control Example .................................................................................................. 3-22
Figure 3-4 System Pressure Diagram ......................................................................................................... 3-26
Figure 4-1 Level Calibration Interface ........................................................................................................... 4-1
Figure 4-2 Analog Override Access ............................................................................................................. 4-1
Figure 4-3 Analog Override Interfaces ......................................................................................................... 4-2
Figure 4-4 Discrete Input Override Access .................................................................................................... 4-2
Figure 4-5 Discrete Input Overrides Interface ............................................................................................... 4-2
Figure 4-6 Valve OCA Pop-up Sample with Automatic PID Output and Limit Switch Override ............. 4-3
Figure 4-7 Motor Faceplate Sample: VFD Controlled Motor ........................................................................ 4-4
Figure 4-8 Sample Motor Status Displays .................................................................................................. 4-5
Figure 4-9 Valve Status Displays .................................................................................................................. 4-6

Equations
Equation 3-1 TMP Calculation ...................................................................................................................... 3-19
Equation 3-2 Permeate Piping System Loss Calculation ............................................................................. 3-19
Equation 3-3 Instantaneous Flux Calculation .............................................................................................. 3-20
Equation 3-4 Average Flux Calculation ........................................................................................................ 3-20
Equation 3-5 Permeability Calculation .............................................................. 3-20
Equation 3-6 MBR Air Flow Calculation ............................................................ 3-24
Equation 3-7 MBT Permeate Flow Calculation .................................................. 3-26
1 Purpose

The Membrane Bioreactor (MBR) system that provides primary treatment in Ovivo’s Port Hadlock, WA waste water treatment facility is comprised of multiple sub-systems. Each sub-system is in turn comprised of multiple components such as rotating equipment, valves, and instruments. The purpose of this document is to describe the automated control features of the Ovivo Port Hadlock MBR system. Equipment which is not controlled by the MBR system is beyond the scope of this document.

Table 1-1 Terms and Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated Sludge</td>
<td>Activated Sludge process is a process in sewage treatment in which air or oxygen is forced into sewage to develop a biological floc which reduces the organic content of the sewage. The biological floc and the treated effluent are then separated by gravity settling or a membrane in the case of an MBR.</td>
</tr>
<tr>
<td>Aerobic</td>
<td>Presence of Oxygen. Aerobic process is carried out by the bacteria which require free elemental oxygen for their growth.</td>
</tr>
<tr>
<td>Anaerobic</td>
<td>Absence of oxygen, as opposed to aerobic. In wastewater treatment the absence of oxygen is indicated as anoxic; and anaerobic is used to indicate the absence of any electron acceptor (nitrate, sulfate or oxygen).</td>
</tr>
<tr>
<td>Anaerobic digestion (AD)</td>
<td>The harnessed and contained, naturally occurring process of anaerobic decomposition</td>
</tr>
<tr>
<td>Anoxic</td>
<td>Absence of oxygen. Other electron acceptors are present in an anoxic environment (nitrate, sulfate, etc).</td>
</tr>
<tr>
<td>Biofilm</td>
<td>A biofilm is a complex aggregation of microorganisms marked by the excretion of a protective and adhesive matrix.</td>
</tr>
<tr>
<td>Biohydraulics</td>
<td>The link between biological process conditions and membrane hydraulics is referred to as biohydraulics.</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>The amount of oxygen that will be required for the stabilization of organic matter through biochemical action at given time and given temperature. It is one indicator of organic pollution of water. The common test used to measure the concentration of biodegradable organic matter present in a sample of water over a 5 day period (BOD5).</td>
</tr>
<tr>
<td>Cassette</td>
<td>A type of routine membrane cleaning procedure.</td>
</tr>
<tr>
<td>Clean-In-Place (CIP)</td>
<td>A group of membrane cartridges.</td>
</tr>
<tr>
<td>Denitrification</td>
<td>The biological process whereby nitrates are converted to nitrogen gas. Certain bacterial species use nitrate as an oxygen source and produce nitrogen gas as a byproduct through a process called denitrification. Denitrification occurs in an anoxic environment where these microbes, nitrates, and BOD are present.</td>
</tr>
<tr>
<td>Diffuser</td>
<td>A submerged device that introduces air into the wastewater. There are fine bubble, medium bubble, and coarse bubble diffusers.</td>
</tr>
<tr>
<td>Dissolved Oxygen (DO)</td>
<td>The concentration of free dissolved oxygen in water.</td>
</tr>
<tr>
<td>Effluent</td>
<td>Treated water that flows out of the treatment plant.</td>
</tr>
<tr>
<td>Flux</td>
<td>The filtration rate per area of membrane is referred to as flux and is given in units of gallons per square foot of membrane material (gfd).</td>
</tr>
<tr>
<td>Fouling</td>
<td>An increase in resistance to flow as a result of particle deposition or pore clogging at the membrane surface.</td>
</tr>
<tr>
<td>GFD</td>
<td>Gallons per square foot per day (gal/ft(^2)*day). a measure of flux rate.</td>
</tr>
<tr>
<td>Gross Flux</td>
<td>The flux at any given moment calculated from flow in gpm. Also referred to as instantaneous flux.</td>
</tr>
<tr>
<td><strong>HMI</strong></td>
<td>The Human-Machine-Interface refers to a desktop or panel mounted computer by which people interact with automated process. The HMI provides the means of: Input, allowing users to manipulate the system; and Output, allowing the system to display the effects of the users' manipulation.</td>
</tr>
<tr>
<td><strong>Influent</strong></td>
<td>Untreated influx of sewage into a wastewater treatment plant.</td>
</tr>
<tr>
<td><strong>Maintenance Clean</strong></td>
<td>A CIP lasting less than between 1 hr and 4 hr. During a Maintenance Cleaning the Membrane Basin shall not be drained or rendered incapable of returning to service within 15 min. Spent solution shall be dispensed back to headworks or rinsed into the mixed liquor using permeate or potable water. The rinse volume shall be greater than or equal to the amount of dilute chemical added. No additional chemicals are required for neutralization of spent solution.</td>
</tr>
<tr>
<td><strong>MBR System</strong></td>
<td>The sum of all equipment and instrumentation that comprise the membrane bioreactor system.</td>
</tr>
<tr>
<td><strong>MBT</strong></td>
<td>Membrane Thickener</td>
</tr>
<tr>
<td><strong>Motor Control Center (MCC)</strong></td>
<td>A motor control center (MCC) is an assembly of one or more enclosed sections having a common power bus and principally housing the switching, starters, VFDs and overload protection equipment used in a system to run motors.</td>
</tr>
<tr>
<td><strong>Membrane Bio-Reactor (MBR)</strong></td>
<td>MBR is an activated sludge process that uses submerged membrane units (SMUs) to filter out suspended solids, including harmful microorganisms such as viruses and bacteria.</td>
</tr>
<tr>
<td><strong>Membrane Cartridge</strong></td>
<td>Each membrane cartridge is constructed by ultrasonically welding a sheet of thin polymeric material to the back and front of a support panel. Between the panel and the membrane material is a porous spacer material that distributes water to a series of grooves that channel filtered water to the top of the cartridge.</td>
</tr>
<tr>
<td><strong>Membrane Tank</strong></td>
<td>Tank in which membranes are submerged in mixed liquor. Can also be referred to as the membrane bioreactor basin as a significant amount of biological activity occurs in the membrane tanks.</td>
</tr>
<tr>
<td><strong>Mixed Liquor</strong></td>
<td>A mixture of activated sludge and water containing organic matter undergoing activated sludge treatment.</td>
</tr>
<tr>
<td><strong>Mixed Liquor Suspended Solid (MLSS)</strong></td>
<td>The mass concentration of the solid portion of Mixed Liquor. The solids are comprised of biomass, and inert inorganic total suspended solids.</td>
</tr>
<tr>
<td><strong>Mixed Liquor Volatile Suspended Solid (MLVSS)</strong></td>
<td>The portion of the MLSS that is vaporized when the dry solids are put in a 500°C oven for 10 minutes. The MLVSS is measured as a percentage of MLSS and is usually around 60-80% of MLSS.</td>
</tr>
<tr>
<td><strong>Modes</strong></td>
<td>The overall control objective for a given subsystem is defined as a mode. Modes are further defined by states.</td>
</tr>
<tr>
<td><strong>Nitrification</strong></td>
<td>The biological process whereby reduced nitrogen is converted to nitrite/nitrate. Nitrification is an aerobic process and therefore can occur only in the presence of oxygen. It is carried out by autotrophic bacteria, and does not require organic carbon (BOD). Converts ammonia to nitrite and then nitrite to nitrate (two-step process) in the presence of oxygen.</td>
</tr>
<tr>
<td><strong>Instantaneous Flux</strong></td>
<td>The flux at any given moment calculated from flow in gpm. Also referred to gross flux.</td>
</tr>
<tr>
<td><strong>Oxic</strong></td>
<td>Containing oxygen.</td>
</tr>
<tr>
<td><strong>Permeability</strong></td>
<td>The ratio of flux to TMP (gfd/psi). Permeability is a measure of membrane performance.</td>
</tr>
<tr>
<td><strong>Permeate</strong></td>
<td>Biologically treated wastewater filtered through the membranes.</td>
</tr>
<tr>
<td><strong>PLC</strong></td>
<td>The Programmable Logic Controller is an industrial computer used for automation of industrial processes. Unlike general-purpose computers, the PLC is designed for multiple input and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact.</td>
</tr>
<tr>
<td><strong>Q</strong></td>
<td>Influent flow (MGD)</td>
</tr>
<tr>
<td><strong>RAS</strong></td>
<td>Recycled activated sludge.</td>
</tr>
<tr>
<td><strong>Relaxation</strong></td>
<td>Temporary suspension of permeate flow.</td>
</tr>
<tr>
<td><strong>SCADA</strong></td>
<td>SCADA is the acronym for Supervisory Control And Data Acquisition. The term refers to a large-scale, distributed measurement (and control) system. SCADA systems are used to monitor and control automated processes.</td>
</tr>
<tr>
<td><strong>SCFM</strong></td>
<td>Standard Cubic Feet per Minute (SCFM) is a volumetric flow rate corrected to standard conditions of gas density, thus representing a precise mass Flow. SCFM is volumetric Flow at a “standardized” pressure, temperature, and relative humidity.</td>
</tr>
<tr>
<td><strong>Set point</strong></td>
<td>Adjustable parameter at the HMI.</td>
</tr>
<tr>
<td><strong>Submerged membrane Unit (SMU)</strong></td>
<td>A membrane unit is comprised of the diffuser, one or more membrane cassettes, membrane cartridges, and attached appurtenances.</td>
</tr>
<tr>
<td><strong>Subsystem</strong></td>
<td>The MBR System is comprised of multiple subsystems, or unit operations, that for the most part are controlled independently.</td>
</tr>
<tr>
<td><strong>Turbidity</strong></td>
<td>Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. Turbidity in water is caused by suspended matter such as clay, silt, and organic matter and by plankton and other microscopic organisms that interfere with the passage of light through the water (American Public Health Association, 1998).</td>
</tr>
<tr>
<td><strong>UV</strong></td>
<td>Ultraviolet (light). UV may be used to disinfect permeate.</td>
</tr>
<tr>
<td><strong>VFD</strong></td>
<td>Variable Frequency Drives, a device that is used to control the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor.</td>
</tr>
<tr>
<td><strong>WAS</strong></td>
<td>Waste activated sludge</td>
</tr>
</tbody>
</table>
2 MBR System Description

2.1. Overview
The Ovivo MBR process differs from traditional municipal treatment systems in that membranes are used to separate solids from treated water. The membranes are submerged in a basin downstream of the traditional processes (anoxic, pre-aeration, etc.). Here the filter media separate the solids in the mixed liquor from the water, producing permeate. The rate at which mixed liquor is filtered per area of membrane material is referred to as flux.

As flux increases the amount of dewatered solids at the membrane surface also increases. Filtered solids contain living organisms that form what is called a biofilm. The pressure required to filter water through a biofilm and the supporting membrane is called transmembrane pressure or TMP.

Ovivo MBR systems prevent increases in biofilm density and reduce membrane fouling by operating at low TMP. However, TMP is also a function of flow and increases as flow increases. Therefore, to normalize the relationship between flow (flux) and TMP, permeability is monitored and used for controlling membrane performance, within typical operating ranges, permeability changes linearly with flux or TMP. Monitoring permeability allows an operator to trend one number as a measure of performance and eliminates any confusion when comparing TMP values at different flows or at different times. Moreover, slight changes in TMP can significantly change permeability making it easier to compare operating conditions and monitor membrane performance.

To prevent solids accumulation on the outside of the filter surface from slowing the filtration process, air scouring (bubbling air across the surface of the filters) is used to keep the surface free solids. Efficient and equal air scouring is critical to operation. Therefore, air scour flow rates are be monitored, recorded and controlled.

Because equal air scouring is required, the diffusers integral to each submerged membrane unit (SMU) must also be kept clean. Diffusers are kept clean by scouring them with mixed liquor. This process is automatically initiated using an automated Diffuser Cleaning Valve (DCV).

There are a few basic guidelines that pertain to the operation of any MBR system:

Filtration cannot occur without a minimum air scour flow rate.
Diffuser cleaning must occur at least once per day.
A minimum permeability should be maintained at all times.
A maximum TMP must never be exceeded.

The overall objective is to control the MBR System so as to attain steady-state operating conditions. Constant flux, level, air scouring intensity, etc. generally promote better long-term membrane performance.
2.2. System Description
The Port Hadlock MBR system consists of 14 subsystems as shown in Table 2-1. The basic function of each subsystem is described in the following sections.

Table 2-1 Plant Subsystems

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Acronym</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splitter Box</td>
<td>SB</td>
</tr>
<tr>
<td>Pre-Anoxic Basin</td>
<td>PAX</td>
</tr>
<tr>
<td>Feed Forward System</td>
<td>-</td>
</tr>
<tr>
<td>Pre-Aeration Basin</td>
<td>PA</td>
</tr>
<tr>
<td>Post-Anoxic Basin</td>
<td>AXP</td>
</tr>
<tr>
<td>Feed Channel</td>
<td>FC</td>
</tr>
<tr>
<td>Membrane Bioreactor</td>
<td>MBR</td>
</tr>
<tr>
<td>Membrane Thickener</td>
<td>MBT</td>
</tr>
<tr>
<td>Waste Activated Sludge</td>
<td>WAS</td>
</tr>
<tr>
<td>Permeate Collection System</td>
<td>PERM</td>
</tr>
<tr>
<td>MBR Aeration System</td>
<td>-</td>
</tr>
<tr>
<td>PA Aeration System</td>
<td>-</td>
</tr>
<tr>
<td>Clean-in-Place System</td>
<td>CIP</td>
</tr>
<tr>
<td>Chemical Addition</td>
<td>CHEM</td>
</tr>
</tbody>
</table>

2.3. Simplified Hydraulic Profile and Plant Layout
Screened influent enters the anoxic basin. In the anoxic basin the influent is mixed with recycled sludge (mixed liquor) and is depleted of oxygen, thus allowing de-nitrification to occur. The denitrified blended sludge is pumped into the pre-aeration basins where additional biological treatment occurs. The mixed liquor drains from the pre-aeration to the MBR basins where it is filtered through submerged membrane cartridges. The filtered effluent, or permeate is then discharged to the UV disinfection system.

The thickened activated sludge overflows from the MBR basin back to the anoxic basin. As water is removed from the system, biosolids are concentrated in the system. To maintain the desired concentration in the mixed liquor, solids are periodically removed. This waste activated sludge (WAS) is pumped to the solids holding basins from which it is periodically removed from the site by truck.

Figure 2-1 Simplified Hydraulic Profile
2.4. MBR PLC System Equipment

Equipment to be controlled and monitored by the MBR System PLC is listed in Table 2-2. Packaged equipment which has its own control system will be monitored by the MBR system using hard-wired signals.

Table 2-2 MBR PLC System Equipment and Instrumentation

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Anoxic Basin 1</td>
<td>LSL / LSH-040105</td>
</tr>
<tr>
<td></td>
<td>LIT-040106</td>
</tr>
<tr>
<td></td>
<td>MXR-040101</td>
</tr>
<tr>
<td></td>
<td>PMP-040102</td>
</tr>
<tr>
<td></td>
<td>PMP-040103</td>
</tr>
<tr>
<td></td>
<td>FIT-040104</td>
</tr>
<tr>
<td>Pre-Anoxic Basin 2</td>
<td>LSL / LSH-040205</td>
</tr>
<tr>
<td></td>
<td>LIT-040206</td>
</tr>
<tr>
<td></td>
<td>MXR-040201</td>
</tr>
<tr>
<td></td>
<td>PMP-040202</td>
</tr>
<tr>
<td></td>
<td>PMP-040203</td>
</tr>
<tr>
<td></td>
<td>FIT-040204</td>
</tr>
<tr>
<td>Pre-air Basin 1</td>
<td>AIT / TIT-050102</td>
</tr>
<tr>
<td></td>
<td>MBR-050101</td>
</tr>
<tr>
<td></td>
<td>XV-050103</td>
</tr>
<tr>
<td>System Type</td>
<td>Code 1</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Pre-air Basin 2</td>
<td>AIT / TIT-050202</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Anoxic Basin 1</td>
<td>MXR-060101</td>
</tr>
<tr>
<td>Post-Anoxic Basin 2</td>
<td>MXR-060201</td>
</tr>
<tr>
<td>MBR Basin 1</td>
<td>XV-070101</td>
</tr>
<tr>
<td>MBR Basin 2</td>
<td>XV-070201</td>
</tr>
<tr>
<td>MBT Basin 1</td>
<td>XV-210201</td>
</tr>
<tr>
<td>Permeate Collection</td>
<td>SV-080004 / 080104 / 080204</td>
</tr>
<tr>
<td></td>
<td>PIT-080002 / 080102 / 080202 / 210106</td>
</tr>
<tr>
<td></td>
<td>FIT-080003 / 080103 / 080203 / 210107</td>
</tr>
<tr>
<td></td>
<td>FCV-080005 / 080105 / 080205</td>
</tr>
<tr>
<td></td>
<td>PMP-080001 / 080101 / 080201 / 210105</td>
</tr>
<tr>
<td></td>
<td>AIT-080006</td>
</tr>
<tr>
<td>Pre-aeration / Stand-by Blowers</td>
<td>BLR-100101 / 100201</td>
</tr>
<tr>
<td></td>
<td>TSH-100101 / 100201</td>
</tr>
<tr>
<td>MBR Blowers</td>
<td>BLR-090001 / 090101 / 090201 / 110101</td>
</tr>
<tr>
<td></td>
<td>TSH-090001 / 090101 / 090201 / 110101</td>
</tr>
<tr>
<td></td>
<td>FIT-090002 / 090102 / 090202</td>
</tr>
<tr>
<td>Chemical Addition</td>
<td>LSL / LSH-160002</td>
</tr>
<tr>
<td></td>
<td>PMP-160101 / 160201</td>
</tr>
<tr>
<td></td>
<td>MIR-160103</td>
</tr>
<tr>
<td>Membrane CIP</td>
<td>XV-170001</td>
</tr>
<tr>
<td></td>
<td>FIT-170002</td>
</tr>
</tbody>
</table>
2.5. Pre-Anoxic Basins (PAX 01 and 02)

Pre-anoxic basins 1 and 2 are equipped with a pressure sensing level transmitter to monitor liquid level in the basin. Low and high analog alarm level set points are operator adjustable at the HMI. Two float switches are provided as backup to the level transmitter.

Upon detecting a low liquid level condition an alarm is posted and all rotating equipment installed in the basin will shut down until the condition clears. Upon detecting a high liquid level condition an alarm is posted until the condition clears, and all available MBRs begin filtering at a high Flow.

**Table 2-3 Pre-anoxic Basin Level Instrument I/O**

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI</td>
<td>High Level Switch</td>
<td>LSH – Provides high level alarm</td>
</tr>
<tr>
<td>DI</td>
<td>Low Level Switch</td>
<td>LSL – Provides low level alarm</td>
</tr>
<tr>
<td>AI</td>
<td>Level Transmitter</td>
<td>4-20 mA signal proportional to ANOXIC basin level</td>
</tr>
</tbody>
</table>

Each pre-anoxic basin is equipped with two variable-speed, submersible feed-forward pumps. The feed-forward pumps operate in an alternating duty/standby mode. If the duty pump fails, the stand-by pump automatically assumes the function of the duty pump. Pump speed is automatically controlled to maintain an operator adjustable feed forward flow setpoint, typically five or six times the design permeate flow. Each permeate flow mode will have its own corresponding feed forward pump flow setpoint. The pumps are equipped with internal temperature and moisture sensors. The internal temperature sensor stops the pump on alarm detection. The pumps will continue to run upon detection of a moisture alarm condition.

A magnetic flow meter, located in the pump discharge line continuously monitors feed-forward flow to the pre-aeration basins.

The feed-forward pump electrical design will utilize the following I/O:

**Table 2-4 Feed-forward Pump I/O**

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Run Command</td>
<td>PLC signal to run the motor</td>
</tr>
<tr>
<td>DI</td>
<td>Running Confirmation</td>
<td>Indicates motor contactor is energized and motor protector is not tripped</td>
</tr>
<tr>
<td>DI</td>
<td>Hand/Off/Auto Switch Position</td>
<td>Indicates the hand/off/auto switch is in the AUTO (REMOTE) position</td>
</tr>
<tr>
<td>DI</td>
<td>Moisture Switch</td>
<td>Indicates water in the motor casing, and failure of the submerged motor’s shaft seal</td>
</tr>
<tr>
<td>DI</td>
<td>Temperature Switch</td>
<td>Indicates high temperature in the motor windings. This signal is hardwired to the motor starter</td>
</tr>
<tr>
<td>AO</td>
<td>Feed-Forward Pump Speed Reference</td>
<td>4-20 mA signal to PLC used to control recycle pump speed</td>
</tr>
<tr>
<td>AI</td>
<td>Feed-Forward Flow Transmitter</td>
<td>4-20 mA signal used to control ANOXIC pump discharge flow</td>
</tr>
</tbody>
</table>

Each pre-anoxic basin is equipped with a mixer driven by a variable frequency drive (VFD). The Anoxic basin mixer runs continuously unless a low level alarm condition is detected. The mixer speed will determined by an operator adjustable setpoint. The operator will set the mixer speed for the minimum required to keep the sludge mixed but allow grit to settle. The mixer is equipped with internal temperature and moisture sensors. The internal temperature sensor shuts down the mixer upon high temperature alarm detection. The mixer will continue to run upon detection of a moisture alarm condition. The electrical design will utilize the following I/O:
2.6. Pre-Aeration Basins (PA-01 and 02)

Dissolved oxygen analyzers monitor the oxygen concentration and temperature of the mixed liquor in the pre-aeration basin. The dissolved oxygen transmitters are luminescent style sensors that have been factory calibrated. If the mixed liquor temperature or dissolved oxygen concentration fall below operator adjustable limits, an alarm is posted. Mixed liquor temperature and dissolved oxygen concentration are monitored and recorded at all times. Dissolved oxygen concentration is used to modulate the pre-aeration blower speed to control air flow to the basins.

The electrical design will utilize the following I/O:

**Table 2-6 Pre-Aeration Basin Dissolved Oxygen / Temperature and pH Analyzer I/O**

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Dissolved Oxygen Concentration Indication</td>
<td>4-20 mA signal to PLC used to control maintain adequate air flow</td>
</tr>
<tr>
<td>AI</td>
<td>Temperature Indication</td>
<td>4-20 mA signal to PLC used to generator low temp alarm</td>
</tr>
</tbody>
</table>

The Pre-aeration basins are each equipped with a mixer driven by a full voltage non-reversing motor (FVNR). The Pre-aeration basin mixers run automatically when the diffuser air is off and turn off when the diffuser air is on. Each mixer is equipped with internal temperature and moisture sensors. The internal temperature sensor shuts down the mixer upon high temperature alarm indication. The mixer will continue to run upon detection of a moisture alarm condition. The electrical design will utilize the following I/O:

**Table 2-7 Pre-aeration Basin Mixer I/O**

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Run Command</td>
<td>PLC signal to run the motor</td>
</tr>
<tr>
<td>DI</td>
<td>Running Confirmation</td>
<td>Indicates motor contactor is energized and motor protector is not tripped</td>
</tr>
<tr>
<td>DI</td>
<td>Hand/Off/Auto Switch Position</td>
<td>Indicates the hand/off/auto switch is in the AUTO (REMOTE) position</td>
</tr>
<tr>
<td>DI</td>
<td>Moisture Switch</td>
<td>Indicates water in the motor casing, and failure of the submerged motor’s shaft seal</td>
</tr>
<tr>
<td>DI</td>
<td>Temperature Switch</td>
<td>Indicates high temperature in the motor windings. This signal is hardwired to the motor starter</td>
</tr>
</tbody>
</table>
2.7. Post-anoxic Basins (AXP-01 and 02)
The Post-anoxic basins are each equipped with a mixer driven by a full voltage non-reversing motor (FVNR). The Pre-aeration basin mixers run continuously. Each mixer is equipped with internal temperature and moisture sensors. The internal temperature sensor shuts down the mixer upon high temperature alarm indication. The mixer will continue to run upon detection of a moisture alarm condition. The electrical design will utilize the following I/O:

Table 2-8 Post-anoxic Basin Mixer I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Run Command</td>
<td>PLC signal to run the motor</td>
</tr>
<tr>
<td>DI</td>
<td>Running Confirmation</td>
<td>Indicates motor contactor is energized and motor protector is not tripped</td>
</tr>
<tr>
<td>DI</td>
<td>Hand/Off/Auto Switch Position</td>
<td>Indicates the hand/off/auto switch is in the AUTO (REMOTE) position</td>
</tr>
<tr>
<td>DI</td>
<td>Moisture Switch</td>
<td>Indicates water in the motor casing, and failure of the submerged motor’s shaft seal</td>
</tr>
<tr>
<td>DI</td>
<td>Temperature Switch</td>
<td>Indicates high temperature in the motor windings. This signal is hardwired to the motor starter</td>
</tr>
</tbody>
</table>

2.8. Membrane Bioreactors (MB-01 / 02)
Membrane bioreactors (MBRs) consist of an aerated mixed liquor basin and a collection of filter cartridges. Individual filter cartridges are assembled into cassettes, which in turn make up submerged membrane units (SMUs). The SMUs are immersed in the tanks in direct contact with mixed liquor. The treated water, also called permeate or filtrate, is forced through the plate membranes by gravity and / or the permeate pumps. Air is introduced below the SMUs, producing turbulence which scours the membrane surface, transferring rejected solids away from the membrane surface. The aeration provided allows additional nitrification to occur in the membrane tank. Solids, including organics, bacteria and most viruses are rejected at the membrane surface and retained in the mixed liquor, which is then returned to the anoxic tank. Each membrane tank is assigned a mode of operation based on incoming flow and anoxic basin level. The five primary modes of operation are shown in Figure 3-1.

Each membrane basin is equipped with an automated diffuser cleaning valve (DCV). The DCV provides the capacity for periodic cleaning of the coarse-bubble diffusers at the base of each SMU. It is mounted downstream of the SMUs, on the end of the process air piping to each MBR. Electrical design will utilize the following I/O:

Table 2-9 MBR Diffuser Cleaning Valve I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Open/Close Command</td>
<td>PLC signal to open and close the valve</td>
</tr>
<tr>
<td>DI</td>
<td>Valve Closed Limit Switch</td>
<td>Limit switch in the valve actuator indicates the valve is closed</td>
</tr>
<tr>
<td>DI</td>
<td>Valve Open Limit Switch</td>
<td>Limit switch in the valve actuator indicates the valve is open</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch Position</td>
<td>Indicates the open/close/auto switch is in the AUTO (REMOTE) position</td>
</tr>
</tbody>
</table>

The HMI provides the ability to schedule multiple diffuser cleanings per day. The user may enable and disable each cleaning schedule and designate a start time for each. One operator adjustable duration set point is used for all scheduled diffuser cleanings. When the DCV opens, process air will take the path of least resistance and, instead of passing through the relatively small holes in the diffusers, will pass through the much larger hole created by the open DCV. As this happens, mixed liquor is drawn back through the coarse-bubble diffuser openings and vented along with the process air through the DCV. The combined flow of air and mixed liquor scours away collected debris in the diffusers, cleaning the small
orifices of obstructions. Diffuser cleanings are initiated sequentially between all online MBRs to minimize the interruption of permeate production.

In addition to scheduled diffuser cleanings, diffuser cleanings may also be initiated after each Intermittent mode air pulse to an MBR. These cleanings use a second operator adjustable duration set point and may be globally enabled or disabled at the operator interface.

Each membrane basin is also equipped with two float switches to detect liquid level conditions in the basin. Upon detecting a low liquid level condition the basin an alarm is posted and the basin will be placed into Intermittent Mode until the condition clears. Upon detecting a high liquid level condition an alarm is posted, the MBR permeate header is placed into high flow, and diffuser cleaning is inhibited until the condition clears. Electrical design will utilize the following I/O:

Table 2-10 MBR Basin Level Instrument I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI</td>
<td>High Level Switch</td>
<td>LSH – Provides high level alarm</td>
</tr>
<tr>
<td>DI</td>
<td>Low Level Switch</td>
<td>LSL – Provides low level alarm</td>
</tr>
</tbody>
</table>

2.9. Membrane Thickener Basin (MBT-01)

The Membrane Thickener (MBT) basin is physically similar to the MBR basins, however, the primary function of the MBT is to concentrate solids for removal from the system. Mixed liquor flow into the MBT will be manually adjusted so that it is significantly less that the mixed liquor flow to the MBR basins. The MBT shall also be operator selectable for service as a third MBR basin if additional treatment capacity is required.

Like the MBR basins, the membrane thickener basin is equipped with an automated diffuser cleaning valve (DCV) for cleaning of the coarse-bubble diffusers. Electrical design will utilize the following I/O:

Table 2-11 MBR Diffuser Cleaning Valve I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Open/Close Command</td>
<td>PLC signal to open and close the valve</td>
</tr>
<tr>
<td>DI</td>
<td>Valve Closed Limit Switch</td>
<td>Limit switch in the valve actuator indicates the valve is closed</td>
</tr>
<tr>
<td>DI</td>
<td>Valve Open Limit Switch</td>
<td>Limit switch in the valve actuator indicates the valve is open</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch Position</td>
<td>Indicates the open/close/auto switch is in the AUTO (REMOTE) position</td>
</tr>
</tbody>
</table>

The HMI provides the ability to schedule multiple diffuser cleanings per day. The operator assigns diffuser cleaning cycle duration, start time and enables the cycles.

The membrane thickener basin is also equipped with two float switches to detect liquid level conditions in the basin. Upon detecting a low liquid level condition the basin an alarm is posted and the basin will be placed into Intermittent Mode until the condition clears. Upon detecting a high liquid level a high level alarm is initiated. Electrical design will utilize the following I/O:

Table 2-12 MBT Basin Level Instrument I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI</td>
<td>High Level Switch</td>
<td>LSH – Provides high level alarm</td>
</tr>
<tr>
<td>DI</td>
<td>Low Level Switch</td>
<td>LSL – Provides low level alarm</td>
</tr>
</tbody>
</table>
2.10. MBR Permeate Collection

2.10.1. Permeate Flow Control Valve

From all of the filter cartridges within each MBR basin, permeate is collected into a header. Each MBR basin has a dedicated permeate header. Under normal conditions, permeate flow through the membranes is gravity driven. The appropriate permeate flow setting is maintained by modulating flow control valves for each on-line MBR basin. Valve position can be manually overridden from the HMI.

Each permeate header includes instruments for measuring permeate header pressure and flow and a solenoid operated vent valve. The pressure sensor uses a sealed diaphragm without process isolation, and has a fixed range of -15 to +15 psig. The flow meter is a magnetic type with field-adjustable range and scaling. Flow and pressure are monitored and recorded at all times. The vent valve is opened as required to release trapped air from the permeate header.

Electrical design will utilize the following I/O:

Table 2-13 Permeate Collection Instrumentation I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Permeate Pressure Indication</td>
<td>4-20 mA signal proportional to pressure</td>
</tr>
<tr>
<td>AI</td>
<td>Permeate Flow Rate Indication</td>
<td>4-20 mA signal proportional to flow rate</td>
</tr>
<tr>
<td>AO</td>
<td>Permeate Flow Control Valve Position Command</td>
<td>PLC signal to the valve setting the valve position.</td>
</tr>
<tr>
<td>DI</td>
<td>Permeate Flow Control Valve Closed Indication</td>
<td>Limit switch in valve actuator confirms the valve is closed</td>
</tr>
<tr>
<td>DI</td>
<td>Permeate Header Vent Valve Local/Remote Switch</td>
<td>Indicates the hand/off/auto switch is in the AUTO (REMOTE) position</td>
</tr>
<tr>
<td>DO</td>
<td>Permeate Header Vent Valve Open Command</td>
<td>Relay output to the open the solenoid valve</td>
</tr>
</tbody>
</table>

In the event that sufficient permeate flow cannot be maintained by gravity alone, a pump is provided for each header. The pumps start when the permeate flow is sufficiently less than the required setting. The pumps continue to run until the required flow is restored by gravity alone, or until the operator manually stops them. Pump speed is operator adjustable from the HMI.

The permeate pump electrical design will utilize the following I/O:

Table 2-14 Permeate Pump I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Run Command</td>
<td>Start/stop signal to the VFD to run the motor</td>
</tr>
<tr>
<td>DI</td>
<td>Running Confirmation</td>
<td>Feedback from the VFD to indicate that it is running</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch Position</td>
<td>Indicates the hand/off/auto switch is in the AUTO (REMOTE) position</td>
</tr>
</tbody>
</table>

If the membranes become fouled and permeability decreases below an adjustable limit, an alarm is posted and the PLC automatically begins reducing the rate of filtration for the affected permeate header in order to maintain an operator adjustable permeability control set point (see Section 0) to prevent further fouling, thus continuing the filtration cycle. If the fouling trend continues, and the TMP increases above the limit set by the operator, an alarm will be posted, the MBRs will transition into intermittent Mode, and filtration will stop.

A turbidimeter analyzes a side-stream sample for the combined permeate discharge to indicate how well the system is filtering solids. If the turbidity rises above an adjustable limit, an alarm is posted but filtration continues. Turbidity is monitored and recorded at all times. Electrical design will utilize the following I/O:
Table 2-15 Permeate Turbidimeter I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Permeate Turbidity</td>
<td>4-20 mA signal proportional to turbidity</td>
</tr>
</tbody>
</table>

2.11. MBT Permeate Collection

2.11.1. MBT Permeate Collection Instrumentation I/O

The MBT permeate header includes instruments for measuring permeate header pressure and flow. The pressure sensor uses a sealed diaphragm without process isolation, and has a fixed range of -15 to +15 psig. The flow meter is a magnetic type with field-adjustable range and scaling. Flow and pressure are monitored and recorded at all times.

Electrical design will utilize the following I/O:

Table 2-16 MBT Permeate Collection Instrumentation I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Permeate Pressure Indication</td>
<td>4-20 mA signal proportional to pressure</td>
</tr>
<tr>
<td>AI</td>
<td>Permeate Flow Rate Indication</td>
<td>4-20 mA signal proportional to flow rate</td>
</tr>
</tbody>
</table>

2.11.2. MBT Permeate Pump

Permeate flow from the membrane thickener is induced by a progressive cavity pump, driven by a variable speed drive (VFD). The calculated permeate flow setting is maintained by modulating the speed of the pump. VFD speed can be manually overridden from the HMI.

Table 2-17 MBT Permeate Collection Instrumentation I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Run Command</td>
<td>Start/stop signal to the VFD to run the motor</td>
</tr>
<tr>
<td>DI</td>
<td>Running Confirmation</td>
<td>Feedback from the VFD to indicate that it is running</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch Position</td>
<td>Indicates the hand/off/auto switch is in the AUTO (REMOTE) position</td>
</tr>
<tr>
<td>AO</td>
<td>Permeate Pump VFD Speed Command</td>
<td>PLC signal to the valve setting the valve position</td>
</tr>
</tbody>
</table>

In the event that additional MBR treatment capacity is required, the MBT basin can function as an additional MBR basin. The operator must manually configure the mixed liquor weir gate, telescope valve, and switch the permeate headers, and then select MBR mode from HMI. The MBT will assume the automatic control functions of the MBR basins, described above.

2.12. Aeration

2.12.1. MBR / MBT Basin Aeration

One positive displacement blower is provided for each MBR and MBT basin. One common stand-by blower is available as a backup for the MBR blowers; this blower is also used as a backup for the membrane thickener and pre-aeration blower.

Air flow to each membrane basin is continuously monitored and recorded by a mass flow meter. The air flow indication is used to maintain adequate air flow to the MBR at various operating conditions. In the event of a low air flow condition a low MBR air flow alarm is generated. The electrical design will utilize the following I/O:
### Table 2-18 MBR / MBT Air Flow I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>MBR Scour Air Flow Indication</td>
<td>4-20 mA signal to PLC used to monitor MBR air flow</td>
</tr>
</tbody>
</table>

The MBR/MBT blowers are driven by variable frequency drives (VFDs). The electrical design will utilize the following I/O:

### Table 2-19 MBR / MBT Blower System I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Run Command</td>
<td>Start/stop signal to the VFD to run the motor</td>
</tr>
<tr>
<td>DI</td>
<td>Running Confirmation</td>
<td>Feedback from the VFD to indicate that it is running</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch Position</td>
<td>Indicates the hand/off/auto switch is in the AUTO (REMOTE) position</td>
</tr>
<tr>
<td>DI</td>
<td>Discharge Air High Temperature</td>
<td>Indicates high discharge temperature condition</td>
</tr>
<tr>
<td>AO</td>
<td>Speed Command</td>
<td>4-20 mA signal proportional to motor speed</td>
</tr>
</tbody>
</table>

#### 2.12.2. Pre-Aeration (PA) Blowers

A dedicated blower is provided for each pre-aeration basin. A common stand-by blower is available as a backup for the pre-aeration blower and MBR blowers. The PA blowers are driven by variable frequency drives (VFDs). The electrical design will utilize the following I/O:

### Table 2-20 Pre-aeration Blower I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Run Command</td>
<td>Start/stop signal to the VFD to run the motor</td>
</tr>
<tr>
<td>DI</td>
<td>Running Confirmation</td>
<td>Feedback from the VFD to indicate that it is running</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch Position</td>
<td>Indicates the hand/off/auto switch is in the AUTO (REMOTE) position</td>
</tr>
<tr>
<td>DI</td>
<td>Discharge Air High Temperature</td>
<td>Indicates high discharge temperature condition</td>
</tr>
<tr>
<td>AO</td>
<td>Speed Command</td>
<td>4-20 mA signal proportional to motor speed</td>
</tr>
</tbody>
</table>

#### 2.13. Chemical Addition

A chemical storage tank, tank mixer, tank level transmitter, and two (duty / standby) metering pumps are provided for Magnesium Hydroxide addition. The operator designates which pump is duty and which is standby at the HMI (there is no automatic switchover). The duty pump will be automatically cycled on and off by an operator adjustable repeat cycle timer. The tank mixer runs continuously except during low level conditions. Upon a low MgOH level indication, an alarm is posted at the HMI. The electrical design includes the following I/O:

### Table 2-21 Chemical Addition System I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>MgOH Pump 1 Run Command</td>
<td>PLC signal to run MgOH metering pump 1</td>
</tr>
<tr>
<td>DO</td>
<td>MgOH Pump 2 Run Command</td>
<td>PLC signal to run MgOH metering pump 2</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch “hand”</td>
<td>Feedback that MgOH mixer HOA is in HAND</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch “auto”</td>
<td>Indicates the MgOH mixer HOA is in the AUTO</td>
</tr>
<tr>
<td>DO</td>
<td>MgOH Mixer Run Command</td>
<td>PLC signal to run MgOH tank mixer</td>
</tr>
<tr>
<td>AI</td>
<td>MgOH Storage Tank Level</td>
<td>indicates tank level, alarms on low level</td>
</tr>
</tbody>
</table>

#### 2.14. Membrane Clean-in-Place System

The CIP system supplies dilute cleaning chemicals for removing accumulated biological growth from the MBR filtration surface. The cleaning is performed after an MBR has been placed offline and the associated basin isolated from the remainder of the system. The cleaning chemicals are transferred to
the cassettes to be cleaned in a manner that fills the inside of the cassettes with the cleaning solution, displacing water inside the cassettes back through the membrane into the MBR basin.

The CIP system consists of an actuated water supply valve, a pressure regulating valve, an eductor, and a flow transmitter. The flow rate transmitter is a magnetic flow-sensing style sensor/indicator/transmitter that has been factory calibrated and spanned to the expected flow range. Electrical design will utilize the following I/O:

### Table 2-22 CIP System I/O

<table>
<thead>
<tr>
<th>I/O Type</th>
<th>Purpose</th>
<th>Notes / Related Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>Open/Close Command</td>
<td>PLC signal to the valve setting the valve position.</td>
</tr>
<tr>
<td>DI</td>
<td>Valve Closed Limit Switch</td>
<td>Limit switch in the valve actuator indicates the valve is closed</td>
</tr>
<tr>
<td>DI</td>
<td>Valve Open Limit Switch</td>
<td>Limit switch in the valve actuator indicates the valve is open</td>
</tr>
<tr>
<td>DI</td>
<td>Local/Remote Switch Position</td>
<td>Indicates the open/close/auto switch is in the AUTO (REMOTE) position</td>
</tr>
<tr>
<td>AI</td>
<td>Process Water Flow Rate Indication</td>
<td>4-20 mA signal proportional to flow rate</td>
</tr>
</tbody>
</table>

Periodic Maintenance Cleans (MCs) are performed only after the bio-film layer has built up beyond the control of the air scour and permeate header relax state cleaning operations designed to maintain optimum biofilm thickness. The entire process is carried out in-situ without draining mixed liquor.

The logic associated with the CIP control is almost exclusively based on menu-driven instructions from the HMI. This is due to a dependency on the operator to perform a series of related manual tasks.

The HMI has the following buttons/selectors which the PLC will monitor:
- a. Buttons defining which MBR basin is to be cleaned
- b. Transfer Start
- c. Transfer Stop/Pause
- d. Soak Timer Start
- e. Soak Timer Stop/Pause
- f. Soak Timer Reset
- g. Transfer Total Reset

The PLC accepts the following numeric inputs from the HMI:
- a. Target Transfer Volume

The PLC provides the following information to the HMI:
- a. Totalized chemical flow volume (gallons)
- b. Soak time

When an MBR basin has been placed offline and selected for CIP, the PLC will show the MBR basin mode as Membrane Clean and open the solenoid vent valve for the selected MBR permeate headers. The operator must ensure that all manual valves are in the proper position for chemical delivery to an upper or lower bank of membrane units within one MBR. The transfer sequence is initiated at the HMI by using the start button to open the water supply valve to the CIP system and begin totalizing the flow to the membrane basin. When the totalized chemical volume equals the input target transfer volume, the PLC will close the water supply valve. While the cleaning chemicals are being transferred, if the transfer Stop/Pause button is selected, the PLC will close the water supply valve. If the Start button is again selected, the PLC will open the water valve until the target volume has been transferred or the Stop/Pause button is again selected. The PLC will zero the totalized chemical flow volume when the Transfer Total Reset button is selected. The PLC will start the soak timer when the Soak Timer Start
button is selected and the timer will count up and begin totalizing the elapsed time. The total elapsed time is for display only and has no impact on CIP controls. The PLC will stop the soak timer when the Soak Timer stop/Pause button is selected by the operator.

**Figure 2-3 Membrane CIP System**

![Membrane CIP System Diagram]

**Table 2-23 CIP Components**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pressure Regulator Inlet</td>
</tr>
<tr>
<td>2</td>
<td>Pressure Regulator Outlet</td>
</tr>
<tr>
<td>3</td>
<td>Makeup Water Supply Valve</td>
</tr>
<tr>
<td>4</td>
<td>Mazzei Eductor</td>
</tr>
<tr>
<td>5</td>
<td>Isolation Valve</td>
</tr>
<tr>
<td>6</td>
<td>CIP Flow Meter</td>
</tr>
<tr>
<td>7</td>
<td>Chemical Tote</td>
</tr>
</tbody>
</table>
3 MBR Operations

3.1. Mode & State Descriptions
Ovivo MBR systems are comprised of equipment subsets, each supporting a unique function within the overall system (eg. permeate pumps, RAS pumps, process air blowers). Ovivo uses the term Modes to define the unique combinations of the equipment states that are used to support the various process conditions needed during the treatment of wastewater. Mode terms are used to describe system conditions for the overall Plant, for individual Trains within the plant, and for describing the status of the MBRs within a train. Within the MBRs, there are also States that are used to describe the zones' supporting subsystems. The various Modes and States are shown below and subsequently discussed.

Figure 3-1 Modes and States

<table>
<thead>
<tr>
<th>MBR Process Mode</th>
<th>Offline</th>
<th>Online</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Train Mode</td>
<td>Offline</td>
<td>Intermittent / Filter</td>
</tr>
<tr>
<td>MBR Mode</td>
<td>Offline</td>
<td>Membrane Clean</td>
</tr>
<tr>
<td>MBR Aeration Header State</td>
<td>Offline</td>
<td>Diffuser Clean</td>
</tr>
<tr>
<td>Permeate Production Mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permeate Header State</td>
<td>Offline</td>
<td>No Flow</td>
</tr>
</tbody>
</table>

3.2. Plant Modes
*Offline Mode* – Offline is a condition in which the PLC has been instructed (via the HMI) to halt all process operations. No automatic control of the system will occur when the plant is placed Offline.

*Online Mode* – Online indicates that the PLC is controlling the system operations based on the measured conditions and process set points.

The transition between Online and Offline is accomplished through the Startup and Shutdown procedures initiated at the HMI.
3.3. Process Train Modes

*Offline* – Offline is a condition in which the PLC has been instructed (via the HMI) to halt all process operations. No automatic control will occur when the process train is placed Offline.

*Intermittent* – The MBR process is in Intermittent Mode when the incoming flow or the level in the controlling basin is below the level necessary for permeate production.

*Filter* – The process train is in Filter Mode when the incoming flow or the level in the controlling basin is high enough to begin permeate production. The actual modes and states of the zones within the MBR process will be dictated by the various set points and commands from the operator interface. (For example, the process train can be in Filter mode while one of its MBR basins is Offline due to an operator selecting the MBR Offline button at the HMI.)

3.4. MBR Modes

1. *Offline Mode* – Offline is a condition in which all equipment supporting an MBR is off (in the case of a motor) or closed (in the case of a valve). A membrane basin may be placed offline via a button at the operator Interface.

2. *Membrane Clean* – Membrane Clean refers to a state unique to the MBR basins in which the basin has been taken Offline and the clean-in-place (CIP) process has been initiated at the operator interface.

3. *Diffuser Clean* – Diffuser Clean refers to a state in which the coarse bubble diffusers at the base of the MBR SMUs are cleaned of accumulated debris. During this process, permeate production is paused and process air to the MBR basin is initiated. Diffuser cleaning occurs a minimum of once per day.

4. *Intermittent Mode* – In Intermittent, permeate production has stopped. The term intermittent stems from the periodic operation of the process air blowers to pulse air into the MBR basins to support the nitrification process.

5. *Filter Mode* – In Filter Mode, the system is producing permeate. The rate at which permeate is produced is dictated permeate production mode.

3.5. Permeate Header States

The MBR permeate header will alternate between eight states based level in the influent lift station, operator commands, and equipment availability.

1. *Offline Mode* – The permeate header is Offline when the basin(s) that is supports is Offline or in Membrane Clean.

2. *No Flow* – The permeate header is in No Flow when the basin(s) that is supports is in Intermittent or Diffuser Clean.

3. *Low Flow* – A header in Low Flow produces permeate at a rate usually equal to half of the average rated throughput of that header.

4. *Medium Flow* – A header in Medium Flow produces permeate at a rate usually equal to the average rated throughput of that header.

5. *High Flow* - A header in High Flow produces permeate at a rate usually equal to the maximum rated throughput of that header.
6. Relax – During Relax, permeate production temporarily stops while scour air continues to flow across the membrane surface. During permeate production the surfaces of the cartridges are pulled slightly inward due to the differential pressure across them. By stopping the permeate flow, the membranes relax (return to a flat profile) and allow the scour air to more effectively remove any accumulated material.

7. Permeability Control – A header in Permeability Control produces permeate at a reduced rate in order to maintain an operator entered minimum permeability value. This state is initiated when a measured increase in the pressure drop across the MBR filter surface is detected.

3.6. MBR Permeate Flow Control
3.6.1. Level Based Permeate Control
In level based permeate control; mode selection is a function of anoxic basin water level. Permeate flow throughput is set to match operator adjustable inputs corresponding to Low, Medium, and High flow rates.

Table 3-1 Sample Level Based Flow Control Matrix

<table>
<thead>
<tr>
<th>Flow Condition/State</th>
<th>Controlling Basin Level</th>
<th>Process Train Mode</th>
<th>Online Permeate Header Flux Rate</th>
<th>Online Permeate Header Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm Low Level</td>
<td>&lt;3 ft.</td>
<td>Intermittent</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No Flow</td>
<td>&lt;6 ft.</td>
<td>Intermittent</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Low Flow</td>
<td>&gt;10 ft.</td>
<td>Filter</td>
<td>½ Q</td>
<td>½ Q</td>
</tr>
<tr>
<td>Medium Flow</td>
<td>&gt;11 ft.</td>
<td>Filter</td>
<td>Q</td>
<td>Q</td>
</tr>
<tr>
<td>High Flow</td>
<td>&gt;12 ft.</td>
<td>Filter</td>
<td>2Q</td>
<td>2Q</td>
</tr>
<tr>
<td>Alarm High Level</td>
<td>&gt;19 ft.</td>
<td>Filter</td>
<td>2Q</td>
<td>2Q</td>
</tr>
</tbody>
</table>

A low alarm level condition as detected by the level transmitter or low level switch will immediately place all online MBRs in Intermittent mode and stop all rotating equipment in the basin with the low level. The PLC will generate an alarm for the condition. When the low level condition is cleared, rotating equipment modes and states will transition back to that indicated by the basin level.

A low level (no flow) condition as detected by the level transmitter will immediately place all online basins in Intermittent mode. Rotating equipment continues to operate as indicated by the basin level. When the low level condition is cleared, the flow modes and states of the permeate headers will transition back to that indicated by the basin level.

A high level (high flow) condition as detected by the level transmitter will immediately place all online basins in High Flow mode. When the high level condition is cleared, the flow modes and states of the permeate headers will transition back to that indicated by the basin level.

A high alarm level condition as detected by the level transmitter or high level switch will immediately place all online basins in High Flow mode. The PLC will generate an alarm for the condition. When the high level condition is cleared, the flow modes and states of the permeate headers will transition back to that indicated by the basin level.

If conflicting low and high level alarms are received by the PLC, the high level alarm shall take priority and all online basins shall be placed into Filter mode. The flow modes and states of the permeate headers will transition to that indicated by a high level.

3.6.2. Level Based Control Transition
Under level based permeate flow control, the PLC is programmed to change the permeate set point of one permeate header at a time. This avoids a relatively large step-function change of permeate flow rate in response to a possibly small change in incoming flow rate. In addition, as permeate flow is increased in response to demand, a single permeate header group is brought up to a Medium Flow state prior to bringing the other permeate header on line. This minimizes the number of blowers running in support of the MBR basins, resulting in less on/off cycling of blowers and lowered energy consumption. Lead MBR
basin assignment is rotated after the expiration of a user defined period of continuous automatic operation, typically 24 hours, or by selection at the HMI.

The following sample control logic describes how Level Based Permeate Control for one controlling (averaged) basin level and 4 MBRs headers is controlled.

### Table 3-2 Variables for Level Based Mode and State Transitions with One Controlling Level

<table>
<thead>
<tr>
<th>Operator Input</th>
<th>Control Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>( L_{lal} )</td>
<td>Low level alarm height in controlling basin, ft. (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( L_{lflow} )</td>
<td>Low flow height in controlling basin, ft. (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( L_{mflow} )</td>
<td>Medium flow height in controlling basin, ft. (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( L_{hflow} )</td>
<td>High flow height in controlling basin, ft. (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( L_{lah} )</td>
<td>High level alarm height in controlling basin, ft. (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( \text{FlowSP}_{low} )</td>
<td>Target flow rate for any permeate header in a Low Flow state, gpm (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( \text{FlowSP}_{med} )</td>
<td>Target flow rate for any permeate header in a Medium Flow state, gpm (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( \text{FlowSP}_{hi} )</td>
<td>Target flow rate for any permeate header in a High Flow state, gpm (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( \text{Tdm} )</td>
<td>Mode change time delay, min (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( \text{Lead MBR} )</td>
<td>MBR assigned as the lead MBR by the PLC (operator adjustable from HMI)</td>
</tr>
<tr>
<td>( \text{Lag MBR} )</td>
<td>MBR assigned as the first lag MBR by the PLC (operator adjustable from HMI)</td>
</tr>
</tbody>
</table>

### Table 3-3 Level Based Control State Transition Logic (Averaged Level)

<table>
<thead>
<tr>
<th>Controlling Basin Level</th>
<th>Permeate Setpoint Incrementing Logic</th>
</tr>
</thead>
</table>
| \( L_{lal} \)           | 1. Immediately place all online MBR basins into Intermittent mode.  
                          | 2. Immediately place all online flow headers into No Flow state.  |
| Below \( L_{lflow} \)   | 1. If any process trains are in Filter mode, evaluate conditions every \( Tdm \) minutes  
                          | 2. At the end of \( Tdm \) minutes:  
                          | a. Remove the highest increment of capacity  
                          | b. Repeat until all MBRs are in Intermittent  |
| Between \( L_{lflow} \)  | Evaluate conditions every \( Tdm \) minutes  
                          | At the end of \( Tdm \) minutes:  
                          | If less than one third of the total Online increments of flow capacity are active, increase the active number by one  
                          | If more than one third of the total Online increments of flow capacity are active, decrease the active number by one.  
                          | Repeat until the number of active flow increments equals one third of the online flow capacity  |
| and \( L_{mflow} \)      | 1. Evaluate conditions every \( Tdm \) minutes  
                          | 2. At the end of \( Tdm \) minutes:  
                          | a. If less than two thirds of the total online increments of flow capacity are active, increase the active number by one  
                          | b. If more than two thirds of the total online increments of flow capacity are active, decrease the active number by one.  
                          | 3. Repeat until the number of active flow increments equals two thirds of the online flow capacity  |
| Above \( L_{hflow} \)    | Evaluate conditions every \( Tdm \) minutes  
                          | At the end of \( Tdm \) minutes:  
                          | If all online flow capacity is not active, increase the active number by one  
                          | Repeat until all online flow capacity is active  |
1. Immediately place all online MBRs to Filter mode. The other MBR will be assigned as Lag with its set points being increased accordingly.

2. The Lead, and Lag assignments will rotate automatically at an operator adjustable frequency. They can also be rotated manually at the HMI.

3. If a Lead MBR is taken offline or forced to intermittent due to an alarm condition, the PLC will rotate the Lead and Lag assignments to the remaining online MBRs.

4. If a Lag MBR is taken offline or forced to intermittent due to an alarm condition, the PLC will rotate the Lag assignments to the remaining online train. When the failed Lag train is again available, the lag assignments will reset to their previous order.

5. Each permeate header will be assigned a discrete flow set points equal to the rate of permeate production when it is in a Low, Medium, and High flow state. Each flow state for each header will represent one increment of flow capacity. (For this plant, the 3 flow states x 2 MBRs results in 6 increments of flow capacity.)

6. The PLC will assign 5 level set points for the influent basin level, defined as:
   a. Alarm Low Level
   b. Low Flow Level
   c. Medium Flow Level
   d. High Flow Level
   e. Alarm High Level

7. The mode change time delay will be used for all mode and flow state transitions related to the measured controlling basin depth (both rising and falling levels).

8. Using the Lead and Lag MBR assignments, the PLC will set the order in which the flow capacity is brought online. (See Figure 3-2)
   a. The first two flow increments are the Lead train Low and Medium flow states
   b. After the Lead MBR is at a Medium flow state, the Lag MBR will be stepped to Low then Medium flow states as required.
   c. After both MBRs are at a Medium flow state, the PLC will increment the system flow capacity by bringing each MBR up to a High flow state starting with the Lead MBR and then the Lag MBR.
   d. When decreasing the system flow capacity, the PLC will decrement the flow capacity in the opposite order in which it was increased

The PLC will increment and decrement the permeate flow capacity as described in Figure 3-2.
3.6.3. Transmembrane Pressure (TMP)

Transmembrane pressure (TMP) is a measure of how much force it takes for the clean water to pass through the filter media. The amount of force required for a given flow rate will increase as the amount of solids on the surface of the filter membrane increases. The measurement is used for two main purposes:

1. As part of the permeability calculation (discussed below)
2. As an absolute gauge to indicate when the membranes have become too fouled to continue operation

The calculation of TMP requires a correlation between flow and piping loss and additional logic to estimate static pressure.

The equation for calculating the TMP is given by:

**Equation 3-1 TMP Calculation**

\[
TMP = P_S - P_P - P_G
\]

Where,

- \( P_P \) = Piping system losses
- \( P_G \) = Gauge pressure reading during filtration (from the permeate pressure transmitter)
- \( P_S \) = Static pressure in the permeate header (of gauge pressure reading during no flow periods)

The piping system losses, \( P_P \), are calculated using a second order polynomial equation as follows:

**Equation 3-2 Permeate Piping System Loss Calculation**

\[
P_P \approx A \cdot X^2 + B \cdot X + C
\]
A, B, and C are constants that will be provided by Ovivo during start-up (based on clean water tests of the system). The constants will be entered via the operator interface at the Ovivo set-up screen. X is the measured flow rate of the permeate header.

The gauge pressure reading during filtration, $P_G$, is the reading from the permeate pressure transmitter.

The PLC will estimate the static pressure by recording the last static pressure measured during a relax period of no flow and set that equal to $P_S$. This means that $P_S$ is constantly being updated during no flow conditions.

**Flux**
The filtration rate per area of membrane is referred to as flux. The PLC will calculate an instantaneous flux and an average flux. The instantaneous flux is calculated as follows:

**Equation 3-3 Instantaneous Flux Calculation**

$$\text{InstFlux} = \frac{\left[\text{Flow}\left(\frac{\text{GAL}}{\text{MIN}}\right)\right] \bullet \left[1,440\left(\frac{\text{MIN}}{\text{DAY}}\right)\right]}{(\text{CAS}) \bullet (\text{CART}) \bullet (A_{\text{CART}})}$$

Where,

- $\text{Flow}$ = the permeate flow rate as measured by the permeate flow transmitter
- $\text{CAS}$ = the number of cassettes per permeate header. This will be an operator adjustable parameter entered from the HMI
- $\text{CART}$ = the number of cartridges per cassette. This will be an operator adjustable parameter entered from the HMI
- $A_{\text{CART}}$ = the filter area per cartridge. This will be an operator adjustable parameter entered from the HMI

The instantaneous flux is calculated continuously.

The average flux is a 24-hour running average of one-minute samples of the instantaneous flux, calculated as follows:

**Equation 3-4 Average Flux Calculation**

$$\text{AverageFlux} = \frac{\text{Flux}_{t=0} + \text{Flux}_{t=i} + \text{Flux}_{t=i+1} + \text{Flux}_{t=i+2} + \ldots + \text{Flux}_{t=n-1} + \text{Flux}_{t=n}}{n + 1}$$

**Permeability Control**
Permeability is calculated value used to monitor membrane performance at any permeate flow. It is defined as ratio of instantaneous flux to TMP. Permeability is continuously calculated for each permeate header.

**Equation 3-5 Permeability Calculation**

$$\text{Permeability} = \frac{\text{InstFlux}}{\text{TMP}}$$

Permeability is generally the best indication of membrane performance and can be used to control permeate flow. Permeability control allows the plant to filter as much water as possible under extreme conditions while protecting the membranes against high TMP operation. The permeate collection header
is automatically placed in this Filter Mode state if the calculated permeability falls below an operator adjustable low permeability set point.

When a low permeability condition is detected, the state of the header will change from Low, Medium, High Flow, or Flow Match to Permeability Control. At this point the permeate flow control valve will modulate to maintain a permeability equal to the low permeability alarm set point with the flow rate restricted to 7% greater than the current state flow set point.

This will continue until one of the following occurs:

The Low Permeability alarm is reset at the HMI. The flow control valve will then return to flow-based control.

The measured flow rate rises 5% or more above the target flow for the present state (Low, Medium, or High) for a period equal to the mode change time delay. If this happens, the PLC will automatically reset the low permeability alarm and resume flow-based control.

The measured flow rate falls 5% or more below the Low Flow state target flow rate for a period equal to the mode change time delay. If this happens, the PLC will generate a second alarm and place the system into Intermittent. In this condition, the alarm will only be reset by the user at the HMI.

**Permeability Control Example**

In the figure below, a header is in filter mode at a Low flow based on the controlling basin water level at Point A. At Point B, the PLC automatically transitions the header to Permeability Control when the calculated permeability falls below the low permeability set point. Notice that the flow (upper curve) drops off as the PLC tries to increase permeability for the affected header. In this example, the flow gradually increases as membrane performance improves even though the permeability stays constant. At Point C, the flow is above the current flow mode set point, as determined by the controlling basin water level, and header is taken out of Permeability Control.
### Figure 3-3 Permeability Control Example

- **FILTER MODE LOW FLOW**: 
  - Permeability = 
  - Flow = 

- **FILTER MODE PERM. CONTROL**: 
  - C

- **FILTER MODE MED. FLOW**

### Table 3-4 Permeability Control Example State Transitions

<table>
<thead>
<tr>
<th>Point</th>
<th>Hour</th>
<th>MODE</th>
<th>STATE</th>
<th>Notes</th>
<th>New Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>00:00</td>
<td>FILTER</td>
<td>CALC. FLOW</td>
<td>Calc. permeability &gt; LPS</td>
<td>NO</td>
</tr>
<tr>
<td>B</td>
<td>11:00</td>
<td>FILTER</td>
<td>PERM. CONTROL</td>
<td>Calc. permeability = LPS</td>
<td>YES</td>
</tr>
<tr>
<td>C</td>
<td>18:00</td>
<td>FILTER</td>
<td>CALC. FLOW</td>
<td>Calc. permeability &gt; LPS</td>
<td>NO</td>
</tr>
</tbody>
</table>
3.7. MBR Aeration Header Status

The MBR aeration headers will alternate between seven states based on the mode in which the MBRs are operating and the state of the supporting permeate headers. These states are related to the set point for the permeate production.

1. **Offline Mode** – The aeration header is Offline when the basin(s) that it supports is Offline.

2. **Diffuser Clean** - Diffuser Clean refers to a state in which the coarse bubble diffusers at the base of the MBR SMUs are cleaned of accumulated debris. During this process, permeate production is paused and process air to the MBR basin is initiated. Diffuser cleaning occurs a minimum of once per day.

3. **No Flow** – The aeration header is in No Flow when the basin(s) that it supports is in Intermittent. In Intermittent air flow to the basin is stopped for an operator adjustable frequency and duration.

4. **Intermittent Pulse** – The aeration header is in Intermittent when the basin(s) that it supports is in Intermittent. In Intermittent Pulse air flow to the basin is initiated for an operator adjustable frequency and duration.

5. **Flux Based Aeration** – When the operator enables Flux Based Aeration, the system modulates air flow to each MBR in proportion to the MBR’s permeate flow setpoint.

6. **Low Flow** – Low Flow is one of four air flow set-point-related states under the MBR Filter Mode. When in level-based control, and the permeate header is operating at low flow, the associated air header will operate at its low flow setpoint. When in flow based control, the air header will operate at its low flow setpoint when the permeate header is operating at less than 75% of its medium flow setting (from level-based control).

7. **Medium Flow** – Medium Flow is one of four air flow set-point-related states under the MBR Filter Mode. When in level-based control, the air header will operate at its medium flow setting when the associated permeate header is operating at its medium setting. When in flow-based control, the air header will operate at its medium flow setting when the associated permeate header is between 75% and 125% of the medium flow setting (from level-based control).

8. **High Flow** – High Flow is one of four air flow set-point-related states under the MBR Filter Mode. When in level-based control, the air header will operate at its high flow setting when the associated permeate header is operating at its high setting. When in flow-based control, the air header will operate at its high flow setting when the associated permeate header is operating at more than 125% of the medium flow setting (from level-based control).

### 3.7.1 MBR Basin Air Flow Calculation

MBR airflow is required during the following modes/conditions:

- a. Intermittent Pulse
- b. Filter
- c. Membrane Relax
- d. Diffuser Clean

During Intermittent Pulse and Diffuser Clean, the air flow setpoint is set to a fixed value which is entered by the operator.
During Filter Mode, the air flow set point for each MBR aeration header is calculated based on one of two schemes selected by the operator. Using the HMI, the operator may select whether the system uses three distinct air flow settings, or varies airflow in proportion to permeate flow.

When the operator selects the Hi/Med/Low scheme, the MBR air flows are set to one of three values, depending on the state of the permeate header. The following air flow set points are operator entered at the HMI:

- Air flow per cartridge High, SP<sub>high</sub>
- Air flow per cartridge Medium, SP<sub>med</sub>
- Air flow per cartridge Low SP<sub>low</sub>
- Air flow per cartridge Intermittent/Diffuser Clean, SP<sub>int</sub>

When the operator selects Proportional Aeration, the MBR air Flow setpoint is calculated as follows:

\[
\text{MBR Air Flow Setpoint} = y^*((d*0.4335+p)/14.7), \text{ (SCFM / Cartridge)}
\]

Where

- \(d\) = MBR diffuser depth, ft.
- \(p\) = \(14.696 * e^{-0.000116546 * h * 0.3048}\)
- \(h\) = elevation

If Flux \(\leq 25.8\), then

- \(y\) = 0.0076 * Flux + 0.1251 for FS SMUs
- \(y\) = 0.0059 * Flux + 0.0975 for ES SMUs
- \(y\) = 0.0038 * Flux + 0.0629 for EK SMUs
- \(y\) = 0.0057 * Flux + 0.0936 for EM and RM SMUs
- \(y\) = 0.0037 * Flux + 0.0606 for EW and RW SMUs

If Flux > 25.8, then

- \(y\) = 0.3211 for FS SMUs
- \(y\) = 0.2503 for ES SMUs
- \(y\) = 0.1615 for EK SMUs
- \(y\) = 0.2402 for EM and RM SMUs
- \(y\) = 0.1555 for EW and RW SMUs

The preceding “proportional” calculation and the three Hi / Med / Low settings are based on units of SCFM per MBR cartridge. This is converted to an actual Flow setting as follows:

**Equation 3-6 MBR Air Flow Calculation**

\[
\begin{align*}
\text{MBRAirSP} &= \text{AirFlowSP}_{\text{Low,Med,High}} \cdot (\text{MBR}) \cdot (\text{SMU}_{\text{MBR}}) \cdot (\text{CAS}_{\text{SMU}}) \cdot (\text{CART})
\end{align*}
\]

Where,

- \(\text{MBR}\) = the number of MBR basins supported by the blower (or air flow control valve) and air flow transmitter
- \(\text{SMU}_{\text{MBR}}\) = the number of SMUs per membrane basin
- \(\text{CAS}_{\text{SMU}}\) = the number of cassettes per SMU
- \(\text{CART}\) = equals the number of cartridges per cassette

During Permeability Control Mode, the air flow set point is equal to high air flow set point.

### 3.8. MBR Mode Selection

Each of the Modes and their respective states indicate the current objective of subsystems and the status of related components. The operator sets the mode of the plant (OFFLINE or ONLINE) and the PLC
automatically determines the mode and state of the MBRs and permeate headers based on the operator selected method of permeate production, the measured incoming flow, the measured basin levels, and status / availability of MBR aeration and permeate production equipment.

The following monitored parameters will determine the operating modes and states of the MBR Zone and supporting systems:

1. Is the MBR Online – An MBR basin may be taken Offline via the operator interface (HMI). The PLC will monitor the status of the MBR Online/Offline HMI selector to determine the availability of each MBR basin.
2. What is the depth of the controlling basin – The depth of the controlling basin will define the permeate production rate set point as well as whether the train is to be in Intermittent mode.
3. Is the Membrane Relax Timer active
4. Is the Diffuser Clean Timer active
5. Is the Intermittent Pulse Timer active
6. Is the Membrane Clean Sequence active

Table 3-5 summarizes the conditions of each monitored parameter and their status for each of the systems modes and states.

**Table 3-5 MBR Modes and Related Parameters (Logic Diagram Only)**

<table>
<thead>
<tr>
<th>Control Mode(State)</th>
<th>Monitored Parameters (Inputs)</th>
<th>Influent Flow &gt; Low Flow SP</th>
<th>Control Basin Level &lt; Low SP</th>
<th>Membrane Relax Timer Active</th>
<th>Diffuser Clean Timer Active</th>
<th>Intermittent Pulse Timer Active</th>
<th>Membrane Clean Sequence Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offline</td>
<td>FALSE</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>Intermittent</td>
<td>TRUE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>(Intermittent Pulse)</td>
<td>TRUE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
<tr>
<td>Filter</td>
<td>TRUE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>(Relax)</td>
<td>TRUE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>Membrane Clean</td>
<td>FALSE</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
<tr>
<td>Diffuser Clean During Filter</td>
<td>TRUE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>Diffuser Clean During Intermittent</td>
<td>TRUE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
</tbody>
</table>
3.9. Main Interlocks
Most MBR components and associated subsystems, including aeration and permeate headers act independently. However, there are six common interlocks that will reduce permeate production and/or place the MBRs into Intermittent mode. These critical interlocks are as follows:

1. Permeability control failure
2. No permeate pumps available or flow control valve failure
3. Low MBR water level
4. High TMP
5. Diffuser Cleaning Valve Fail to Close
6. No or too few MBR blowers available

3.10. MBT Permeate Flow Control
Permeate Flow Rate Calculator
The following calculator is available to the operator for determining the appropriate permeate flow rate:

Equation 3-7 MBT Permeate Flow Calculation

\[ Q_p = \frac{Q_{WAS}}{1440 \text{ min/day}} \cdot \frac{T_p}{T_p + T_R} \left[ 1 - \left( \frac{C_{WAS}}{C_{TWAS}} \cdot (1 - TSR) \right) \right] \]

Where,

- \( Q_p \) = recommended permeate flow, gpm
- \( Q_{WAS} \) = waste activated sludge flow rate, gpd (operator input)
- \( T_p \) = Time permeating per relax cycle (relax frequency – relax duration), minutes
- \( T_R \) = Time in relax per relax cycle (relax duration), minutes
- \( C_{WAS} \) = waste activated sludge solids concentration, mg/L or % solids (operator input)
- \( C_{TWAS} \) = desired thickened waste activated sludge solids concentration, mg/L (operator input)
- TSR = total solids reduced in thickened digester, expressed as a fraction of the WAS total solids (operator input, default value is 0.25, typical range is 0.20-0.35)
4 Function Specific Controls

The HMI provides several function specific control pop-ups tailored to Ovivo MBR controls.

4.1. Level Calibration

The level calibration feature allows the operator to manually calibrate the signal received from a submerged level transmitter. Access to the interface is granted by clicking the level probe graphic. The calibration procedure is listed in the interface window.

Figure 4-1 Level Calibration Interface

4.2. Analog Input Overrides

The HMI provides access to an override selection dialog, containing a pair of buttons for Normal and Override, for each analog input. Access to the override dialog is gained, with proper security login, by clicking or otherwise activating the process variable text display. A tooltip is displayed at mouse over for each analog input. When Override is selected, a value may be entered which will be used by the PLC whenever there should be a non-zero value. The HMI will also indicate when an analog value is overridden by changing the color of the process variable.

Figure 4-2 Analog Override Access
4.3. Discrete Input Overrides

The HMI provides access to an override selection dialog, containing Normal and Override selections buttons, for each discrete input switch (level, actuator limit, etc…). Access to the override dialog is gained, with proper security login, by clicking or otherwise activating the discrete input or valve status text display. A tooltip is displayed at mouse over for each discrete input. When Override is selected, the PLC will assume that all valves are in the desired positions at all times and all high and low level alarms will be ignored. The states of level switches used for setting the mode of the plant are selectable. The HMI will indicate when a switch is overridden by changing the color of the Override text display.
4.4. Speed/Position Automatic Overrides
Engaging the Override function when a valve or motor is in Auto at the HMI will disengage the control loop’s response to the process variable and result in the PLC holding a fixed output whenever the system is in a mode in which the control loop would be active. An Override selector button and input value box are provided in the equipment control pop-up. The input value is 0 to 100%.

Figure 4-6 Valve OCA Pop-up Sample with Automatic PID Output and Limit Switch Override
4.5. Equipment Control
Access to equipment control displays is provided by clicking the desired apparatus. Access to these features is limited, as appropriate, based on the user login. These displays are available regardless of field mounted HOA status, and are represented as pop-up controls or windows.

Each control display window contains selectable switches to place the desired apparatus into Manual or Automatic, Start and Stop buttons, motor speed or valve position input/display, as well as a listing of permissive conditions necessary for automatic operation. The selection of Manual or Automatic control is also accompanied by visual indications (connecting lines, highlighted or grayed out items, etc…) that point out the functions available to the user in each mode.

Figure 4-7 Motor Faceplate Sample: VFD Controlled Motor
Motor status
The on-off state of motor driven equipment, such as pumps, blowers, and mixers is indicated by a set of text boxes that provide a snapshot of the equipment’s status.

Table 4-1 Motor Status Display

<table>
<thead>
<tr>
<th>Heading</th>
<th>Display</th>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCC HOA Control Status</td>
<td>Local</td>
<td>Red</td>
<td>HOA is not in the A position and the PLC does not have control of the equipment</td>
</tr>
<tr>
<td></td>
<td>Remote</td>
<td>Green</td>
<td>HOA is in the A position and the PLC does have control of the equipment</td>
</tr>
<tr>
<td>HMI Mode Status</td>
<td>Auto</td>
<td>Green</td>
<td>The motor will run based on PLC programming</td>
</tr>
<tr>
<td></td>
<td>Manual</td>
<td>Red</td>
<td>The motor will run based on Operator Input</td>
</tr>
<tr>
<td>Motor Status</td>
<td>Run</td>
<td>Green</td>
<td>Indicates that the motor is running</td>
</tr>
<tr>
<td></td>
<td>Stop</td>
<td>Red</td>
<td>Indicates that the motor is stopped</td>
</tr>
<tr>
<td>Motor Failure</td>
<td>Fail</td>
<td>Blink Yellow</td>
<td>in alarm Solid Yellow = acknowledged alarm but not cleared White = no alarm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Indicates an unsuccessful request by the PLC to start or run the motor</td>
</tr>
<tr>
<td>Motor Fault (Optional)</td>
<td>Fault</td>
<td>Blink Yellow</td>
<td>in alarm Solid Yellow = acknowledged alarm but not cleared White = no alarm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Based on hardwired signals (aux contacts or VFD output)</td>
</tr>
<tr>
<td>Speed Indication</td>
<td>VFD: ###%</td>
<td>White</td>
<td>not in override Pink = in override</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Indicates the output signal to the motor VFD. When the system is in Rem and Auto, this will be the PLC output. When the system is in Rem and Man, the operator can type in the speed to manually control the VFD</td>
</tr>
<tr>
<td>Internal Temperature Sensor</td>
<td>Hi Temp</td>
<td>Blink Yellow</td>
<td>in alarm Solid Yellow = acknowledged alarm but not cleared White = no alarm</td>
</tr>
<tr>
<td>Internal Moisture Sensor</td>
<td>Hi Temp</td>
<td>Blink Yellow</td>
<td>in alarm Solid Yellow = acknowledged alarm but not cleared White = no alarm</td>
</tr>
<tr>
<td>Override</td>
<td>Override</td>
<td>Pink</td>
<td>Active Green = Inactive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Motor/VFD Speed Auto-Override indication</td>
</tr>
</tbody>
</table>

Figure 4-8 Sample Motor Status Displays

Motor status is also indicated by changing the color of the motor graphic or graphic outline according to the following color scheme:

- Off/Not Running – Red
- On/Running -- Green
Valve Status
Actuated valves include a set of text boxes that provide a snapshot of the equipment’s status.

Table 4-2 Valve Status Display

<table>
<thead>
<tr>
<th>Heading</th>
<th>Display</th>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCC HOA Control Status</td>
<td>Local</td>
<td>Red</td>
<td>HOA is not in the A position and the PLC does not have control of the equipment</td>
</tr>
<tr>
<td></td>
<td>Remote</td>
<td>Green</td>
<td>HOA is in the A position and the PLC does have control of the equipment</td>
</tr>
<tr>
<td>HMI Mode Status</td>
<td>Auto</td>
<td>Green</td>
<td>The valve will operate based on PLC programming</td>
</tr>
<tr>
<td></td>
<td>Manual</td>
<td>Red</td>
<td>The valve will operate based on Operator Input</td>
</tr>
<tr>
<td>Valve Status</td>
<td>Open</td>
<td>Green</td>
<td>Indicates that the valve is open</td>
</tr>
<tr>
<td></td>
<td>Closed</td>
<td>Red</td>
<td>Indicates that the valve is closed</td>
</tr>
<tr>
<td></td>
<td>Traveling (Optional)</td>
<td>Yellow</td>
<td>Indicates that the valve is between the open and closed states</td>
</tr>
<tr>
<td>Valve Position Failure</td>
<td>Failure</td>
<td>Blink Yellow = in alarm Solid Yellow = acknowledged alarm but not cleared White = no alarm</td>
<td>Indicates an unsuccessful request by the PLC to open or close the valve.</td>
</tr>
<tr>
<td>Valve Position Command Indication</td>
<td>%Opn: ###</td>
<td>White</td>
<td>Indicates the output signal to the valve positioning board. When the system is in Rem and Auto, this will be the PLC output. When the system is in Rem and Man, the operator can type in a value to manually control the valve position</td>
</tr>
<tr>
<td>Override</td>
<td>Override</td>
<td>Pink = Active Green = Inactive</td>
<td>Valve position or limit switch override indication</td>
</tr>
</tbody>
</table>

Figure 4-9 Valve Status Displays

Valve status is also indicated by changing the color of the valve actuator graphic or graphic outline according to the following color scheme:

- Closed – Red
- Open – Green
- In Transition – Yellow (non-modulating valves)

4.6. Local Control
In addition to soft (computer) controls, hardwired switches can be used to run all components at a loss of PLC operation. All motors can be operated automatically or manually by changing position of the HAND-OFF-AUTO (HOA) switch, located at the front of the MCP or MCC. When the switch is in the AUTO position, the PLC has complete control of the motor including all logic functions, permissives, and lock-outs. In the HAND position, the motor will start immediately, bypassing all PLC control. In OFF the motor will not start.
5 Alarm Listing

Table 5-1 contains an alphabetical listing of standard alarm messages. Not all alarms are critical and not all alarms trigger operator call-outs. All alarms and messages are designed to alert the operator to abnormal operational conditions.

5.1. Critical Alarms
If alarm call out is provided, there are eleven critical alarms which trigger operator calls:

1. Permeability control failure
2. No permeate pumps available or flow control valve failure
3. Low MBR water level
4. High TMP
5. Diffuser Cleaning Valve Fail to Close
6. No or too few MBR blowers available
7. Low MBR air flow
8. Recycle pump failure
9. PLC-HMI communications failure
10. PLC not running
11. High level in any basin / imminent overflow

Table 5-1 Alarm Tags and Messages

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAX1Lal</td>
<td>Pre-anoxic Basin 1 Level Alarm Low</td>
</tr>
<tr>
<td>PAX1Lah</td>
<td>Pre-anoxic Basin 1 Level Alarm High</td>
</tr>
<tr>
<td>Pax1Pmp1Fail</td>
<td>Pre-anoxic Basin 1 Pump 1 Failed</td>
</tr>
<tr>
<td>Pax1Pmp1Mah</td>
<td>Pre-anoxic Basin 1 Pump 1 High Moisture</td>
</tr>
<tr>
<td>Pax1Pmp1Tah</td>
<td>Pre-anoxic Basin 1 Pump 1 High Motor Temperature</td>
</tr>
<tr>
<td>Pax1Pmp2Fail</td>
<td>Pre-anoxic Basin 1 Pump 2 Failed</td>
</tr>
<tr>
<td>Pax1Pmp2Mah</td>
<td>Pre-anoxic Basin 1 Pump 2 High Moisture</td>
</tr>
<tr>
<td>Pax1Pmp2Tah</td>
<td>Pre-anoxic Basin 1 Pump 2 High Motor Temperature</td>
</tr>
<tr>
<td>Pax1Mix1Fail</td>
<td>Pre-anoxic Basin 1 Mixer 1 Failed</td>
</tr>
<tr>
<td>Pax1Mix2Mah</td>
<td>Pre-anoxic Basin 1 Mixer 1 High Moisture</td>
</tr>
<tr>
<td>Pax1Mix2Tah</td>
<td>Pre-anoxic Basin 1 Mixer 1 High Motor Temperature</td>
</tr>
<tr>
<td>Ras1FitLo</td>
<td>Pre-anoxic Basin 1 Feed Forward Flow Low</td>
</tr>
<tr>
<td>Ras1FitHi</td>
<td>Pre-anoxic Basin 1 Feed Forward Flow High</td>
</tr>
<tr>
<td>Ras1FitDev</td>
<td>Pre-anoxic Basin 1 Feed Forward Flow Deviation from Setpoint</td>
</tr>
<tr>
<td>PAX2Lal</td>
<td>Pre-anoxic Basin 2 Level Alarm Low</td>
</tr>
<tr>
<td>PAX2Lah</td>
<td>Pre-anoxic Basin 2 Level Alarm High</td>
</tr>
<tr>
<td>Pax2Pmp1Fail</td>
<td>Pre-anoxic Basin 2 Pump 1 Failed</td>
</tr>
<tr>
<td>Pax2Pmp1Mah</td>
<td>Pre-anoxic Basin 2 Pump 1 High Moisture</td>
</tr>
<tr>
<td>Pax2Pmp1Tah</td>
<td>Pre-anoxic Basin 2 Pump 1 High Motor Temperature</td>
</tr>
<tr>
<td>Pax2Pmp2Fail</td>
<td>Pre-anoxic Basin 2 Pump 2 Failed</td>
</tr>
<tr>
<td>Pax2Pmp2Mah</td>
<td>Pre-anoxic Basin 2 Pump 2 High Moisture</td>
</tr>
<tr>
<td>Pax2Pmp2Tah</td>
<td>Pre-anoxic Basin 2 Pump 2 High Motor Temperature</td>
</tr>
<tr>
<td>Pax2Mix1Fail</td>
<td>Pre-anoxic Basin 2 Mixer 1 Failed</td>
</tr>
<tr>
<td>Symbol</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pax2Mix1Mah</td>
<td>Pre-anoxic Basin 2 Mixer 1 High Moisture</td>
</tr>
<tr>
<td>Pax2Mix1Tah</td>
<td>Pre-anoxic Basin 2 Mixer 1 High Motor Temperature</td>
</tr>
<tr>
<td>Ras2FitLo</td>
<td>Pre-anoxic Basin 2 Feed Forward Flow Low</td>
</tr>
<tr>
<td>Ras2FitHi</td>
<td>Pre-anoxic Basin 2 Feed Forward Flow High</td>
</tr>
<tr>
<td>Ras2FitDev</td>
<td>Pre-anoxic Basin 2 Feed Forward Flow Deviation from Setpoint</td>
</tr>
<tr>
<td>Pa1DotLo</td>
<td>Pre-aeration Basin 1 Dissolved Oxygen Low Alarm</td>
</tr>
<tr>
<td>Pa1DotHi</td>
<td>Pre-aeration Basin 1 Dissolved Oxygen High Alarm</td>
</tr>
<tr>
<td>Pa1TitLo</td>
<td>Pre-aeration Basin 1 Temperature Low Alarm</td>
</tr>
<tr>
<td>Pa1Mix1Fail</td>
<td>Pre-aeration Basin 1 Mixer 1 Failed</td>
</tr>
<tr>
<td>Pa1Mix1Mah</td>
<td>Pre-aeration Basin 1 Mixer 1 High Moisture</td>
</tr>
<tr>
<td>Pa1Mix1Tah</td>
<td>Pre-aeration Basin 1 Mixer 1 High Motor Temperature</td>
</tr>
<tr>
<td>Pa2DotLo</td>
<td>Pre-aeration Basin 2 Dissolved Oxygen Low Alarm</td>
</tr>
<tr>
<td>Pa2DotHi</td>
<td>Pre-aeration Basin 2 Dissolved Oxygen High Alarm</td>
</tr>
<tr>
<td>Pa2TitLo</td>
<td>Pre-aeration Basin 2 Temperature Low Alarm</td>
</tr>
<tr>
<td>Pa2Mix1Fail</td>
<td>Pre-aeration Basin 2 Mixer 1 Failed</td>
</tr>
<tr>
<td>Pa2Mix1Mah</td>
<td>Pre-aeration Basin 2 Mixer 1 High Moisture</td>
</tr>
<tr>
<td>Pa2Mix1Tah</td>
<td>Pre-aeration Basin 2 Mixer 1 High Motor Temperature</td>
</tr>
<tr>
<td>Axp1Mix1Fail</td>
<td>Post-anoxic Basin 1 Mixer 1 Failed</td>
</tr>
<tr>
<td>Axp1Mix1Mah</td>
<td>Post-anoxic Basin 1 Mixer 1 High Moisture</td>
</tr>
<tr>
<td>Axp1Mix1Tah</td>
<td>Post-anoxic Basin 1 Mixer 1 High Motor Temperature</td>
</tr>
<tr>
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<td>Post-anoxic Basin 2 Mixer 1 Failed</td>
</tr>
<tr>
<td>Axp2Mix1Mah</td>
<td>Post-anoxic Basin 2 Mixer 1 High Moisture</td>
</tr>
<tr>
<td>Axp2Mix1Tah</td>
<td>Post-anoxic Basin 2 Mixer 1 High Motor Temperature</td>
</tr>
<tr>
<td>Mbr1PrmFluxADFHigh</td>
<td>MBR1 Avg Daily Flux High</td>
</tr>
<tr>
<td>Mbr1PrmFluxPeakDayInProgress</td>
<td>MBR1 Peak Day Met</td>
</tr>
<tr>
<td>Mbr1PrmFluxPIFHigh</td>
<td>MBR1 Instantaneous Flux High</td>
</tr>
<tr>
<td>Mbr1PrmPrmbltyoLatch</td>
<td>MBR1 Permeability Control</td>
</tr>
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<td>MBR1 Low Permeability Shutdown</td>
</tr>
<tr>
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<td>Mbr1PrmFitdev</td>
<td>MBR1 Permeate Flow Deviation</td>
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<td>MBR1 Permeate Pump Failed</td>
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<td>MBR Permeate Turbidity High</td>
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<td>MBR2 Avg Daily Flux High</td>
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<tr>
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<td>MBR2 Peak Day Met</td>
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<tr>
<td>Mbr2PrmFluxPIFHigh</td>
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</tr>
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</tr>
<tr>
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<td>MBR2 Low Permeability Shutdown</td>
</tr>
<tr>
<td>Mbr2PrmScourAlm</td>
<td>MBR2 Excessive Air Scour</td>
</tr>
<tr>
<td>Mbr2PrmTmPhiLatch</td>
<td>MBR2 TMP High Shutdown</td>
</tr>
<tr>
<td>Mbr2PrmFcvoCloseFail</td>
<td>MBR2 Permeate Valve Failed to Close</td>
</tr>
<tr>
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<td>MBR2 Permeate Valve Failure</td>
</tr>
<tr>
<td>Condition</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Mbr2PrmFcvOpenFail</td>
<td>MBR2 Permeate Valve Failed to Open</td>
</tr>
<tr>
<td>Mbr2PrmFitdev</td>
<td>MBR2 Permeate Flow Deviation</td>
</tr>
<tr>
<td>Mbr2PrmPmpFail</td>
<td>MBR 2 Permeate Pump Failed</td>
</tr>
<tr>
<td>Mbr3PrmFluxADFHigh</td>
<td>MBR3 Avg Daily Flux High</td>
</tr>
<tr>
<td>Mbr3PrmFluxPeakDayInProgress</td>
<td>MBR3 Peak Day Met</td>
</tr>
<tr>
<td>Mbr3PrmFluxPIFHigh</td>
<td>MBR3 Instantaneous Flux High</td>
</tr>
<tr>
<td>Mbr3PrmPrmbltyloLatch</td>
<td>MBR3 Permeability Control</td>
</tr>
<tr>
<td>Mbr3PrmPrmbltyFail</td>
<td>MBR3 Low Permeability Shutdown</td>
</tr>
<tr>
<td>Mbr3PrmFcvOpenFail</td>
<td>MBR3 Permeate Valve Failed to Open</td>
</tr>
<tr>
<td>Mbr3PrmFitdev</td>
<td>MBR3 Permeate Flow Deviation</td>
</tr>
<tr>
<td>Mbr3PrmPmpFail</td>
<td>MBR3 Permeate Pump Failed</td>
</tr>
<tr>
<td>MbtPrmFluxADFHigh</td>
<td>MBT Avg Daily Flux High</td>
</tr>
<tr>
<td>MbtPrmFluxPeakDayInProgress</td>
<td>MBT Peak Day Met</td>
</tr>
<tr>
<td>MbtPrmFluxPIFHigh</td>
<td>MBT Instantaneous Flux High</td>
</tr>
<tr>
<td>MbtPrmTMPhiLatch</td>
<td>MBT TMP High Shutdown</td>
</tr>
<tr>
<td>MbrBlr1Fail</td>
<td>MBR1 Blower Failed To Start</td>
</tr>
<tr>
<td>MbrBlr1MtrTah</td>
<td>MBR1 Blower High Motor Temperature</td>
</tr>
<tr>
<td>MbrBlr1AirTah</td>
<td>MBR 1 Blower High Air Discharge Temperature</td>
</tr>
<tr>
<td>MbrBlr2Fail</td>
<td>MBR2 Blower Failed To Start</td>
</tr>
<tr>
<td>MbrBlr2MtrTah</td>
<td>MBR2 Blower High Motor Temperature</td>
</tr>
<tr>
<td>MbrBlr2AirTah</td>
<td>MBR2 Blower High Air Discharge Temperature</td>
</tr>
<tr>
<td>MbtBlrFail</td>
<td>MBT Blower Failed To Start</td>
</tr>
<tr>
<td>MbtBlrMtrTah</td>
<td>MBT Blower High Motor Temperature</td>
</tr>
<tr>
<td>MbtBlrAirTah</td>
<td>MBT Blower High Air Discharge Temperature</td>
</tr>
<tr>
<td>StdbyBlrFail</td>
<td>STAND-BY Blower Failed To Start</td>
</tr>
<tr>
<td>StdbyBlrMtrTah</td>
<td>STAND-BY Blower High Motor Temperature</td>
</tr>
<tr>
<td>StdbyBlrAirTah</td>
<td>STAND-BY Blower High Air Discharge Temperature</td>
</tr>
<tr>
<td>PaBlr1Fail</td>
<td>PRE-AERATION Blower 1 Failed To Start</td>
</tr>
<tr>
<td>PaBlr1MtrTah</td>
<td>PRE-AERATION Blower 1 High Motor Temperature</td>
</tr>
<tr>
<td>PaBlr1AirTah</td>
<td>PRE-AERATION Blower 1 High Air Discharge Temperature</td>
</tr>
<tr>
<td>PaBlr2Fail</td>
<td>PRE-AERATION Blower 2 Failed To Start</td>
</tr>
<tr>
<td>PaBlr2MtrTah</td>
<td>PRE-AERATION Blower 2 High Motor Temperature</td>
</tr>
<tr>
<td>PaBlr2AirTah</td>
<td>PRE-AERATION Blower 2 High Air Discharge Temperature</td>
</tr>
<tr>
<td>MgOHTnkLsh</td>
<td>MgOH Storage Tank High Level</td>
</tr>
<tr>
<td>MgOHMixFail</td>
<td>MgOH Tank Mixer Failed</td>
</tr>
<tr>
<td>CipVlvFail</td>
<td>Clean-in-place Water Supply Valve Failed</td>
</tr>
<tr>
<td>CipFitLo</td>
<td>Clean-in-place Cleaning Fluid Flow Low</td>
</tr>
</tbody>
</table>
SECTION 409008 – WASTE ACTIVATED SLUDGE (WAS) PUMP CONTROL STRATEGY

PART 1 - GENERAL

1.1 SUMMARY

A. The WAS pump is a non-clog dry-pit submersible pump that operates on a VFD. The WAS Pump System is a single pump system that transfers sludge from any of the three membrane tanks to a waiting tanker truck. The discharge hose can be redirected to another membrane tank to transfer the contents of one membrane tank to another. Flushing water from the plant C3 pump station is piped to the suction header of the WAS pump system. Manual use of the flushing water is part of the operation and maintenance of the WAS Pump System.

1.2 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-408</td>
<td>Membrane Bioreactor 1</td>
</tr>
<tr>
<td>I-409</td>
<td>Membrane Thickener</td>
</tr>
<tr>
<td>I-410</td>
<td>Membrane Bioreactor 2</td>
</tr>
<tr>
<td>I-417</td>
<td>Waste Activated Sludge (WAS) Pumps</td>
</tr>
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</table>

1.3 ABBREVIATIONS

A. The following abbreviations are used in this section:

1. HIM: Human Interface Module
2. HMI: Human Machine Interface
3. HOR: Hand-Off-Remote
4. PLC: Programmable Logic Controller
5. SCADA: Supervisory Control and Data Acquisition system

1.4 SYSTEM OVERVIEW

A. The WAS pump conveys WAS flow from the membrane tank to a tanker truck for transport to another location for further processing treatment. The level element in the membrane tank shall indicate the water surface elevation in the membrane tank. The pump shall automatically shut off when water level reaches the low level point. The submersible pumps are equipped with winding temperature and moisture sensors.

B. Besides manual control, WAS flow can be controlled on a flow-based schedule. A single WAS flow meter shall measure the rate of WAS flow and quantity pumped to the tanker truck. Flow meter shall provide for local graphical display of the rate of flow and accumulated flow. When the operator accumulated flow is reached, the pump shall be automatically shut off.
C. Flow meter output will indicate the existence of flow from the WAS pump.

D. Flushing water from the plant C3 pump system is piped to the suction header of this pump system.

E. Level Control

1. Primary control elements for in each basin (MBT, MBR1 or MBR2) shall be utilized for level control based Operator selection at SCADA. (i.e if the Operator selects MBR1 to draw from, the Level element in MBR1 shall be used for level control).

F. Flow Control

1. Flow Control shall be made available to the operator for use during Tank to Truck transfers. An operator adjustable flow setpoint shall be included in the SCADA screens as well as selection of the control mode (Level or Flow). Pump shall operate at the flow setpoint until the target volume is achieved or the low level alarm is activated.

1.5 EQUIPMENT

A. Process Equipment:

<table>
<thead>
<tr>
<th>Equipment No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMP-190101</td>
<td>WAS Pump</td>
</tr>
</tbody>
</table>

B. Field Instruments and Panel Devices:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSH-190101</td>
<td>Pump Motor Winding Temp</td>
</tr>
<tr>
<td>MS-190101</td>
<td>Pump Seal Fail</td>
</tr>
<tr>
<td>VFD-190101</td>
<td>VFD</td>
</tr>
<tr>
<td>HS-190101</td>
<td>Pump HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>FIT-190102</td>
<td>Discharge Flow Transmitter</td>
</tr>
<tr>
<td>FE-190102</td>
<td>Discharge Flow Meter</td>
</tr>
<tr>
<td>LIT-210104</td>
<td>Membrane Thickener Basin Level</td>
</tr>
<tr>
<td>ZSC-190103</td>
<td>WAS Pump Check Valve</td>
</tr>
<tr>
<td>LSL-070102</td>
<td>Membrane Reactor Basin 1 Low Level Switch</td>
</tr>
<tr>
<td>LSH-070102</td>
<td>Membrane Reactor Basin 1 High Level Switch</td>
</tr>
<tr>
<td>LSL-210102</td>
<td>Membrane Thickener Basin Low Level Switch</td>
</tr>
<tr>
<td>LSH-210102</td>
<td>Membrane Thickener Basin High Level Switch</td>
</tr>
<tr>
<td>LSL-070202</td>
<td>Membrane Reactor Basin 2 Low Level Switch</td>
</tr>
<tr>
<td>LSH-070202</td>
<td>Membrane Reactor Basin 2 High Level Switch</td>
</tr>
</tbody>
</table>

1.6 SCADA / HMI DISPLAYS

A. HMI screens shall be provided at the SCADA locations. The HMI screen displays shall include the data indicated on the P&ID drawings as well as data included in this section.
1.7 ALARMS

A. Alarms shall be generated by the local PLC and shall be displayed on the SCADA and local HMI. Alarms shall include process and equipment operating parameters outside of normal operating range, etc. All alarms shall have adjustable time delays accessible to the operator.

B. The following alarms shall be displayed on the local and SCADA HMI:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAH-190101</td>
<td>Pump High Winding Temperature</td>
</tr>
<tr>
<td>MAH-190101</td>
<td>Pump Seal Fail</td>
</tr>
<tr>
<td>YA-190101A</td>
<td>Pump Fail</td>
</tr>
<tr>
<td>YA-190101B</td>
<td>VFD Fault</td>
</tr>
<tr>
<td>FAL-190102</td>
<td>WAS Discharge Low Flow Alarm</td>
</tr>
<tr>
<td>LAL-210104</td>
<td>Membrane Thickener Basin Low Level (transmitter generated)</td>
</tr>
<tr>
<td>LAL-070102</td>
<td>Membrane Reactor Basin 1 Low Level Alarm</td>
</tr>
<tr>
<td>LAH-070102</td>
<td>Membrane Reactor Basin 1 High Level Alarm</td>
</tr>
<tr>
<td>LAL-210102</td>
<td>Membrane Thickener Basin Low Level Alarm</td>
</tr>
<tr>
<td>LAH-210102</td>
<td>Membrane Thickener Basin High Level Alarm</td>
</tr>
<tr>
<td>LAL-070202</td>
<td>Membrane Reactor Basin 2 Low Level Alarm</td>
</tr>
<tr>
<td>LAH-070202</td>
<td>Membrane Reactor Basin 2 High Level Alarm</td>
</tr>
</tbody>
</table>

1.8 REMOTE ALARM NOTIFICATION SYSTEM

A. The following data points shall be configured in the remote alarm notification system software:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>YA-190101A</td>
<td>Pump Fail</td>
</tr>
<tr>
<td>YA-190101B</td>
<td>VFD Fault</td>
</tr>
<tr>
<td>FAL-190102</td>
<td>Discharge Low Flow Alarm</td>
</tr>
<tr>
<td>LAL-210104</td>
<td>Membrane Thickener Basin Low Level</td>
</tr>
</tbody>
</table>

1.9 PROCESS DATA HISTORIAN

A. In addition to the alarms listed above, the following data shall be generated by the local SCADA PLC and logged by the process data historian:

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KQI-190101</td>
<td>Pump 1 Runtime</td>
</tr>
<tr>
<td>YQ-190101</td>
<td>Pump 1 Starts</td>
</tr>
<tr>
<td>FI-190102</td>
<td>Discharge Flow Rate</td>
</tr>
<tr>
<td>FQI-190102</td>
<td>Discharge Flow Total</td>
</tr>
</tbody>
</table>

1.10 OPERATION

A. Manual Control:
1. An HOR switch shall be provided at the MCC for the pump. The pumps shall run with the switch in HAND and stop with the switch in OFF.
2. Pump speed is adjustable using the HIM provided at the MCC.
3. Alarms are provided for the following, but pump operation is allowed to continue:
   a. Bringing the water level in MBR1, MBR2 or MBT below minimum water surface elevation.
   b. Low Discharge Flow
   c. Operator set volume of sludge is pumped
4. Pump high temperature alarm and corresponding automatic shutdowns occur to maintain warranty status.

B. Automatic Control:
1. The pumps shall respond to the local PLC when the switch is in REMOTE. The HOR switch must be set to REMOTE for automatic operation.
2. Pumping control level set points shall be adjustable at SCADA HMI screens.
3. Pump is started manually at a SCADA HMI screen.
4. Pump speed is operator adjustable at a SCADA HMI screen.
5. Pump shutdown automatically occurs when any of the following conditions are met:
   a. Liquid surface elevation in the membrane tank is less than or equal to the operator setpoint (in the case of the MBT) or low level switch (in the case of the selected MBR).
   b. Operator selected volume of sludge is pumped
   c. Pump Monitoring: High winding temperature triggers alarm and pump shutdown
   d. Flow meter registers unusually low flow after a set period of time
   e. Check valve fails to open when pump is energized
   f. If the High Level switch in the basin the pump is currently pumping into is actuated.

<table>
<thead>
<tr>
<th>Tag</th>
<th>Sump Level (ft)</th>
<th>Control Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSL</td>
<td>0-16 ft</td>
<td>Pump Stop level TBD @ startup</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tag</th>
<th>Volume (Gal)</th>
<th>Control Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOL</td>
<td>0-5000</td>
<td>Pump Stop TBD @ startup</td>
</tr>
</tbody>
</table>

C. Interlocks: All fault related shutdowns shall require manual reset at the LCP or HMI.
1. Programmed:
   a. Pump failure alarm shall be activated after time delay if check valve fails to open when pump is energized.
   b. The PLC shall remove the Start command when a fault occurs.
   c. The PLC shall remove the Start command when there is a loss of utility power. This interlock does not require a manual reset. The pumps will be free to start again as needed when generator power or utility power is restored.
2. Hardwired:
a. Pump shall be shut down on detection of overload, or phase fail.
b. A protection module shall be provided for the pump to monitor for high winding and bearing temperature and seal failure. The pump shall be shut down on detection of high winding temperature. These faults shall be reset at the local control panel.

PART 2 - MATERIALS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 409008
SECTION 409009 – UV DISINFECTION CONTROL STRATEGY

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the integration and operation of the UV disinfection systems. The UV reactors are provided as a complete system by the supplier. Contractor shall integrate status and alarm systems into the Plant PLC and SCADA system as described below.

1.2 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-500</td>
<td>UV Disinfection</td>
</tr>
</tbody>
</table>

1.3 ABBREVIATIONS

A. The following abbreviations are used in this section:

1. HMI: Human Machine Interface
2. PLC: Programmable Logic Controller
3. SCADA: Supervisory Control and Data Acquisition system

1.4 SYSTEM OVERVIEW

A. UV Disinfection is achieved by closed vessel UV reactors installed downstream of the membrane bioreactors. Two UV reactors will be installed initially and space is provided to expand to 4 reactors as shown on the drawings. Each UV reactor is rated to disinfect 0.4 mgd at 65% UV transmittance and can treat up to 0.5 mgd if the UV transmittance is 72%.

B. One of the two initial reactors will act as a Lead reactor and the other as the Lag reactor. The assignment of Lead and Lag shall be operator selectable at SCADA. When peak flows exceed the rated capacity of the duty UV unit, a third reactor will be brought in service such that two will be duty and one will be standby.

C. The UV reactors shall operate in three flow paced modes: maintenance mode, parallel mode and series mode. All three modes shall utilize the flow signals from the Permeate flow meters (FI-080103, FI-080203 and FI-080003) for the flow pace signal.

1. Mode 1- Maintenance Mode, One UV Reactor
   a. Mode 1 is used when one duty reactor is available and the other reactor is down for maintenance.
b. Isolation valves are manually set to route flow through the duty reactor and no flow through the other reactor.
c. Duty reactor is turned on manually.
d. Calculate total flow (Q) through the reactor as sum of flow meters FI-080103, FI-080203, and FI-080003.
e. Send 4-20ma signal to the duty UV reactor to flow pace dose. The signal represents total flow (Q), with 20 mA = set point capacity of duty reactor ~0.50 MGD.
f. Activate high flow alarm at flow set point of 0.40 MGD or Ballast Power Level setting of 80% (operator adjustable).

2. Mode 2 – Two UV Reactors in Series
   a. Mode 2 is used when both reactors are available, flow is usually less than the capacity of one reactor, and flow through membranes is mostly by gravity with little need for pumping.
   b. Isolation valves are manually set to route flow through reactors 1 and 2 in series.
   c. Both reactors are set for remote on/off control by plant PLC.
   d. Calculate total flow (Q) through the reactors as sum of flow meters FI-080103, FI-080203, and FI-080003.
   e. For total flow (Q) from 0 MGD to set point 0.45 MGD (operator adjustable).
      1) Turn on lead reactor.
      2) Send a 4-20 mA signal to lead reactor to flow pace dose. Signal represents total flow (Q), with 20 mA = set point capacity of lead reactor ~0.50 MGD.
   f. When (Q) rises to set point at 0.40 MGD or Ballast Power Level setting of 80% 
      1) Turn on lag reactor and warm-up for set point time interval (~5 minutes, operator adjustable)
      2) After warm-up period, send 4-20 mA signal to both the lead and lag reactors to flow pace dose. The signal represents a set point fraction (~half) of total flow Q, with 20 mA = set point capacity of each reactor ~0.5 MGD. For example when Q = 0.5 MGD, send signal for 0.25 MGD (12 ma) to each reactor.
   g. When (Q) falls below set point (~0.40 MGD, 0.20 MGD/reactor) and Ballast Power Level is 60% for set point time interval (~20 minutes, operator adjustable).
      1) Send signal to lead reactor that represents total flow (Q), with 20 mA = set point flow capacity of lead reactor ~0.50 MGD.
      2) Turn off lag reactor.
   h. Activate high flow alarm at flow set point initially set at 0.9 MGD (operator adjustable).

3. Mode 3 – Two UV Reactors in Parallel
   a. Mode 3 is used when both reactors are available, flow is usually more than the capacity of one UV reactor, and significant pumping is needed to pull flow through
the membranes. Parallel operation reduces pumping because it has lower hydraulic headloss than series operation.

b. Isolation valves are manually set to route flow through reactors 1 and 2 in parallel.
c. Both reactors are manually turned on.
d. Calculate total flow (Q) through the reactors as sum of flow meters FI-080103, FI-080203, and FI-080003.

1) Send 4-20mA signal to both UV reactors to flow pace dose. Signal represents a set point fraction (~half) of total flow (Q), with 20 mA = set point capacity of each reactor ~0.5 mgd. For example when Q = 0.5 mgd, send signal for 0.25 MGD (12 mA) to each reactor.

e. Activate high flow alarm at flow set point initially set at 0.9 MGD (operator adjustable).

4. Operating modes shall be Operator selectable at SCADA.
5. The contractor shall coordinate and verify the functional requirements of the control strategy with the UV system supplier.

D. An automatic cooling loop operated by a solenoid valve will be activated during low flow conditions such as initial plant startup flows and night time when normal permeate flow is interrupted for several hours. The minimum flow rate would be 5 gpm and the plant C3 water would be used for this operation.

E. Each UV Reactor is directly monitored/controlled from a Control Circuit Board (CCB). The CCB is located within the Power Distribution Center (PDC) into which power supply mains is fed. Communications from the PDCs to the UV System Controller for hard wired sensors on the reactor are sent via an Ethernet link. All lamp and ballast status signals are transferred using Modbus RTU protocol from the CCB boards to the UV System Controller.

1.5 EQUIPMENT

A. Process Equipment:

<table>
<thead>
<tr>
<th>Equipment No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV-180001</td>
<td>UV Reactor 1</td>
</tr>
<tr>
<td>UV-180002</td>
<td>UV Reactor 2</td>
</tr>
<tr>
<td>SAM-180014</td>
<td>Effluent Sampler</td>
</tr>
</tbody>
</table>

B. Field Instrumentation:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIT -180020</td>
<td>Ultra Violet Transmittance Monitor</td>
</tr>
<tr>
<td>AE - 180020</td>
<td>Ultra Violet Transmittance Element</td>
</tr>
</tbody>
</table>
1.6 SCADA / HMI DISPLAYS

A. HMI screens shall be provided at the SCADA locations. The HMI screen displays shall include the data indicated on the P&ID drawings as well as data included in this section.

1. Turbidity
2. Flow rate
3. UV Ballast Power level
4. Operation Status - Series or Parallel
5. UV Transmittance (UVT)
6. UV Dose
7. UV Intensity

1.7 ALARMS

A. Alarms shall be generated by the local PLC and shall be displayed on the SCADA and local HMI. Alarms shall include process and equipment operating parameters outside of normal operating range, etc. All alarms shall have adjustable time delays accessible to the operator.

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>YI-180001A</td>
<td>UV Reactor 1 Ready</td>
</tr>
<tr>
<td>YI-180001B</td>
<td>UV Reactor 1 Running</td>
</tr>
<tr>
<td>YI-180001C</td>
<td>UV Reactor 1 Warming</td>
</tr>
<tr>
<td>YI-180002A</td>
<td>UV Reactor 2 Ready</td>
</tr>
<tr>
<td>YI-180002B</td>
<td>UV Reactor 2 Running</td>
</tr>
<tr>
<td>YI-180002C</td>
<td>UV Reactor 2 Warming</td>
</tr>
<tr>
<td>YA-180001A</td>
<td>UV Reactor 1 Critical Alarm</td>
</tr>
<tr>
<td>YA-180001B</td>
<td>UV Reactor 1 Major Alarm</td>
</tr>
<tr>
<td>YA-180001C</td>
<td>UV Reactor 1 Minor Alarm</td>
</tr>
<tr>
<td>YA-180002A</td>
<td>UV Reactor 2 Critical Alarm</td>
</tr>
<tr>
<td>YA-180002B</td>
<td>UV Reactor 2 Major Alarm</td>
</tr>
<tr>
<td>YA-180002C</td>
<td>UV Reactor 2 Minor Alarm</td>
</tr>
<tr>
<td>YA-180014A</td>
<td>Sampler Alarm 1</td>
</tr>
<tr>
<td>YA-180014B</td>
<td>Sampler Alarm 2</td>
</tr>
<tr>
<td>YA-180014C</td>
<td>Sampler Alarm 3</td>
</tr>
<tr>
<td>YA-180014D</td>
<td>Sampler Alarm 4</td>
</tr>
</tbody>
</table>

1.8 REMOTE ALARM NOTIFICATION SYSTEM

A. The following data points shall be configured in the remote alarm notification system software:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>YA-180001A</td>
<td>UV Reactor 1 Critical Alarm</td>
</tr>
<tr>
<td>YA-180001B</td>
<td>UV Reactor 1 Major Alarm</td>
</tr>
<tr>
<td>YA-180001C</td>
<td>UV Reactor 1 Minor Alarm</td>
</tr>
<tr>
<td>YA-180002A</td>
<td>UV Reactor 2 Critical Alarm</td>
</tr>
<tr>
<td>YA-180002B</td>
<td>UV Reactor 2 Major Alarm</td>
</tr>
<tr>
<td>YA-180002C</td>
<td>UV Reactor 2 Minor Alarm</td>
</tr>
</tbody>
</table>
1.9 PROCESS DATA HISTORIAN:

A. In addition to the alarms listed above, the following data shall be generated by the local SCADA PLC and shall be logged by the process data historian:

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI-180020</td>
<td>Ultra Violet Transmittance (UVT)</td>
</tr>
</tbody>
</table>

1.10 OPERATION

A. Effluent Sampler

1. The sampler shall receive a pulse. The sampler shall take a sample upon receiving each pulse. The sampler pulse signal shall be based on sum of the flow totals from the permeate flow meters (FI-080103 + FI-080203 + FI-080003) equaling 1000 gallons. The Sample Interval shall be operator adjustable from 0 to 10000 gallons. Additionally, the operator shall be able to select the flowmeters to be included in the total flow calculation. There shall be a visual indication of flowmeters that are excluded from the total flow calculation i.e. flashing indicator.

2. The sampler will be configured to send 4 alarm signals to the Plant PLC. Coordinate with supplier for the alarm descriptions.
SECTION 409010 – C3 WATER SYSTEM CONTROL STRATEGY

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the operation of the plant wash water system. Plant wash water shall be supplied from UV disinfected effluent from the effluent stand pipe. The plant wash water system features storage in the effluent pipe and stand pipe, two dry-pit multistage centrifugal pumps, hydropneumatic tank, flow meter, eductor and NaOCl tank. The C3 pumps provide treated plant effluent for maintenance use and ancillary uses in treatment processes. Effluent has the following uses: hose down water at hose bibs, spray water at the headworks screen, and dilution water for periodic membrane cleaning.

1.2 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-501</td>
<td>C3 Water System</td>
</tr>
</tbody>
</table>

1.3 ABBREVIATIONS

A. The following abbreviations are used in this section:

1. HMI: Human Machine Interface
2. HOR: Hand-Off-Remote
3. PLC: Programmable Logic Controller
4. SCADA: Supervisory Control And Data Acquisition system

1.4 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-501</td>
<td>C3 Water System</td>
</tr>
</tbody>
</table>

1.5 SYSTEM OVERVIEW

A. Flow from the UV system shall flow into the standpipe via an isolation valve. Water level in the standpipe shall be monitored with high and low level float switches.

B. Each of the pumps is controlled based on the water pressure measured by pressure transmitter PIT-240003 in the hydropneumatic tank system. The C3 pumps respond to maintain pressure in the tank within a set range. If the tank pressure is less than the lower limit of its range, a pump
is called to run. If the tank pressure cannot be reestablished by a single pump, the second pump is called to run. In addition, a pressure regulating valve downstream of the hydropneumatic tank shall maintain constant pressure of the downstream C3 distribution system.

C. The hydropneumatic tank shall be set to maintain a pressure between 90 psi (208 ft) and 125 psi (288 ft). Each C3 pump can deliver a range of flow from 0 gpm to 75 gpm at these pressures. The pressure in the hydropneumatic tank shall be monitored through pressure transmitter and control the operation of C3 pumps based on a set of operator adjustable but preset values in the hydropneumatic tank.

D. The PLC will monitor the motor current to confirm that the pump is running.

E. The flow rate and accumulated quantity of secondary effluent delivered to the plant washwater system shall be monitored and recorded.

F. A supplemental disinfection system is provided to disinfect the plant wastewater with sodium hypochlorite. Manual control valves with eductor are provided to provide hypochlorite feed to the plant water system. The level in the hypochlorite storage tank shall be monitored and displayed on SCADA. Level in the tank shall be calculated based on the load cell input. Verify the weight of the empty container with the owner. Level status indicator shall indicate the level to be within preset but operator-adjustable levels, as “LOW,” “NORMAL,” or “HIGH.”

1.6 EQUIPMENT

A. Process Equipment:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMP-240001</td>
<td>C3 Pump 1</td>
</tr>
<tr>
<td>PMP-240002</td>
<td>C3 Pump 2</td>
</tr>
<tr>
<td>ED-240004</td>
<td>Eductor</td>
</tr>
<tr>
<td>T-240006</td>
<td>Storage Tank (Stand Pipe)</td>
</tr>
<tr>
<td>HT-240003</td>
<td>Hydro Pneumatic Tank</td>
</tr>
<tr>
<td>T-240005</td>
<td>NaOCl Tank</td>
</tr>
</tbody>
</table>

B. Field Instruments and Panel Devices:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand Pipe</td>
<td></td>
</tr>
<tr>
<td>LSH-240007</td>
<td>Float Switch High</td>
</tr>
<tr>
<td>LSL-240008</td>
<td>Float Switch Low</td>
</tr>
<tr>
<td>Pumps</td>
<td></td>
</tr>
<tr>
<td>HS-240001</td>
<td>Pump 1 HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>IT-240001</td>
<td>Pump 1 Motor Current</td>
</tr>
<tr>
<td>HS-240002</td>
<td>Pump 2 HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>IT-240002</td>
<td>Pump 2 Motor Current</td>
</tr>
<tr>
<td>Hydropneumatic Tank</td>
<td></td>
</tr>
</tbody>
</table>
PIT-240003  |  Pressure Indicator Transmitter
---|---
Flow Meter
FIT-240009  |  Flow Indicator Transmitter
FE-240009  |  Flow Sensor
NaOCl Tank
WIT-240005  |  Weight Indicator Transmitter (Hypo Level Indication)

### 1.7 SCADA / HMI DISPLAYS

A. SCADA HMI display screens shall be provided at the MBR OIT and at SCADA workstations located in the operations buildings. The HMI screen displays shall include the data indicated on the P&ID drawings as well as data included in this section.

### 1.8 ALARMS

A. Alarms shall be generated by the PLC and shall be displayed on SCADA HMI. Alarms shall include process and equipment operating parameters outside of normal operating range, discrepancies between command and status signals (Sequence Fault), etc. The following alarms shall be configured:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAH-240007</td>
<td>Float Switch High</td>
</tr>
<tr>
<td>LAL-240008</td>
<td>Float Switch Low</td>
</tr>
<tr>
<td>YA-240001</td>
<td>Pump 1 Fail</td>
</tr>
<tr>
<td>YA-240002</td>
<td>Pump 2 Fail</td>
</tr>
<tr>
<td>PAL-240003</td>
<td>Pressure Alarm Low</td>
</tr>
<tr>
<td>PAH-240003</td>
<td>Pressure Alarm High</td>
</tr>
</tbody>
</table>

### 1.9 REMOTE ALARM NOTIFICATION SYSTEM

A. The following data points shall be configured in the remote alarm notification system software:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAL-240005</td>
<td>NaOCl Tank Low Level</td>
</tr>
<tr>
<td>LAL-240035</td>
<td>Float Switch Low</td>
</tr>
<tr>
<td>YA-240001</td>
<td>Pump 1 Fail</td>
</tr>
<tr>
<td>YA-240002</td>
<td>Pump 2 Fail</td>
</tr>
<tr>
<td>PAL-240003</td>
<td>Pressure Alarm Low</td>
</tr>
<tr>
<td>PAH-240003</td>
<td>Pressure Alarm High</td>
</tr>
<tr>
<td>LAL-240005</td>
<td>NaOCl Tank Low Level</td>
</tr>
</tbody>
</table>
1.10 PROCESS DATA HISTORIAN

A. In addition to the alarms listed above, the following data shall be generated by the local SCADA PLC and shall be logged by the process data historian:

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KQI-240001</td>
<td>Pump 1 Run Time</td>
</tr>
<tr>
<td>YQI-240001</td>
<td>Pump 1 Starts Count</td>
</tr>
<tr>
<td>KQI-240002</td>
<td>Pump 2 Run Time</td>
</tr>
<tr>
<td>YQI-240002</td>
<td>Pump 2 Starts Count</td>
</tr>
<tr>
<td>FI-240009</td>
<td>Flow Rate</td>
</tr>
<tr>
<td>FQI-240009</td>
<td>Flow Total</td>
</tr>
</tbody>
</table>

1.11 OPERATION

A. Manual Control:

1. An HOR switch shall be provided at the MCC for each pump. The pumps shall run with the switch in HAND and stop with the switch in OFF.

B. Automatic Control:

1. The pumps shall respond to the local PLC when the switch is in REMOTE. The HOR switch must be set to REMOTE for automatic operation.
2. Pumping control pressure set points shall be adjustable at SCADA HMI screens.
3. A PUMP1/PUMP2/ALTERNATE control element shall be provided on the SCADA HMI allowing selection of lead pump or alternation. When set to a fixed duty pump the selected pump shall remain the lead pump until the setting is changed or the lead pump fails or is turned off. When set to ALTERNATE the lead pump shall switch after each cycle. The unselected pump defaults to standby. If the lead pump fails, is turned off, or is otherwise unavailable, the standby pump shall be promoted to lead pump.
4. Pumping control and alarm pressure set points and time delays shall be adjustable at the SCADA HMI screens. PLC logic shall be provided to restrict set point and time delay entry ranges and relationships as required for normal operation. Pressure signal filtering shall be provided as required to prevent erratic operation or short cycling of pumps.
5. When the pressure in the hydropneumatic tank is less than the start setpoint, the lead pump is called to start.
6. Standby pump shall automatically be promoted if the lead pump is either faulted or turned off.
7. If the lead pump is called to run and fails to do so, the standby pump is called to run and is now considered the lead pump. An alarm is displayed at the SCADA.
8. If the pressure continues to drop below the standby pump start pressure setpoint with the lead pump active, the standby pump starts, if available.
9. If the pressure does not rise with the lead pump active for an adjustable time delay, the lag pump starts, if available.
10. Pump shutdown occurs when any of the following conditions are met:
   a. Pressure in the hydropneumatic tank reaches the high end of the pressure range.
b. Motor current is outside of the expected operating parameters.
c. Flow rate measured by FIT-240009 is less than an operator adjustable setpoint for an adjustable preset period, initially set at 5 minutes. Reset shall via the Hand / Off / Remote switch cycling to Off and back to Remote.

C. Interlocks: All fault related shutdowns shall require manual reset at the HMI.
   1. Programmed:
      a. Pump failure alarm shall be activated after time delay if the measured motor current is not within the expected operating parameters when pump is energized.
      b. The PLC shall remove the Start command when a fault occurs.
      c. The PLC shall remove the Start command when there is a loss of utility power. This interlock does not require a manual reset. The pumps will be free to start again as needed when generator power or utility power is restored.
   2. Hardwired:
      a. Stop pump on overload.
      b. Stop pump on phase fail.

PART 2 - MATERIALS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 409010
SECTION 409011 – MISCELLANEOUS CONTROL STRATEGY

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the operation of the miscellaneous plant systems including the Generator, Generator Fuel Inventory Panel, Automatic Transfer Switch (ATS), Fire Alarm Panel, Site Lighting, and Power Monitoring.

1.2 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-600</td>
<td>Miscellaneous Systems</td>
</tr>
</tbody>
</table>

1.3 ABBREVIATIONS

A. The following abbreviations are used in this section:

1. HMI: Human Machine Interface
2. HOR: Hand-Off-Remote
3. PLC: Programmable Logic Controller
4. SCADA: Supervisory Control And Data Acquisition system

1.4 SYSTEM OVERVIEW

A. Generator

1. The PLC and SCADA system shall monitor status and alarm signals from the Generator Control Panel (PNL-320001). These include Not in Auto, Trouble, Fail, and Running status signals.

2. Upon Utility power fail, the following sequence shall be initiated.

   a. Remove all motor calls from the PLC
   b. Generator starts and ancillary loads come online.
   c. Initiate call to the UV system.
   d. After a 10 second delay, allow the Influent Pumps to start with a 5 second delay between pumps.
   e. 10 seconds after the last Influent pumps has been called, allow the Feed Forward (FF) Pumps and Mixers to start (no delay between motors).
   f. 10 seconds after the FF pumps and Mixers have been enabled, enable Blower to start with a 5 second delay between each Blower.
   g. 10 seconds after the last Blower has been enabled, enable all other loads.
3. Upon return to Utility Power.
   a. Remove all motor calls from the PLC
   b. Ancillary loads come online.
   c. Initiate call to the UV system.
   d. After a 10 second delay, allow the Influent Pumps to start with a 5 second delay between pumps.
   e. 10 seconds after the last Influent pumps has been called, allow the Feed Forward (FF) Pumps and Mixers to start (no delay between motors).
   f. 10 seconds after the FF pumps and Mixers have been enabled, enable Blower to start with a 5 second delay between each Blower.
   g. 10 seconds after the last Blower has been enabled, enable all other loads.

B. Generator Fuel Inventory Panel

1. The PLC and SCADA system shall monitor status and alarm signals from the Fuel Inventory Panel (PNL-320003). These include the Fuel Tank Level, Low Level, and Leak alarms.

C. Automatic Transfer Switch

1. The PLC and SCADA system shall monitor status and alarm signals from the Automatic Transfer Switch (ATS-340003). These include the On Utility, On Generator, Utility Available, and Generator Available status signals.

D. Fire Alarm Panel

1. The PLC and SCADA system shall monitor status and alarm signals from the Fire Alarm Panel (PNL-340015). These include the Alarm, Trouble, and Supervisory alarm signals.

E. Site Lighting

1. The PLC and SCADA system shall monitor the status from the photocell located on the Administration Building. At dusk the PLC will enable all of the exterior site lighting.

F. Power Monitoring

1. The SCADA system shall monitor the energy usage for each of the motors and panelboard PNL-340009 through meters or through connections to the VFDs and smart motor controllers (smart MCC). Provide applicable software drivers to interface with the power monitoring devices. Refer to the one diagram on drawings E-005, E-006 and E-007. Data collected shall include but is not limited to kWh, Amps and Voltage. A SCADA screen shall display data from each source and sum up the energy usage per each process area. Process areas shall be: the Influent Pump Station, Headworks, Membrane System, UV System and Ancillary Systems (HVAC, Lighting, Receptacles, and all other loads). SCADA shall display the energy consumption relative to the processed waste stream (kWh/MG).
1.5 EQUIPMENT

A. Process Equipment:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN-320003</td>
<td>Generator</td>
</tr>
<tr>
<td>ATS-340003</td>
<td>Automatic Transfer Switch</td>
</tr>
</tbody>
</table>

B. Field Instruments and Panel Devices:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UE-360007</td>
<td>Photocell</td>
</tr>
</tbody>
</table>

1.6 SCADA / HMI DISPLAYS

A. SCADA HMI display screens shall be provided at the MBR OIT and at SCADA workstations located in the operations buildings. The HMI screen displays shall include the data indicated on the P&ID drawings as well as data included in this section.

1.7 ALARMS

A. Alarms shall be generated by the PLC and shall be displayed on SCADA HMI. Alarms shall include process and equipment operating parameters outside of normal operating range, discrepancies between command and status signals (Sequence Fault), etc. The following alarms shall be configured:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAL-320003</td>
<td>Low Fuel Level</td>
</tr>
<tr>
<td>YA-320003</td>
<td>Fuel Leak</td>
</tr>
<tr>
<td>YA-320001A</td>
<td>Generator Trouble</td>
</tr>
<tr>
<td>YA-320001B</td>
<td>Generator Fail</td>
</tr>
<tr>
<td>YA-340015A</td>
<td>Fire Alarm Panel Alarm</td>
</tr>
<tr>
<td>YA-340015B</td>
<td>Fire Alarm Panel Trouble</td>
</tr>
<tr>
<td>YA-340015C</td>
<td>Fire Alarm Panel Supervisory Alarm</td>
</tr>
</tbody>
</table>

1.8 REMOTE ALARM NOTIFICATION SYSTEM

A. The following data points shall be configured in the remote alarm notification system software:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAL-320003</td>
<td>Low Fuel Level</td>
</tr>
<tr>
<td>YA-320003</td>
<td>Fuel Leak</td>
</tr>
<tr>
<td>YA-320001A</td>
<td>Generator Trouble</td>
</tr>
<tr>
<td>YA-320001B</td>
<td>Generator Fail</td>
</tr>
<tr>
<td>YA-340015A</td>
<td>Fire Alarm Panel Alarm</td>
</tr>
</tbody>
</table>
1.9 PROCESS DATA HISTORIAN

A. In addition to the alarms listed above, the following data shall be generated by the local SCADA PLC and shall be logged by the process data historian:

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

PART 2 - MATERIALS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 409011
SECTION 409012 – FLOW EQUALIZATION CONTROL STRATEGY

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the integration and operation of flow equalization in MBR trains 1 and 2 during peak flow events. Automatic operation of the pumps will be controlled by the Ovivo control panel. Contractor shall coordinate with Ovivo and integrate status and alarm systems into the Plant PLC and SCADA system as described below.

1.2 REFERENCES

A. Process and Instrumentation Diagrams:

<table>
<thead>
<tr>
<th>Dwg No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-400</td>
<td>Splitter Box</td>
</tr>
<tr>
<td>I-401</td>
<td>Pre-Anoxic Basin #1</td>
</tr>
<tr>
<td>I-402</td>
<td>Pre-Anoxic Basin #2</td>
</tr>
<tr>
<td>I-403</td>
<td>Pre-Aeration Basin #1</td>
</tr>
<tr>
<td>I-404</td>
<td>Pre-Aeration Basin #2</td>
</tr>
<tr>
<td>I-405</td>
<td>Post-Anoxic Basin #1</td>
</tr>
<tr>
<td>I-406</td>
<td>Post-Anoxic Basin #2</td>
</tr>
</tbody>
</table>

B. Refer to Section 409007, MBR System Control Strategy.

1.3 ABBREVIATIONS

A. The following abbreviations are used in this section:

1. HMI: Human Machine Interface
2. HOR: Hand-Off-Remote
3. PLC: Programmable Logic Controller
4. SCADA: Supervisory Control And Data Acquisition system

1.4 SYSTEM OVERVIEW

A. During start up and low flow conditions, when one MBR train is in operation, the second MBR train shall act as a peak flow storage basin. Depending on the MBR train in operation (either #1 or #2) the process described below shall be repeated for storing excess flows in either of the two MBR trains. In the future, when the MBR train #1 reaches the peak capacity for treatment then MBR train #2 shall also be dedicated for wastewater treatment, and peak flows shall be diverted and stored in the “Future Storage Pond”.

B. Feed Forward Pump Modes: The feed forward pumps shall operate in the following two modes for each treatment train:
1. **MBR Mode:** When a treatment train is in the MBR mode the feed forward pumps shall pump the influent and RAS from Pre-anoxic (PAX) tank to Pre-aeration (PA) basin for normal treatment operation. Refer to MBR control strategy for the operation of the FF pumps in MBR mode.

2. **Equalization Mode:** When a treatment train is in the flow equalization mode, the feed forward pumps shall pump liquid from Pre-anoxic basin to Pre-aeration basin for peak flow storage. Level sensors located in Pre-anoxic, Pre-aeration, and Post-anoxic basins shall be used to control the pump on and off operation.

C. Peak flow pumped to the basins shall be monitored and recorded in the plant SCADA system using the flow meter located on the feed forward pump piping system and the level sensors located in each of the pre-aeration and post-anoxic basins (AXP).

D. Water level depths in pre-aeration and post-anoxic basins shall also be monitored and recorded during draining operation.

E. Based on level sensor data, screen display shall indicate level and volume (gallons) stored in each PAX, PA and AXP basins, total stored volume (gallons), and total remaining available storage volume (gallons) in all of the basins.

F. Graphs shall be displayed for total stored volume and % full vs time for PAX, PA and AXP basins.

1.5 **EQUIPMENT**

A. **Process Equipment:**

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMP-040102</td>
<td>Feed Forward Pump #1 in MBR Train #1</td>
</tr>
<tr>
<td>PMP-040103</td>
<td>Feed Forward Pump #2 in MBR Train #1</td>
</tr>
<tr>
<td>PMP-040202</td>
<td>Feed Forward Pump #1 in MBR Train #2</td>
</tr>
<tr>
<td>PMP-040203</td>
<td>Feed Forward Pump #2 in MBR Train #2</td>
</tr>
</tbody>
</table>

B. **Field Instruments and Panel Devices:**

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Forward Pumps</td>
<td></td>
</tr>
<tr>
<td>TSH-040102</td>
<td>Train #1 Pump 1 Winding Temp</td>
</tr>
<tr>
<td>MS-040102</td>
<td>Train #1 Pump 1 Seal Fail</td>
</tr>
<tr>
<td>VFD-040102</td>
<td>Train #1 Pump 1 Variable Frequency Drive</td>
</tr>
<tr>
<td>HS-040102</td>
<td>Train #1 Pump 1 HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>SS-040102</td>
<td>Train #1 Pump 1 VFD HIM interface</td>
</tr>
<tr>
<td>TSH-040103</td>
<td>Train #1 Pump 2 Winding Temp</td>
</tr>
<tr>
<td>MS-040103</td>
<td>Train #1 Pump 2 Seal Fail</td>
</tr>
<tr>
<td>VFD-040103</td>
<td>Train #1 Pump 2 Variable Frequency Drive</td>
</tr>
<tr>
<td>HS-040103</td>
<td>Train #1 Pump 2 HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>SS-040103</td>
<td>Train #1 Pump 2 VFD HIM interface</td>
</tr>
<tr>
<td>TSH-040202</td>
<td>Train #2 Pump 1 Winding Temp</td>
</tr>
</tbody>
</table>
1.6 SCADA / HMI DISPLAYS

A. SCADA HMI display screens shall be provided at the control panel and at SCADA workstations located in the operations buildings. The HMI screen displays shall include the data indicated on the P&ID drawings as well as data included in this section. Coordinate SCADA screens and database with Ovivo per section 409007.

1.7 ALARMS

A. Alarms shall be generated by the PLC and shall be displayed on SCADA HMI. Alarms shall include process and equipment operating parameters outside of normal operating range, discrepancies between command and status signals (Sequence Fault), etc. Coordinate the alarm list with Ovivo per section 409007. The following alarms shall be configured:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-040202</td>
<td>Train #2 Pump 1 Seal Fail</td>
</tr>
<tr>
<td>VFD-040202</td>
<td>Train #2 Pump 1 Variable Frequency Drive</td>
</tr>
<tr>
<td>HS-040202</td>
<td>Train #2 Pump 1 HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>SS-040202</td>
<td>Train #2 Pump 1 VFD HIM interface</td>
</tr>
<tr>
<td>TSH-040203</td>
<td>Train #2 Pump 2 Winding Temp</td>
</tr>
<tr>
<td>MS-040203</td>
<td>Train #2 Pump 2 Seal Fail</td>
</tr>
<tr>
<td>VFD-040203</td>
<td>Train #2 Pump 2 Variable Frequency Drive</td>
</tr>
<tr>
<td>HS-040203</td>
<td>Train #2 Pump 2 HAND/OFF/REMOTE Switch</td>
</tr>
<tr>
<td>SS-040203</td>
<td>Train #2 Pump 2 VFD HIM interface</td>
</tr>
<tr>
<td>Flow Meter</td>
<td></td>
</tr>
<tr>
<td>FIT-040107</td>
<td>Train #1 Flow Indicator Transmitter</td>
</tr>
<tr>
<td>FE-040107</td>
<td>Train #1 Flow Sensor</td>
</tr>
<tr>
<td>FIT-040207</td>
<td>Train #2 Flow Indicator Transmitter</td>
</tr>
<tr>
<td>FE-040207</td>
<td>Train #2 Flow Sensor</td>
</tr>
<tr>
<td>Level Sensors</td>
<td></td>
</tr>
<tr>
<td>LE-040106</td>
<td>Pre-Anoxic Basin #1 level Sensor</td>
</tr>
<tr>
<td>LT-040106</td>
<td>Pre-Anoxic Basin #1 level Transmitter</td>
</tr>
<tr>
<td>LSH-040105</td>
<td>Pre-Anoxic Basin #1 Float Switch High</td>
</tr>
<tr>
<td>LSL-040105</td>
<td>Pre-Anoxic Basin #1 Float Switch Low</td>
</tr>
<tr>
<td>LE-040206</td>
<td>Pre-Anoxic Basin #2 level Sensor</td>
</tr>
<tr>
<td>LT-040106</td>
<td>Pre-Anoxic Basin #2 level Transmitter</td>
</tr>
<tr>
<td>LSH-040105</td>
<td>Pre-Anoxic Basin #2 Float Switch High</td>
</tr>
<tr>
<td>LSL-040105</td>
<td>Pre-Anoxic Basin #2 Float Switch Low</td>
</tr>
<tr>
<td>LT-050106</td>
<td>Pre-Aeration Basin #1 Level Transmitter</td>
</tr>
<tr>
<td>LT-050206</td>
<td>Pre-Aeration Basin #2 Level Transmitter</td>
</tr>
<tr>
<td>LT-060104</td>
<td>Post Anoxic Basin #1 Level Transmitter</td>
</tr>
<tr>
<td>LT-060204</td>
<td>Post Anoxic Basin #2 Level Transmitter</td>
</tr>
</tbody>
</table>
1.8 REMOTE ALARM NOTIFICATION SYSTEM

A. Coordinate the list of alarms with Ovivo per section 409007.

1.9 PROCESS DATA HISTORIAN

A. Coordinate the list of data for inclusion in the historian with Ovivo per section 409007. Data shall include but is not limited to the follow:

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIR-040107</td>
<td>Train #1 Flow</td>
</tr>
<tr>
<td>FIR-040207</td>
<td>Train #2 Flow</td>
</tr>
<tr>
<td>LIR-040106</td>
<td>Pre-Anoxic Basin #1 Level</td>
</tr>
<tr>
<td>LIR-040206</td>
<td>Pre-Anoxic Basin #2 Level</td>
</tr>
<tr>
<td>LIR-050106</td>
<td>Pre-Aeration Basin #1 Level</td>
</tr>
<tr>
<td>LIR-050206</td>
<td>Pre-Aeration Basin #2 Level</td>
</tr>
<tr>
<td>LIR-060104</td>
<td>Post-Anoxic Basin #1 Level</td>
</tr>
<tr>
<td>LIR-060204</td>
<td>Post-Anoxic Basin #2 Level</td>
</tr>
</tbody>
</table>

ZA-040102    | Feed Forward Pump Fail           |
ZA-040103    | Feed Forward Pump Fail           |
ZA-040202    | Feed Forward Pump Fail           |
ZA-040203    | Feed Forward Pump Fail           |
1.10 OPERATION

A. When MBR train #1 is in operation, then MBR train #2 and the corresponding feed forward pumps in Pre-anoxic basin #2 shall be set to “Equalization Mode”.

1. Feed Forward (FF) pump operation:
   a. The Feed Forward pumps shall operate in a Duty/Standby configuration.
   b. When in the “Equalization Mode” the FF pump speed is automatically controlled to maintain an operator adjustable flow rate (gpm).
   c. When water level in Pre-anoxic (PAX) basin reaches to operator set point elevation (PAX-LTH) then the duty FF pump shall turn on and pump to Pre-aeration (PA) basin and run at operator set point gpm rate. When water level in PAX basin drops to operator set point elevation (PAX-LTL) then Duty FF pump shall turn off. Should the Duty pump fail, the Standby pump shall start automatically.
   d. The PA and Post-anoxic (AXP) basins are equipped with level sensors to monitor the water level in the basin. FF pumps shall turn off when water level in PA and AXP reach operator set point elevation (PA-LTH, AXP-LTH). No more flow shall be pumped to the PA and AXP basins.

2. After peak flow to the plant is reduced, mud valves located in each basin shall be opened manually such that the stored wastewater is returned to the influent pump station through 8” drain system located under the basin slab. Mud valves shall be opened slowly so that each tank is drained at a slow rate of 300 – 400 gpm. A position indicator located on the valve T-nut operator shall indicate the percent open for the valve. Only one basin at a time shall be drained to the influent pump station. The FF pumps shall be enabled to resume operation if the levels of the PA basin and AXP basin drop below a .5ft deadband below the high level shutoff setpoint.

3. The same process shall be used to operate the FF pumps as train #1 if train #2 is in operation.

4. In the future, when the a single MBR train reaches the peak capacity for treatment then the second MBR train shall also be dedicated for wastewater treatment. The FF pumps will then be switched to “MBR Mode”, and peak flows shall be diverted and stored in the “Future Storage Pond”.

B. Manual Control:

1. An HOR switch shall be provided at the MCC for each pump. The pumps shall run with the switch in HAND and stop with the switch in OFF.

2. Pump high temperature alarm and corresponding automatic shutdowns occur to maintain warranty status.

C. Automatic Control:

1. The pumps shall respond to the MBR PLC when the switch is in REMOTE. The HOR switch must be set to REMOTE for automatic operation.

2. Pumping control level set points shall be adjustable at SCADA HMI screens.

3. The “Equalization Mode” pump start, stop, and alarm level set points shall be adjustable at the SCADA HMI. The table below shows default level set points.

<table>
<thead>
<tr>
<th>Tag</th>
<th>Level (ft)</th>
<th>Control Action</th>
</tr>
</thead>
</table>

FLOW EQUALIZATION CONTROL STRATEGY
4. Float switches shall be provided to back up the level instrument in the PAX and the PA basins. If the PAX level reaches the high level float switch the FF pump shall turn on and run until the level reaches the low level float switch or the PA and AXP basins are full. Pumps shall always stop when the low level float switch is reached.

5. If the level transmitter signal is lost or out of range an alarm shall be activated. The pumps shall operate on float switches until the level transmitter is repaired.

6. If the tank level is at or above the PAX-LAH set point for an adjustable time delay (default is 30 seconds), the high level alarm shall be activated.

7. Lead Pump starts when water reaches specified “Start lead pump” elevation (LTH) or when the high level switch is activated, subject to interlocks.

8. Lead pump stops when any of the following conditions are met:
   a. Water surface elevation reaches specified “Stop FF pump” elevation (PAX-LTL).
   b. Water surface elevation falls below the low level float switch (PAX-LSL).
   d. Flow meter registers unusually low flow after a set period of time.

9. The standby pump starts if the lead pump is called to run and fails to start, or when the lead pump is stopped due to high winding temperature or unusually low flow condition.

10. The discharge flow meter will be used to confirm that a pump is operating. When a pump is running the PLC will confirm that water is flowing at an expected flow rate.

D. Interlocks: All fault related shutdowns shall require manual reset at the HMI.

1. Programmed:
   a. Pump failure alarm shall be activated after time delay if the flow meter reads an unusually low flow rate for greater than 30 seconds.
   b. The PLC shall remove the Start command when a fault occurs.
   c. The PLC shall remove the Start command when there is a loss of utility power. This interlock does not require a manual reset. The pumps will be free to start again as needed when generator power or utility power is restored.

2. Hardwired:
   a. Pumps shall be shut down on detection of overload, phase fail, or sequence failure.
b. A protection module shall be provided for the pumps to monitor for high winding temperature and seal failure. The pumps shall be shut down on detection of high winding temperature. These faults shall be reset at the local control panel.

PART 2 - MATERIALS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 409012
SECTION 409100 – FIELD INSTRUMENTS GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies general requirements for field instruments. This section applies to instrumentation elements that quantitatively convert sensed process energy into a form/signal compatible with process measurement, control, and display devices and accessories.

B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

C. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more demanding requirements shall govern.

1. ANSI B16.5  Pipe Flanges and Flanged Fittings
3. ASTM A276  Stainless Steel Bars and Shapes
4. NEMA 250  Enclosures for Electrical Equipment (1000 Volts Maximum)

B. Listing:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. Per Section 409000 “Instrumentation and Control Systems.”
PART 2 - PRODUCTS

2.1 TRANSMITTERS:

A. Unless otherwise specified, transmitters shall comply with the following requirements:

1. Two-wire type with operating power derived from the signal transmission circuit, unless otherwise specified.
2. Output shall be 4 to 20 mA, current regulated DC.
3. Load variations within the range of 0 to 500 ohms with the power supply at 24 VDC.
4. Output shall be galvanically isolated.
5. Time constant of transmitters used for flow or pressure measurement, including level transmitters used for flow measurement, shall be adjustable from 0.0 to 5.0 seconds.
6. Output shall increase with increasing measurement.
7. Unless otherwise specified, enclosures shall be rated NEMA 250, Type 4X.
8. Provide with surge protectors when located outdoors:
9. Where two-wire transmitter is located in a classified area, use intrinsic safety barrier as specified below.
10. Digital Communications: Provide HART or approved equal digital communications where available. Only one instrument communications protocol will be allowed.
11. Provide programming device and software utilities for communications capable devices.
12. Acceptable manufacturer:
   a. Rosemount Model 470A
   b. Control concepts model TMR
   c. Approved equal.

2.2 OUTPUT INDICATORS

A. Provide with any transmitter that does not include an integral indicator.

B. Output indicator shall be a loop powered current-to-digital display indicator.

C. Input current shall be 4-20 mA and display shall be a 3 1/2 active digit liquid crystal display with black numerals at least 0.35 inches high.

D. Display scalable with decimal point to read process engineering units.

E. Enclosed in a hockey puck type housing with glass window, classified as appropriate for the area in which the output indicator is installed.

F. A diode shall be provided to maintain loop continuity in case of indicator failure or removal.

G. Accuracy shall be +/- 0.1 percent of reading.

H. Indicators, whether integral or separate, shall be calibrated in process units.

I. The units shall be engraved on the indicator scale plate.
J. The installed orientation of the output indicator shall enable operators to easily read the display from the operating floor.

K. Acceptable Manufacturer:
   1. Action Instruments models V561/V565
   2. Precision Digital models 697/698
   3. Moore Industries models PSD/SPD
   4. Approved equal.

2.3 DETAILED INSTRUMENT REQUIREMENTS

A. Detailed requirements for specific instruments are specified in other Division 40 specification sections.

2.4 INTRINSIC SAFETY BARRIERS

A. Shall be two-wire, active, isolating, loop powered type.

B. Mounting: DIN Rail

C. Acceptable Manufacturer:
   1. Measurement Technology LTD, type MT3042
   2. Stahl 9005/01-252/100/00
   3. P + F SafeSnap Plus Z728 series
   4. Approved equal.

2.5 SIGNAL CURRENT ISOLATOR (FIELD MOUNTED)

A. Provides Galvanic isolation of milliampere transmission signals from transmitters with inadequately isolated output circuits. House in a NEMA 250, type 4X/7 conduit body. Derive its operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 mA and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Acceptable Manufacturer:
   1. Action Instruments model T700
   2. Moore Industries model SCX
   3. Acromag model 150i
   4. Approved equal.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation requirements per Section 409000 “Instrumentation and Control Systems.”

B. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of two feet.

C. Tagging: All field instruments shall be labeled with function and instrument number, i.e. (FIT-301/EFFLUENT FLOW METER). Tag shall be 10ga 316 stainless steel with stamped letters and numbers attached to device with 12ga 316 stainless steel wire.

3.2 TESTING

A. Testing requirements per Section 409000 “Instrumentation and Control Systems.”

END OF SECTION 409100
SECTION 409113 – ANALYTICAL INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for analytical instruments. This section applies to instrumentation elements that quantitatively convert sensed process parameters into a form/signal compatible with process measurement, control, and display devices and accessories.

B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

C. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Per 409100 Field Instruments General

1.3 SUBMITTALS

A. Per Section 409000 “Instrumentation and Control Systems.”

PART 2 - PRODUCTS

2.1 DETAILED INSTRUMENT REQUIREMENTS

A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.

B. Installation and application requirements are specified in this Section, Section 409004 “Schedules,” and/or on the contract Drawings.
PART 3 - EXECUTION

3.1 INSTRUSPEC SHEETS

A. INSTRUSPEC sheets provide detailed requirements for the instruments listed below.

<table>
<thead>
<tr>
<th>INSTRUSPEC Symbol</th>
<th>Instrument Description</th>
<th>Instrument Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE</td>
<td>Combustible Gas Monitor</td>
<td>Combustible Gas Detection</td>
</tr>
<tr>
<td>AIT3</td>
<td>Process Fluid Analyzer</td>
<td>PH Measurement</td>
</tr>
<tr>
<td>AIT9</td>
<td>Process Fluid Analyzer</td>
<td>Conductivity Measurement</td>
</tr>
</tbody>
</table>
**Instrument Identification:** AE

**Instrument Function:** Analysis of Gas for Combustible hydrocarbons (C1-C7)

**Instrument Description:** Gas Analyzer, Combustibles

**Power Supply:** 24 VDC nominal, 18-27 VDC, 10 VA maximum

**Signal Input:** NA

**Signal Output:** 4-20 mA DC, HART

**Process Connection:** Air sample

**Product Requirements:**

**Sensor:**
1. Design: NDIR Optical or Catalytic bead sensor optimized for CH4 and combustibles, corrosion-resistant contacts.
2. Range: 0-100% LEL based on methane
3. Connection: Flow cell with aspirator or Stand alone
4. Temperature limit: -4 degrees to 122 degrees F (-20 to 50C)
5. Humidity range: 0 to 95% RH, non-condensing

**Transmitter:**
1. Housing: NEMA 7, Class 1, Div. 1, Groups B to D
2. Housing material: Epoxy-coated Aluminum or Stainless steel
3. Temperature limit: -4 degrees to 122 degrees F (-20 to 50C)
4. Calibration: Non intrusive method, Microprocessor-based, able to retain configuration through power outage.
5. Response time: <30 seconds to 90% full scale
6. Linearity: +/-3% LEL below 40% LEL
7. Repeatability: +/- 2% LEL below 40% LEL
9. Approval: UL/FM/CSA
10. Cable: Three conductor shielded plus conforming ground. Maximum separation between sensor and transmitter: 50 ft.

**Special requirements:**
1. Provide Aspirator assembly sampler pump with flow switch capable of drawing a sample of 2.0 SCFH through analyzer sample chamber.
2. Provide 1/2-inch diameter 316 SS sample tubing and end-of-line filters.

**Approved Manufacturers:**
1. MSA model Ultima-IR; Ultima-XE sensor and transmitter
2. Scott Instruments
3. Approved equal.

**Installation:**
1. Per manufacturers recommendations
2. As shown on the Contract Drawings

**Calibration:**
1. Application, calibration, and set point requirements per Section 17901.
**Instrument Identification:** AIT3  
**Instrument Function:** pH measurement  
**Instrument Description:** pH Analyzer  
**Power Supply:** 9-30VDC  
**Signal Input:** NA  
**Signal Output:** 4-20 ma DC, HART  
**Process Connection:** Probe, submersible, 1” MNTP  

### General
1. Measurement of pH by the sensor is accomplished by immersing a glass or metal electrode and a reference electrode into a process solution. Measured pH is related to the logarithm of hydrogen ion activity in the solution. This instrument also provides temperature compensation.
2. Cable: Provide signal cable between the primary element and transmitter by the system manufacturer, 15 feet maximum length.

### Sensor
1. Sensing electrode: Flat glass suitable for abrasive solutions.
2. Preamplifier: Remote, sensor to transmitter distance 15 feet maximum.
3. Temperature range: 32 to 212 degrees F.
4. Pressure range: 0 to 100 psig.
5. Temperature Compensation: Integral pt100 sensor. Automatic compensation from 32 to 185 degrees F.
7. Submersion depth: 2.5 inches to 23 feet.
8. Maximum pressure at operating temperature: 100 psi at 65 degrees F, 50 psi at 85 degrees F.
10. Provide Integral cable with quick disconnect
11. Approval: FM.
12. Rating: Class 1, Division 1, Groups A, B, C, and D; Class 2, Division 1, Groups E and G, hazardous locations, explosion proof, intrinsically safe.
13. Installation in hazardous location shall be intrinsically safe, FM certified, and listed per NEC 504. Provide all required certificates, control drawings, and intrinsic safety calculations, etc, as required by the application.

### Transmitter
2. Display: 2 line 7 segment LCD display.
3. Configuration: Provide software configuration tools and all required connection accessories.
4. Ambient temperature range: -4 to 149 degrees F.
5. Relative humidity: 0 to 95% non condensing.
6. Temperature resolution: .1 degree C.
7. RFI/EMI: EN-61326, CE.
8. Measurement range: 0 to 14 pH.
9. Preamplifier: Integral, sensor to transmitter distance 15 feet maximum.
10. Temperature compensation: Pt 100 RTD located in the sensor, 5 to 270 degrees F.
11. Accuracy: ±1 mV @ 25degrees C ± 0.01 pH.
12. Repeatability: ±1 mV @ 25degrees C ± 0.01 pH.
13. Stability: .025% per year at 25 degrees C.
15. Mounting option: Field, as indicated on the drawings.
16. Approval: FM.
17. Rating: Class 1, Division 1, Groups A, B, C, and D; Class 2, Division 1, Groups E and G, hazardous locations, explosion proof, intrinsically safe.
18. Installation in hazardous location shall be intrinsically safe, FM certified, and listed per NEC 504. Provide all required certificates, control drawings, and intrinsic safety calculations, etc, as required by the application.

Acceptable Manufacturer:
1. Rosemount Model 399 combination pH/ORP sensor
2. Rosemount Model 5081-P pH/ORP Transmitter
3. Yokogawa FU20/PH202S
4. Approved equal.

Installation:
1. Per the manufacturer's instructions and recommendations
2. Sensor Mounting:
   a. In-line via ball valve assembly.
   b. In a sample line via twist-lock flow chambers.
   c. In-line via twist-lock bushings or tees.
   d. In-situ via electrode protection sleeve.

 Calibration:
1. Calibrate per the manufacturer's instructions.
**Instrument Identification:** AIT9

**Instrument Function:** Conductivity measurement

**Instrument Description:** Conductivity Analyzer

**Power Supply:** 9-30VDC

**Signal Input:** NA

**Signal Output:** 4-20 ma DC, HART

**Process Connection:** Probe, submersible, 1” MNTP

**Product Requirements:**

**General:**
1. Measurement of conductivity of the liquid by the sensor is accomplished by immersing an inductive sensor in a conductive liquid and inducing a voltage into the surrounding liquid. An ionic current is induced into the liquid and measured by the receive coil of the sensor.
2. Cable: Provide signal cable between the primary element and transmitter by the system manufacturer, 20 feet maximum length.

**Sensor:**
1. Sensor: Glass filled PEEK
2. Temperature: 248 degrees F maximum.
3. Pressure range: 0 to 295 psig.
5. Provide Integral cable with quick disconnect
6. Approval: FM,
7. Rating: Class 1, Division 1, Groups A, B, C, and D; Class 2, Division 1, Groups E and G, hazardous locations, explosion proof, intrinsically safe.
8. Installation in hazardous location shall be intrinsically safe, FM certified, and listed per NEC 504. Provide all required certificates, control drawings, and intrinsic safety calculations, etc, as required by the application.

**Transmitter:**
2. Display: 2 line 7 segment LCD display.
3. Configuration: Provide software configuration tools and all required connection accessories.
4. Ambient temperature range: -4 to 149 degrees F.
5. Relative humidity: 0 to 95% non condensing.
6. Temperature resolution: .1 degree C.
7. RFI/EMI: EN-61326, CE.
8. Measurement range: 50 to 1000 μS/cm.
11. Accuracy: ±1 % up to 5000 μS/cm
12. Repeatability: ±25% @ 25 degrees C
13. Stability: .025% per month at 25 degrees C.
15. Mounting option: Field, as indicated on the drawings.
16. Approval: FM.
17. Rating: Class 1, Division 1, Groups A, B, C, and D; Class 2, Division 1, Groups E and G, hazardous locations, explosion proof, intrinsically safe.
18. Installation in hazardous location shall be intrinsically safe, FM certified, and listed per NEC 504. Provide all required certificates, control drawings, and intrinsic safety calculations, etc, as required by the application.

**Acceptable Manufacturer:**
1. Rosemount Model 226 Conductivity sensor
2. Rosemount Model 5081 Conductivity Transmitter
3. Approved equal.

**Installation:**
1. Per the manufacturer's instructions and recommendations
2. Sensor Mounting:
   a. In-line via ball valve assembly.
   b. In a sample line via twist-lock flow chambers.
   c. In-line via twist-lock bushings or tees.
   d. In-situ via electrode protection sleeve.

Calibration:

1. Calibrate per the manufacturer's instructions.

END OF SECTION 409113
SECTION 409119.29 – PRESSURE TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section specifies requirements for pressure transmitters. This section applies to
      instrumentation elements that quantitatively convert sensed process pressure into a form/signal
      compatible with process measurement, control, and display devices and accessories.
   B. Performance Benchmarks: Items listed by part number are intended to serve as performance
      benchmarks. Submit most current model meeting the benchmark performance requirements for
      items that have been superseded or are otherwise obsolete UNO.
   C. Listed instruments: Not all products listed are required for all applications. Submit only
      products required for the application.

1.2 QUALITY ASSURANCE
   A. Per Section 409100 “Field Instruments General”

1.3 SUBMITTALS
   A. Per Section 409000 “Instrumentation and Control Systems.”

PART 2 - PRODUCTS

2.1 DETAILED INSTRUMENT REQUIREMENTS
   A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in
      Part 3.
   B. Installation and application requirements are specified in this section, Section 409004
      “Schedules,” and/or on the contract Drawings.

PART 3 - EXECUTION

3.1 INSTRUSPEC SHEETS
   A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

<table>
<thead>
<tr>
<th>INSTRUSPEC Symbol</th>
<th>Instrument Description</th>
<th>Instrument Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIT or PT</td>
<td>Gage pressure transmitter</td>
<td>Pressure measurement</td>
</tr>
</tbody>
</table>
**Instrument Identification:** PIT or PT  
**Instrument Description:** Gage pressure transmitter  
**Instrument Function:** Pressure measurement  
**Power Supply:** 9-30 VDC  
**Signal Input:** NA  
**Signal Output:** 4-20 mA DC, digital  
**Process Connection:** 1/2-inch female NPT flange adapter.

**Product Requirements:**

1. Pressure transmitter shall be capacitance type or silicone strain gage type.
2. Unless otherwise specified, wetted parts shall be ASTM A276, type 316 stainless steel.
4. Fill fluid shall be DC 200 Silicone oil, unless otherwise specified.
5. Adjustable dampening: 0.5 to 10 seconds.
7. Accuracy shall be ±0.1 percent of span.
8. Range: Transmitters shall be available in 0 to 600 PSIG ranges. Specific ranges shall be designated in Section 409004 “Schedules.”
9. Transmitters with spans less than or equal to 25 psig shall be provided with one 1/2-inch flanged process connection and two 1/4-inch drain/vent ports, one plugged and one provided with bleed valve.
10. Reference diaphragm shall be provided with a weatherproof, bug-proof atmospheric vent.
11. Transmitters for spans greater than 25 psig shall be similar to the above except shall be designed for gage pressure service, and overpressure rating shall be greater than the lesser of 2000 psig and 150 percent of maximum range.
12. Provide smart transmitter sub-carrier capability compatible with digital protocol.
13. PIT shall include a local indicator, integral to the transmitter.

**Acceptable manufacturer:**

1. Rosemount 1151 Alphaline Series  
2. Foxboro/Invensys IGP10 series  
3. Yokogawa EJA series  
4. Approved equal.

**Installation:**

1. Install in accordance with manufacturer’s instructions  
2. Follow the recommendations of API RP550 to the specified requirements.  
3. Provide root valves at all process pressure taps.  
4. Provide gage valves at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
5. DO NOT connect safety instruments to the same process tap as instruments used for control, indication, or recording.
6. Unless otherwise specified, pressure instruments shall be located as close as practical to the process tap and shall be positioned to permit observation and maintenance from grade or a maintenance platform.
7. Pressure instruments shall NOT be supported from process piping.

**Calibration:**

1. Per Section 409004 “Schedules” Instrument Schedule.

**END OF SECTION 409119.29**
SECTION 409119.43 – LEVEL TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for level transmitters. This section applies to instrumentation elements that quantitatively convert sensed process level into a form/signal compatible with process measurement, control, and display devices and accessories.

B. The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor’s responsibility to perform all the work required by the Contract Documents.

1. Section 409100 “Field Instruments General”

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Per Section 409100 “Field Instruments General.”

1.3 SUBMITTALS

A. Per Section 409000 “Instrumentation and Control Systems.”

PART 2 - PRODUCTS

2.1 DETAILED INSTRUMENT REQUIREMENTS

A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.

B. Installation and application requirements are specified in this section, section 409004 “Schedules,” and/or on the contract Drawings.
PART 3 - EXECUTION

3.1 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

<table>
<thead>
<tr>
<th>INSTRUSPEC Symbol</th>
<th>Instrument Description</th>
<th>Instrument Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT1</td>
<td>Submersible Pressure Transmitter</td>
<td>Level Measurement</td>
</tr>
<tr>
<td>LT8</td>
<td>Integrated Ultrasonic level Controller</td>
<td>Level Measurement</td>
</tr>
<tr>
<td>LT10</td>
<td>Guided Wave Radar Transmitter</td>
<td>Level Measurement</td>
</tr>
<tr>
<td>LT11</td>
<td>Drum Scale</td>
<td>Level/Weight Measurement</td>
</tr>
</tbody>
</table>
**Instrument Identification:** LT1  
**Instrument Description:** Submersible Venter Gage Pressure Transmitter  
**Instrument Function:** Level measurement (wastewater application)  
**Power Supply:** 9-30 VDC  
**Signal Input:** NA  
**Signal Output:** 4-20 mA DC, digital  
**Process Connection:** Diaphragm with retaining ring, 1” dia. minimum  
**Product Requirements:**

**Sensor:**
1. Pressure sensor shall be temperature-compensated Silicone piezo-resistive bridge type, shock- and vibration-resistant design.
2. Wetted parts shall be ASTM A276, type 316 stainless steel, titanium, or Teflon, unless otherwise specified.
3. Fill fluid shall be inert Silicone oil/grease, unless otherwise specified.
4. Process Connection: Teflon-coated flush elastomeric diaphragm with retaining ring, 1” dia. minimum

**Transmitter:**
1. Transmitter is integral to the sensor assembly.
2. Accuracy: +/-0.25 percent full scale - best straight line.
3. Operating Range: 0-6 ft to 0-46 ft water column (3 to 20 PSIG ranges. Specific ranges shall be designated in Section 409004 “Schedules” Instrument Index.
4. Operating Temperature: -5º F to 140º F (-20º C to 60º C).
5. Compensated Temperature Range: 40º F to 86º F (4º C to 30ºC)
7. Cable: 2-wire plus case ground. Polyurethane jacket, length per detailed specifications
8. Agency approvals: UL or FM listed intrinsically safe, Class I Div 1, Groups A-D.
9. Rating: NEMA 250, Type 6 (IP68), waterproof for immersion to 3x range.

**Terminal Enclosure:**
1. Location: Unclassified area  
2. Rating: NEMA 250, Type 4X  
3. Provides vent tube with a weatherproof, bug-proof atmospheric vent.  
4. Provide intrinsic safety barrier for transmitter/sensor assembly (if needed for hazardous areas).

**Acceptable Manufacturers:**
1. GE/Druck model PTX-1290 w/STE-110 termination encl.
2. US Filter model A-1000-157GSCD w/option 11 Intrinsic Safety Barrier (if needed for hazardous areas)
4. Approved equal.

**Installation:**
1. Per the manufacturer's instructions and recommendations
2. Follow the recommendations of API RP550.
3. Provide and install sink weight accessory as required.

**Calibration:**
1. Per 409004
2. As required by the process.
3. Range set and certified at the factory
Instrument Identification: **LT8**

Instrument Function: Level measurement

Instrument Description: Integrated Ultrasonic level Controller.

Power Supply: 12 - 28 VDC

Signal Input: Ultrasonic

Signal Output: 4 - 20 mA DC non-isolated into 750 ohms maximum, digital

Product Requirements:

1. The single-point level transmitter shall be a microprocessor based echo-time measuring type providing an electronic output signal proportional to the level of the material or the distance to the material being measured.
2. The device shall consist of an integral transmitter, transducer, and temperature sensor package.
3. System housing Main case material shall be CPVC and the transducer portion shall be Tefzel TM. Connection shall be 2” NPT.
4. Programming Via dual buttons with data entry prompts displayed
5. EEPROM memory retains parameters during power loss.
6. Weight - 3.3 lbs
7. Cable entry through dual 7/8” ports
8. Enclosure rating: IP65, NEMA 4X, CSA Type 4
9. Approvals: FM and CSA
10. Transmitter shall process all echoes from stored memory which is continually updated after echo enhancement.
11. Echo Processing: Echos shall be processed comparing returns for largest area echo, tallest echo spike and first echo returned. The patented Sonic Intelligence shall compare the various returns and select the echo with the greatest confidence factor.
12. Operating temperature: - 40 to 140 F
13. Range: 1 - 16 feet
14. Accuracy: 0.25% of full scale
15. Resolution: 0.125”
16. Display: Three (3) digit LCD
17. The device shall be available in the following configurations:
   a. 2 wire or 3 wire
   b. Standard, extended, or intrinsically safe versions.

Acceptable Manufacturers:

1. Milltronics Probe
2. Approved equal.

Installation:

1. Install in accordance with manufacturer's instructions
2. Follow the recommendations of API RP550
3. Install as required by the application

Calibration:

1. Per Section 409004 “Schedules” Instrument Schedule.
**Instrument Identification:** LT10  
**Instrument Function:** Level/Weight measurement  
**Instrument Description:** Drum Scale  
**Power Supply:** 110 VAC  
**Signal Input:** mV/V  
**Signal Output:** 4 - 20 mA DC  
**Process Connection:** Non Contact  

**Product Requirements:**

1. Waveguide shall a single rod probe be made of 316 stainless steel. Length as required for application. Connection shall be stainless steel flange.
2. Transmitter shall be explosion proof.
8. Enclosure rating: IP65, NEMA 4X, CSA Type 4
12. Operating temperature: -40 to 140 F
13. Range: 0-20 feet
14. Accuracy: +/- 0.5% of probe length
15. Resolution: 0.1”
16. Display: 2-line x 8-character LED

**Acceptable Manufacturers:**
1. Magnetrol Eclipse  
2. Approved equal.

**Installation:**
1. Install in accordance with manufacturer's instructions  
2. Follow the recommendations of API RP550  
3. Install as required by the application

**Calibration:**
1. Per Section 409004 “Schedules” Instrument Schedule.
**Instrument Identification:** LT11

- **Instrument Function:** Level/Weight measurement
- **Instrument Description:** Drum Scale
- **Power Supply:** 110 VAC
- **Signal Input:** mV/V
- **Signal Output:** 4 - 20 mA DC

**Product Requirements:**

1. Drum scale shall be an electronic load cell with a digital readout and transmitter.
2. The scale platform shall be sized to accept up to a 24” diameter drum.
3. Platform shall have integral secondary containment with a capacity of 66 gallons. Platform and containment system shall be non-metallic to eliminate the possibility of corrosion.
4. Flexible cable shall connect the scale platform to the indicator to allow easy remote installation of the readout. Cable length as required.
5. A remote transmitter/readout shall be a 32 character LCD indicator housed in a NEMA 4X, UL approved enclosure. LCD indicator shall be back lit with 0.5” characters.

**Acceptable Manufacturers:**

- Force Flow SpillSafe Drum Scale with SRG2-1 Indicator
- Approved equal.

**Installation:**

1. Install in accordance with manufacturer's instructions
2. Follow the recommendations of API RP550
3. Install as required by the application

**Calibration:**

1. Per Section 409004 “Schedules” Instrument Schedule.

END OF SECTION 409119.43
SECTION 409123 – PACKAGED METERING MANHOLE

PART 1 - GENERAL

1.1 SUMMARY

A. Work consists of providing one 9x3-inch and one 3-inch throat influent Parshall flume packaged metering manholes as shown on the Drawings and as specified.

1.2 SUBMITTALS

A. Procedures: Submit in accordance with Division 1, Section 013300 “Submittal Procedures.”

B. Submit complete data in accordance with the requirements of Division 1, Section 017823 “Operation and Maintenance Data.”

C. Submit product data and shop drawings in accordance with the requirements of Division 1 Section 013300, “Submittal Procedures.”

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. ACCEPTABLE MANUFACTURER

1. Plasti Fab, Inc.
2. Approved equal.

2.2 PACKAGED METERING MANHOLES

A. Each Packaged Metering Manhole shall be a completely integral unit consisting of: a corrosion resistant fiberglass reinforced plastic (FRP) manhole with sealed fiberglass bottom, fiberglass hinged cover, fiberglass access ladder, Parshall metering flume and accessories as required. Two neoprene boots with stainless steel clamps sized to connect inlet and outlet pipe stubs shall be supplied by the manhole manufacturer and the manhole will be equipped with hold down brackets for anchoring the unit to a concrete slab. A 1/2 inch thick expanded polystyrene foam board shall be supplied for placement on the concrete slab under the manhole.

B. The Packaged Metering Manhole will be furnished with 48 inch diameter hinged fiberglass cover with hasp for locking.

C. The 3 inch Flume Packaged Metering Manholes will be 6 feet in height from the invert of the inlet pipe to the hinged cover. The 9x3 inch Flume Packaged Metering Manholes will be 9.5 feet in height from the invert of the inlet pipe to the hinged cover.

E. The 3 inch Flume Packaged Metering Manhole shall have an integral Parshall flume including approach section, throat, and downstream section in one piece. The flume shall be equipped with a head gage molded into the side of the flume reading 0 to 24 inches of head and 0 to 1.89 mgd flow for 3 inch flume.

F. The 9x3 inch Flume Packaged Metering Manhole shall have an integral 9-inch Parshall flume including approach section, throat, and downstream section in one piece. A 3-inch Parshall flume shall be nested inside the 9-inch flume for measuring low flows during early years of operation, and the 3-inch flume shall be removable in the future so the 9-inch flume can be used to measure higher flows in future years. The flumes shall each be equipped with a head gage molded into the side of the flume reading both 0 to 24 inches of head and 0 to 5.7 mgd flow for 9 inch flume, and 0 to 30 inches of head and 0 to 2.65 mgd flow for 3 inch flume.

G. Flume liner shall be constructed of molded fiberglass reinforced polyester resin with a minimum wall thickness of 1/4 inch and a glass content of not less than 30% by weight. Inside surface shall be smooth and free of any cracks, crazes or other irregularities. Outside surface shall include flanges and anchoring ribs for firm permanent anchorage in the concrete sidewalk.

H. The manhole barrel shall be fitted with a 2" FRP through-wall utility tap having threaded connections to permit sub-grade entrance for sample pipe without damaging the watertight integrity of the manhole. A 3/8" OD sample pipe T-304 S/S shall extend from the bottom to the top of the flume with quick connector suitable for connecting to 3/8-inch flexible sample tubing provided with the automatic sampler specified in section 444248.

I. Flume shall be shipped in one piece and shall be structurally designed to serve as formwork for concrete placement.

J. Flume shall be provided with cast 304 SS anchor bolts recommended by manufacturer

K. After installation, the flume shall be field-calibrated by the manufacturer and a flow curve provided for the entire design range. Accuracy shall be 2% of actual rate.

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. General: The Packaged Metering Manhole shall have a minimum l/2" wall thickness and be designed and manufactured in accordance with ANSI/ASTM D3753-81 Standard Specification for fiber reinforced manholes. Any portion of the flume or end adapters extending outside the manhole shall have a reinforced cover. The manhole sides, bottom and external flume sections shall be designed to withstand a static load of 150 lb/ft per foot of depth with less than 1/4" deflection. There shall be no light duty angles of flanges protruding beyond the flume or manhole, that can be damaged by shear or load forces. The fiberglass manhole shall be fabricated with polyester resin, in one integral piece that is structurally strong, lightweight, watertight and corrosion resistant to salt water, ground water, corrosive soil conditions and many commonly encountered industrial chemicals.
B. Manhole Barrel: Fiberglass barrel shall be 48 inch in diameter. The barrel shall have a minimum 1/2 inch thickness. Interior of barrel shall have a 15-20 mil. thick white gel coat. Barrel manufacturer shall be the same as that of the flume and the accessories.

C. Internal Ladder: The Packaged Metering Manhole shall be furnished with an internal fiberglass ladder to provide easy access. The ladder rungs shall have a non-slip traction surface and internal stainless steel safety bar. The ladder shall meet or exceed OSHA General Industry Standards, Part 1910.27 for "Fixed Ladders".

D. Fiberglass safety grating shall be installed over the flume to provide a walking surface and to prevent debris from falling into the flume.

3.2 INSTALLATION

A. General: The Packaged Metering manhole shall be installed in accordance with the Engineer’s specifications and local codes and in a manner consistent with the installation instructions and recommendations of the manufacturer. The contractor shall see that good construction and installation procedures are followed throughout handling, storage and placement to insure that the manhole is not damaged in any manner, and that maximum serviceable results are achieved.

B. Handling and Storage: During loading, unloading and storage care shall be exercised to insure that the manhole is not dropped or otherwise damaged through impacting with solid surfaces. The manhole shall be stored on a smooth surface, free of sharp objects, and if laid horizontally, shall be placed in such a way as to avoid structural damage to the inlet and outlet channels. Slinging will be accomplished using nylon or other fabric material. Under no circumstances shall cable or chain slings be used in direct contact with fiberglass surfaces.

C. Site Preparation: The site shall be excavated wide enough to accommodate the manhole and to provide a safe working environment for workers. The contractor shall provide a level concrete slab with a thickness as shown on the drawings with smooth troweled surface. Pad elevation shall be as shown on the drawings, and positioned so that the invert of manhole piping matches that of the pipeline. Pad size shall be of dimensions shown on the drawings and fitted with cast T-304 stainless steel anchor bolts of the size and location indicated on the manufacture's approved shop drawings.

D. Placement and Final Installation: Prior to manhole placement, the slab shall be cleaned of all sharp objects and debris. Foam board, supplied with unit. After placement on the foam pad, all anchor bolts shall be securely tightened to tie downs on packaged manhole, and the flume level shall be checked and adjusted as necessary. Fill all open spaces under the flume with cement grout to provide adequate structural support. Neoprene boots supplied with unit, shall also be placed onto existing pipes before lowering manhole onto concrete slab. Packaged Metering Manhole shall be lowered onto slab and properly located on anchor bolts in accordance with the manufacturers written instructions and recommendations. Slip neoprene boots with stainless steel clamps over pipe ends on metering manhole, and tighten clamps securely. Under no circumstances shall petroleum lubricants of any type be used to install boots.

E. Back Filling: Care shall be taken to avoid uneven backfill loads on the packaged manhole. Groundwater or surface water runoff shall not be allowed to accumulate in the open excavation around a manhole which has not been completely backfilled. Backfill materials shall be placed evenly around the packaged manhole in maximum 12 inch lifts. Backfill material shall be 1/4
inch to 3/8 inch pea gravel. Backfill around the flume shall be taken using sand or earth fill. All fill work will be in compliance with local codes, and shall meet the inspection standards established by the Engineer.

F. Stable Soils: (Bearing capacity greater than 2000 lbs/sq. ft.) Native soil, 1/4-inch by 3/8-inch round aggregate gravel or sand shall be used as backfill material, and placed in accordance with the above specifications.

G. Finish to Grade: For concentric top, contractor shall finish to grade using brick and mortar or precast concrete rings to construct chimney of required height. Mortar bed and first grade ring shall be firmly supported on flat, bearing shoulder of packaged manhole.

END OF SECTION 409123
SECTION 409123.33 – FLOW TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for flow transmitters. This section applies to instrumentation elements that quantitatively convert sensed process flow energy into a form/signal compatible with process measurement, control, and display devices and accessories.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor’s responsibility to perform all the work required by the Contract Documents.

1. Section 409100 “Field Instruments General”

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Per Section 409100 “Field Instruments General.”

1.3 SUBMITTALS

A. Per Section 409000 “Instrumentation and Control Systems.”

PART 2 - PRODUCTS

2.1 DETAILED INSTRUMENT REQUIREMENTS

A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.

B. Installation and application requirements are specified in this section, section 409004 “Schedules,” and/or on the contract Drawings.
PART 3 - EXECUTION

3.1 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

<table>
<thead>
<tr>
<th>INSTRUSPEC Symbol</th>
<th>Instrument Description</th>
<th>Instrument Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM1</td>
<td>Magnetic flow meter</td>
<td>Flow measurement</td>
</tr>
<tr>
<td>FM4</td>
<td>Ultrasonic Level Transmitter</td>
<td>Flow measurement</td>
</tr>
</tbody>
</table>
**Instrument Identification:** FM1

**Instrument Function:** Flow measurement

**Instrument Description:** Magnetic flow metering system

**Power Supply:** 120 VAC (transmitter)

**Signal Input:** Induced Voltage

**Signal Output:** 4-20 mA DC, Digital

**Process Connection:** Flange, ANSI B16.5 Class 150, raised face

**Product Requirements:**

**General:**
1. Magnetic flow meter shall be provided as a system consisting of a flow tube and remotely mounted converter/transmitter complete with all necessary interconnecting cables for the flow tube to transmitter separation shown.
2. System shall be suitable for measuring raw sewage flow.
3. Provide grounding rings for both upstream and downstream connections with the process piping.
4. Provide mechanical protection for the flow tube flanges and liner during installation or removal of the flow tube.
5. Provide pipe reducer and expander where pipe run size is different from specified flow tube size.
6. The reducer and expander shall be uniformly diverging and converging swages with a total reducing angle not exceeding 8 degrees.
7. Flow Tube and transmitter shall be the products of the same manufacturer recommended for use together by the manufacturer.

**Flow Tube:**
1. The inside diameter of the flow tube is shown in Section 409004 “Schedules.”
2. Flow tube features: measuring tube material 304 stainless steel; liner material will be Teflon-PTFE for sizes less than 1”, polypropylene for 1” - 6”, and hard rubber for sizes larger than 6”.
3. Pulsed DC field excitation with automatic zero point correction.
4. Field coil insulation class E.
5. Field replaceable electrodes replaceable when flow tube is under operating pressure.
6. Electrode material 316 Ti stainless steel, unless designated differently in Section 409004 “Schedules.”
8. Grounding ring material 316 Ti stainless steel, unless designated differently in Section 409004 “Schedules.”
9. Suitable for installation in Class1, Division 1, Group D classified areas.

**Transmitter:**
1. Signal converter/transmitter shall be suitable for an adjustable full-scale flow within the limits of from 1 to 30 feet per second.
2. Signal converter / transmitter shall be remotely mounted from flow tube and microprocessor based.
3. Bi-directional flow and totalization measurement.
4. Integral high-contrast LCD display, integral control panel.
5. Accuracy of 0.3% of Rate.
6. Signal output 4-20 mA DC, galvanically isolated and internally powered 500 ohm driving capability.
7. Low-flow cutoff: adjustable from 1% to 3% of range
8. Terminals and signal converter modules plug in and replaceable without recalibration or resetting and upgradeable to comply with future communication standards.
9. Adjustable dampening: 0.2 to 256 seconds
10. Power 120 VAC.
11. Enclosure: NEMA 4X wall mount.
12. Flow rate calibration per Section 409004 “Schedules.”

Acceptable manufacturer:
1. Krohne OPTIFLUX Flanged Flow tube
2. Krohne IFC 300 Flow Transmitter
3. Rosemount Series 8700F Flow Tube
4. Rosemount series 8712 Flow Transmitter
5. Approved equal.

Installation:
1. Install in accordance with manufacturer's instructions, API RP550, and the specified functional requirements.
2. Install ground rings upstream and downstream of the flow tube.
3. Install the transmitter on the wall near to but remotely from the flow tube.
4. Provide signal cable between the primary element and transmitter by the system manufacturer.
5. Provide a sufficient length of cable for installation of a continuous run between the primary element and the remotely mounted transmitter.

Calibration:
1. Range shall be per 409004 Instrument Schedule.
2. Instrument shall be calibrated and certified at the factory by the manufacturer.
**Instrument Identification:**  
**FM4**

**Instrument Function:** Flow Measurement  
**Instrument Description:** Ultrasonic Level transmitter (for flow calculation)

**Power Supply:**  
**Signal Input:** Ultrasonic  
**Signal Output:** 4-20 mA DC, digital  
**Process Connection:** Non Contact

**Product Requirements:**
1. As specified by the listed manufacturer  
2. Suitable for the environment and area classification

**Acceptable manufacturer:**
1. Siemens Milltronics Multi Ranger  
2. Approved equal.

**Installation:**
1. Install per manufacturer’s instructions and recommendations.

**Calibration:**
1. Per 409004 Instrument Schedule

END OF SECTION 409123.33
SECTION 409124 – PROCESS SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for process and non process activated switches.

B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

C. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more demanding requirements shall govern.

2. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
3. NEMA ICS 2 Industrial Control Devices, Controllers and Assemblies
4. NEMA ICS 6 Industrial Control and Systems: Enclosures

B. Listing

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. Per Section 409000 “Instrumentation and Control Systems.”
PART 2 - PRODUCTS

2.1 GENERAL

A. Switches: Unless otherwise specified, switches shall comply with the following requirements:

1. Contact outputs used for alarm actuation shall be ordinarily closed and shall open to initiate the alarm.
2. Contact outputs used to control equipment shall be ordinarily open and shall close to start the equipment.
3. Contacts monitored by solid-state equipment such as programmable logic controllers or annunciators shall be hermetically sealed and designed for switching currents from 20 to 100 mA at 24 VDC.
4. Contacts monitored by electromagnetic devices such as mechanical relays shall be rated NEMA ICS 2, designation B300.
5. Double barriers shall be provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
6. Switch electrical enclosures shall be rated NEMA 250, Type 4X minimum.
7. Provide suitable intrinsic-safety barriers for contacts in hazardous areas that are monitored by equipment in safe areas.

B. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.

C. Installation and application requirements are specified in this section, Section 409004 “Schedules,” and/or on the contract Drawings.

2.2 INTRINSIC SAFETY BARRIERS AND RELAYS

A. Intrinsic safety barriers for process switches:

1. Dual input, passive type.
2. Shunt diode barrier construction with non-replaceable fuse and internal current limiting resistor
3. Listings: UL, FM or CSA certified for use in Class I Groups A, B, C, D; Class II Groups E, F, G.
4. Acceptable manufacturers:
   a. Ronan X57 Series
   b. Turck MZ-61 Series
   c. Approved equal.

B. Intrinsic safety relays:

1. Isolates field contacts in classified location from control circuits in non-classified location.
2. Input:
   a. Maximum field contact current/voltage: 10 mA/11 VAC
   b. Turn-on sensitivity: < 100K Ohms
   c. Turn-off sensitivity: > 1 Megaohm

3. Output:
   a. SPST N.O./N.C. switching action field programmable
   b. Rating: 1 A resistive at 24 VDC or 120 VAC

4. Power: 100 to 130 VAC, 50-60 Hz, 4 VA maximum

5. Listings: UL of FM approval for use in Class I Groups A, B, C, D, Class II Groups E, F, G

6. Enclosure: NEMA 1

7. Acceptable manufacturers:
   a. Gems SafePak model 54820
   b. Stahl IS Isolator Type 9170
   c. Square-D series 8501 TO or NY2
   d. Warrick series 17 or 27
   e. Approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

   A. Installation requirements per Section 409000 “Instrumentation and Control Systems.”

   B. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of two feet.

   C. Tagging: All field instruments shall be labeled with function and instrument number, i.e. (FIT-301/EFFLUENT FLOW METER). Tag shall be 10ga 316 stainless steel with stamped letters and numbers attached to device with 12ga 316 stainless steel wire.

3.2 TESTING

   A. Testing requirements per Section 409000 “Instrumentation and Control Systems.”
3.3 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed devices.

<table>
<thead>
<tr>
<th>INSTRUSPEC Symbol</th>
<th>Instrument Description</th>
<th>Instrument Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS1</td>
<td>Level Switch, float</td>
<td>Level measurement</td>
</tr>
<tr>
<td>LS2</td>
<td>Multi-level measurement</td>
<td>Level measurement</td>
</tr>
<tr>
<td>ZS1</td>
<td>Door position switch</td>
<td>Intrusion detection</td>
</tr>
<tr>
<td>PS</td>
<td>Pressure Switch</td>
<td>Pressure measurement</td>
</tr>
</tbody>
</table>
Instrument Identification: LS1
Instrument Function: Level measurement
Instrument Description: Float level switch
Power Supply: N/A
Signal Input: N/A
Signal Output: Contacts
Process Connection: N/A

Product Requirements:
1. SPST tilt actuated switch
2. Switch shall not contain mercury
3. High buoyancy, foam filled, durable, corrosion resistant float housing
4. 14-AWG wire type SO cable with PVC outer jacket
5. Tilt switch shall be rated for two amps at 120 VAC minimum
6. Cable length as needed, field verify
7. Contacts: 1 NO or 1 NC

Acceptable manufacturer:
1. US Filter Model 9G-EF
2. Anchor Scientific Solo-Float
3. Approved equal.

Installation:
1. Install per Contract Drawings.
2. Install per the manufacturer’s instructions.

Calibration:
1. Per Section 409004 “Schedules”
**Instrument Identification:**  LS2  
**Instrument Function:**  Multi-level measurement  
**Instrument Description:**  Stem Mounted Multiple Float Switch  
**Power Supply:**  120VAC  
**Process:**  Waste water  
**Signal Input:**  N/A  
**Signal Output:**  Contacts  
**Process Connection:**  N/A  
**Product Requirements:**

1. Switch shall be a SPST  
2. Switch shall be UL or FM approved  
3. Provide four actuation levels  
4. Lead wire length shall be 24”  
5. Mount and stem material shall be 316 SS  
6. Float material shall be SS  
7. Float diameter shall be Manufacturer standard  
8. Float operating temperature limit shall be up to 150 degrees F  
9. Float operating maximum pressure shall be 100 PSI  
10. Electrical connection junction box shall be NEMA 4 type  

**Acceptable manufacturer:**

1. GEMS Model LS700  
2. Barksdale BLS-800  
3. Approved equal.  

**Installation:**

1. Install per Manufacturer’s recommendations
**Instrument Type Symbol:** ZS1

**Instrument Function:** Door position threshold detection.

**Instrument Description:** Magnetic reed switch.

**Product Requirements:**

1. Provide industrial grade switch suitable for harsh environments.
2. Contacts: SPDT form C, .5 amp max, 100 VAC/DC max at .25 amps, 7 VA max.
3. Magnetic reed switch.
4. Prevent sticking or freezing between the two switch plates that form the magnetic field.
5. Electrical components hermetically sealed.
6. 316 Stainless Steel armored lead type.
7. Operating temperature: -40 to 150 degrees F.
8. UL listed.
9. Warranty exceeding 10 years for workmanship, material and factory defects.

**Acceptable manufacturer:**

1. GE Security Products 2500 series
2. George Risk Industries
3. Approved equal.

**Installation:**

1. Install in accordance with manufacturer’s instructions and the application requirements.
2. Suitable for metal door installation

**Calibration:**

1. Per site requirements
**Instrument Identification:** PS  
**Instrument Function:** Pressure measurement  
**Instrument Description:** Pressure switch  
**Power Supply:** NA  
**Signal Input:** NA  
**Signal Output:** Contacts  
**Process Connection:** 1/4-inch female NPT.

**Product Requirements:**

1. **Construction:** Pressure element and a precision switch.
2. **Pressure element:**
   a. **Type:** Diaphragm type with Buna-N diaphragm, or brass dual bellows.
   b. **Overpressure:** capable of withstanding 10 times overrange pressure without affecting calibration.
3. **Switch:**
   a. Hermetically sealed SPDT, unless otherwise specified.
   b. Contacts rated 10 A at 120 VAC; 0.5 A at 120 VDC, resistive
   c. Adjustable set-point and deadband of approximately 10% to 90% of operating range, unless otherwise specified.
4. **Range:** As specified. Set point should fall between 30% and 70% of operating range. Set point and reset point shall be indicated on calibrated scales.
5. **Accuracy:** Repeatability and sensitivity shall be ±1% of operating range or better.
6. **Enclosure:**
   a. Cast aluminum rated NEMA 4X or NEMA 7, as required
   b. Two 3/4-inch conduit connections

**Acceptable Manufacturers:**

1. Square-D series 9012 G
2. Ashcroft LP Series
3. Mercoid Series 1000
4. Approved equal

**Installation:**

1. Install per manufacturer's instructions and the recommendations of API RP550 to the specified requirements.
2. Provide root valves at all process pressure taps except taps made for safety instruments.
3. Provide gage valves at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
4. Do not connect safety instruments to the same process tap as instruments used for control, indication, or recording. Unless otherwise specified, locate as close as practical to the process tap and position to permit observation and maintenance.

**Calibration:**

1. Application, calibration, and set points shall be per Section 17901.

**END OF SECTION 409124**
SECTION 409200 – PROCESS TAPS AND PRIMARY ELEMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. The Contractor is responsible for all aspects of required process taps including but not limited to modification of existing piping, installation of weldolets, etc., as required to connect specified instrumentation to process media and process parameter measurement points.

B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete.

C. Listed products: Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more demanding requirements shall govern.

2. ASTM A269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
3. ASTM A276 Specification for Stainless Steel Bars and Shapes
4. ASTM D1248 Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable
5. SAMA PMC 17-10 Bushings and Wells for Temperature Sensing Elements

B. Listing:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.
1.3 SUBMITTALS

A. Per 409000

B. Flow calculation for each differential-type flow element

PART 2 - PRODUCTS

2.1 GENERAL:

A. Requirements primary elements are specified in this Section and in INSTRUSPEC sheets in Part 3.

2.2 VALVES

A. Isolation Valves:

1. Full port ball valves with ASTM A276, 316 stainless steel trim and body.
2. Teflon seats and packing.
3. Acceptable manufacturer:
   a. Parker Hannifin
   b. Whitey
   c. Hoke
   d. Approved equal.

B. Gage Valves:

1. Machined from ASTM A276 bar stock.
2. Use with 1/2-inch NPT connections and integral bleed valve.
3. Acceptable manufacturer:
   a. Anderson Greenwood M9530
   b. Hoke 6801L8Y
   c. Approved equal.

C. Root Valves:

1. ASTM A276, Type 316 stainless steel bar stock
2. 1/2-inch NPT male process connection and three 1/2-inch NPT female instrument connections
3. One instrument connection shall be provided with an ASTM A276, Type 316 stainless steel bleed valve.
4. ASTM A276, Type 316 stainless steel plugs for unused ports
5. Lagging type units shall be provided for insulated vessels and pipes.
6. Acceptable manufacturer:
   a. Anderson Greenwood M5 AVS-44
   b. Hoke 6802L8Y
c. Approved equal.

D. Manifolds:
   1. Three-valve bar-stock type
   2. Body: machined from ASTM A276, Type 316 stainless steel bar stock
   3. Valves shall be globe configuration with 316 stainless steel ball seats and Teflon stem packing.
   4. Designed for direct mounting to differential pressure transmitters in place of the flanges normally furnished
   5. Fabricated manifolds or manifolds employing needle or soft seat valves are not acceptable.
   6. Purge taps, 1/8-inch NPT shall be furnished on manifolds where water purge is specified.
   7. Acceptable manufacturer:
      a. Anderson Greenwood M4TVS
      b. Hoke 8123F8Y
      c. Approved equal.

2.3 TUBING AND TUBING FITTINGS

A. Instrument tubing:
   1. 1/2-inch x 0.065-inch seamless annealed ASTM A269 Type 316 stainless steel between the process connection and instruments.

B. Tubing fittings:
   1. Type 316 stainless steel
   2. Swage ferrule design with components (nut, body and ferrule system) interchangeable with those of at least one other manufacturer.
   3. Flare and ball sleeve compression type are not acceptable.
   4. Acceptable manufacturer:
      a. Parker Hannifin
      b. Swagelok
      c. Hoke
      d. Approved equal.

2.4 CHEMICAL SEALS

A. Diaphragm:
   1. Unless otherwise specified, seal shall be the diaphragm type with flushing connection, Type 316 stainless steel body and Type 316L diaphragm.
   2. Unless otherwise specified, fill fluid shall be DC200 silicone oil.
   3. Acceptable manufacturer:
      a. WIKA Series 990. TC
b. Ashcroft Type 101
c. Approved equal.

B. Annular:

1. Seal shall be the in-line full stream captive sensing liquid type.
2. Metallic wetted parts shall be 316 stainless steel.
3. Unless otherwise specified, flexible cylinder shall be Buna-N.
4. Rated 200 psig with not more than 5-inch WC hysteresis.
5. Unless otherwise specified, fill fluid shall be DC200 silicone oil.
6. Acceptable manufacturer
   a. Red Valve Series 40
   b. Ashcroft Series 80
   c. Approved equal.

2.5 BUSHINGS AND THERMOWELLS

A. Comply with SAMA PMC17-10.

B. Unless otherwise specified, machined from 316 stainless steel bar stock.

C. On insulated vessels or pipes, temperature taps with 1/2-inch NPT, and lagging extensions.

2.6 PURGE ASSEMBLIES

A. Air purge assembly:

1. Constant-differential relay, needle valve, check valve and 0.2 to 2.0 SCFH rotometer.
2. Acceptable manufacturer:
   a. Bailey / Fischer & Porter 10A6100 Purgemaster
   b. Approved equal.

B. Water purge assembly:

1. Strainer, constant-differential regulator, needle valve, check valve, and 20 to 200 cc/m rotometer.
2. Acceptable manufacturer:
   a. Assembly:
      1) Moore Products 63BD4A
      2) Fischer & Porter 10A3137N-53BR2110
      3) Approved equal.
   b. Strainer: 155 micron wye-type
      1) ASCO 8600A2
2) Crane
3) Approved equal.

2.7 FLOW STRAIGHTENING VANES
A. Acceptable manufacturer and Models:
   1. Daniel Industries
   2. Model 1106F
   3. Approved equal.

2.8 TEMPERATURE SENSORS, THERMOCOUPLES (T/C, RTD)
A. Acceptable Manufacturers and Models:
   1. Weed Instruments Co.
   2. Model Series: 305 with ½-H260, with 2A or 1A
   3. Approved equal.

2.9 SEALS
A. Acceptable Manufacturers and Models:
   1. Ashcroft
   2. Model Series: Diaphragm and ISO-Ring
   3. Approved equal.

2.10 FLOW INDICATOR (FI)
A. Acceptable Manufacturers and Models:
   1. Yokogawa
   2. Model Series: RAGH, EJA110A, EJA530A, YTA320
   3. Approved equal.

2.11 LEVEL INDICATOR (LI)
A. Acceptable Manufacturers and Models:
   1. Jerguson
   2. Model Series: 300L
   3. Approved equal.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Process Connections:

1. Unless otherwise specified, process taps shall comply with API RP550.
2. Root valves shall be provided at taps, except temperature taps and pump discharge pressure taps.
3. Arrange, where possible, such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels.
   a. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
   b. Where process taps are not readily accessible from instrument locations, a block valve shall be provided at the instrument. Block valves shall also be provided for each instrument where multiple instruments are connected to one process tap.

B. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of two feet.

3.2 IDENTIFICATION

A. Tagging: All field instruments shall be labeled with function and instrument number, i.e. (FIT-301/EFFLUENT FLOW METER). Tag shall be 10ga 316 stainless steel with stamped letters and numbers attached to device with 12ga 316 stainless steel wire.

3.3 TESTING

A. Testing requirements per Section 409000 “Instrumentation and Control Systems.”

END OF SECTION 409200
SECTION 409443 – PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies Programmable Logic Controller (PLC) hardware, programming software, system configuration, and testing requirements. Each PLC system shall consist of a PLC processor, input/output modules, communication modules, and accessories which form a system. Each PLC system shall be programmable in industrial standard relay ladder logic symbols and be delivered fully programmed for the functions required per Section 409635 “Programming,” and the requirements of the process in the case of packaged systems. Each PLC system shall be delivered fully configured to process bi-directional communication with a plant SCADA system if specified. Each PLC system shall be provided with and Graphical HMI (Human Machine Interface) in the form of a touch screen operator interface panel or a SCADA HMI.

B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

C. Not all products listed are required for all applications. Submit only products required for the application.

D. Contractor Responsibilities include but are not limited to the following:

1. Coordinate installation of the PLC equipment with the plant SCADA system.
2. Perform Control system startup, testing and commissioning as defined in Section 409002 “Testing and Commissioning.”
3. Coordinate the Work defined by this Section with other work defined under this Contract.

E. Small and medium capacity PLC’s shall meet all of the requirements of this section unless specifically indicated as applying to only small or medium capacity PLC’s, in which case the requirement shall apply only to the indicated class of PLC. PLC shall be as specified elsewhere in the contract documents or as required by the application. Application of small capacity PLC’s not specifically specified as such shall require project approval following submittal review. Medium capacity PLC’s are acceptable for all project PLC requirements.

F. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

G. Programming not provided by the Contractor: Unless noted otherwise the contractor shall program all PLC’s on the project except as noted below:

1. Suppliers of packaged control systems shall program PLC equipment they supply.
2. Designated third party programmers shall program contractor supplied PLC equipment as specifically noted.
3. These parties shall provide all services related to PLC program development, documentation, and testing including coordination, submittals, program development, documentation, etc.

4. The contractor shall support these programmers as requested by the Engineer as required to support the testing and integration of the programs supplied by others to the extent that the programs supplied by others interact with contractor supplied equipment.

5. The contractor shall be relieved of responsibilities specified in this and related sections that have been specifically assigned to others.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revisions of the following documents. It is a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the more stringent requirements shall prevail.

1. NEMA ICS 1 General Standards for Industrial Controls and Systems
2. NEMA ICS 1.1 Safety Guidelines for the Application of Industrial Control Systems
3. NFPA 70 National Electrical Code (NEC)

B. Listing: Equipment shall be listed for the purpose for which it is used by UL, FM or CSA.

1. All equipment, materials, and the design, construction, installation, and application thereof shall comply with all applicable provisions of the National Electrical Code (NEC), the Occupational Safety and Health Act (OSHA), and any applicable federal, State, and local ordinances, rules and regulations. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing label.

2. Equipment listed/labeled by an NRTL shall be as dictated by the latest printing of the Electrical Testing Laboratories Accreditation Report available from the State of Washington Department of Labor and Industries, Electrical Inspection Division, or applicable document and agency in other states. Any NRTL listing/labeling shall be acceptable to and approved by the local authority having jurisdiction.

3. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the Manufacturer’s place of assembly. All costs and expenses incurred for such inspections shall be included in the original Contract price.

C. Accessories: Manufacturer recommended accessories are acceptable only when not available directly from the PLC Manufacturer.

1.3 SUBMITTALS

A. Per Section 409000 “Instrumentation and Control Systems.”
1.4 DESIGN REQUIREMENTS

A. Each PLC system shall consist of one PLC Central Processing Unit (CPU) and one or more I/O chassis populated with I/O modules as shown in the Contract Drawings. PLC systems shall be mounted in the control panels.

B. Each PLC system shall receive input signals and transmit output signals to circuits and components as needed to perform required process control and monitoring functions.

C. Each PLC system shall be programmed in industry standard relay ladder symbols and shall be delivered fully programmed for the functions required per Section 409635 “Programming.”

D. Each PLC system shall be fully configured to process bi-directional serial communications with the plant SCADA system.

E. Power Supply Requirements: Each PLC I/O rack shall contain a power supply to provide DC power necessary for the CPU, and/or input and output modules. Power shall be from 100 to 130 volts AC, 60 Hz source.

F. Plant SCADA Interface: The PLC system will include small or medium capacity PLC’s that will control plant processes and communicate with the plant SCADA system. The PLC system and associated accessories shall be compatible with and shall provide direct communications with G.E. Proficy iFix, Rockwell Automation Factory Talk View SE and ME, or Wonderware Intouch SCADA software, most current versions at the time of purchase. The PLC’s shall communicate peer to peer and with the SCADA systems via Ethernet network.

G. PLC’s shall be capable of on-line programming remotely over their communication connection. Remote on-line programming shall not interfere with communication to/from network connected PLC’s (which are not being programmed) and the SCADA system.

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS

A. Provide complete PLC Systems in accordance with the Contract Documents or in the case of packaged system as required to monitor and control the submitted equipment and processes.

1. Include all hardware required to provide a complete and operable PLC system.
2. Ensure hardware is fully compatible with the software that is to operate on the hardware.
3. Provide components from the same manufacturer, model, part number, and revision for any specified component.
4. Provide products compatible with plant SCADA System.
5. Acceptable Manufacturers and product line:

   a. Allen-Bradley Control Logix or Compact Logix, size depending on specific contract document requirements or in the case of packaged systems on the demands of the process application.
   b. Approved equal.
c. PLC systems at the plant shall be standardized. All PLC’s at the plant shall be the products of the same manufacturer and shall consist of the same product lines. Contractor and suppliers shall coordinate to ensure consistency.

2.2 PROGRAMMING SOFTWARE

A. Programming software shall be a product of the PLC Manufacturer specifically intended for the submitted PLC system. Programming software shall be as specified in Section 409635 “Programming.”

2.3 PLC SYSTEM REQUIREMENTS

A. The processor models, I/O quantities and I/O configurations shall comply with the following general control requirements:

1. PLC CPUs shall not be required to be redundant unless specifically noted otherwise.
2. Processes shall be tolerant of the removal or failure of any individual I/O module.
3. All programs loaded into the PLCs shall comply with Section 409635 “Programming” and shall be written in Ladder Logic or other approved program languages. Use of programming techniques other than approved program languages is prohibited without written approval from the project.

B. Communications Interfaces:

1. Provide, install, and test the communications between the PLC System and the plant SCADA system as shown on the drawings. Additionally, provide, install and test the communications (Modbus) between the Control Panel and SWB-340004 for the purpose of power monitoring. Supply the appropriate Prosoft MVI Modbus card for communication to the UV power monitoring circuits. Install in the first spare slot in the Control Logix rack.

C. I/O Card Connections:

1. Provide connections utilizing cables and wiring arm connectors.
2. Provide all discrete and analog field wiring loops with individual fuses. Provide terminal blocks with integral fusing.

D. Programmable Logic Controller Equipment

1. Provide all appurtenant hardware required to support the installation, operation and maintenance of the PLC.
2. Rack Communications: Provide modules to communicate with I/O subsystem racks as required.
3. Wire spare I/O on installed cards to terminal blocks

2.4 SPARE PARTS AND CAPACITY

A. Provide at least 10% installed spare I/O points for each type and voltage of installed IO as follows:
1. Analog Inputs (1-5 VDC or 4-20 ma)
2. Analog Outputs (4-20 ma)
3. Discrete Inputs (120 VAC and/or 24VDC, as required)
4. Discrete Outputs (120 VAC, 24 VDC, and/or Relay Outputs, as required)

B. Provide spare rack capacity for 4 additional I/O modules.

C. Provide one spare of every PLC system component supplied. This set of spares shall include one of everything that is required for the full functionality and process mission of the PLC system including communications and media converter devices and process network switch.

2.5 Environmental Conditions

A. The environmental conditions are specified in Sections 409000 “Instrumentation and Control Systems” and 409513 “Panels” unless noted otherwise.

B. General: Equipment provided under this section shall be suitable for operation under the ambient conditions listed below.

C. All Areas:

   1. Atmospheric contaminants:
      a. Hydrogen sulfide         0.1 mg/1
      b. Chlorine                0.01 mg/1
      c. Ammonia                 0.5 mg/1
      d. Dust                    50.0 ug/m3

   2. Electromagnetic radiation: 27/500 MHz, 10 volts/m

D. Control Room:

   1. Temperature       60 to 120 degrees F
   2. Humidity          20 to 95 percent non-condensing

E. Outdoor Field Locations:

   1. Temperature       0 to 120 degrees F
   2. Humidity          5 to 95 percent

F. The Programmable Controller processor shall be able to withstand conducted tests as outlined in the following:

   1. Temperature       IEC 60068-2-1
                         IEC 60068-2-2
                         IEC 60068-2-14
   2. Humidity          IEC 60068-2-30
   3. Vibration         IEC 60068-2-6
   4. Shock             IEC 60068-2-27
   5. Emissions          ISPR 11: Group 1, Class A
   6. ESD Immunity      IEC 61000-4-2
7. Radiated RF Immunity IEC 61000-4-3
8. EFT/B Immunity IEC 61000-4-4
9. Surge Transient Immunity IEC 61000-4-5
10. Conducted RF Immunity IEC 61000-4-6

G. Ambient temperature rating for storage shall be –40 to +85 degrees C (- 40 to +185 degrees F).

H. The programmable Controller system shall be described and tested to operate in a high electrical noise environment.

2.6 SYSTEM OVERVIEW

A. General

1. Medium Capacity PLC Systems: The system shall consist of, at a minimum, a 10 slot chassis, processor and memory cards, power supply, and I/O cards. Processor, memory, and local communication modules shall be plug-in style boards in the main chassis. I/O cards and remote communications modules shall be plug-in style (modular) and capable of installation in the main chassis or in remote racks. Maximum rack size with I/O cards installed shall not exceed 19.5” W X 11.5” H X 9.5” D. Minimum size shall be at least 19” W X 6” H X 6” D.

B. Major Components: The PLC Systems shall consist of the following major components:

1. I/O Chassis – Local and Remote and expanded
2. Power Supply
3. Central Processor Unit (CPU)
4. Input/output modules.
5. Programming accessories.
6. Communications modules (Ethernet, DeviceNet, Modbus, Operator Interface, and Expanded (Remote) I/O as necessary).

2.7 POWER SUPPLY

A. PLC(s) (including all hardware) shall be capable of operating from a 120 VAC, 60 Hz unregulated power source (85-132 VAC, 47 to 63 Hz). One power source will be provided for each I/O rack. Power supplies shall be capable of powering all racks fully populated. Power supply shall be fused for short circuit protection.

B. The Manufacturer shall be able to provide as standard equipment a system power supply capable of converting AC standard low voltage line power to the DC power required to operate the Programmable Controller system.

C. A single main power supply shall have the capability of supplying power to the CPU and local input/output modules. Other power supplies shall provide power to remotely located racks.

D. The power supply shall automatically shut down the Programmable Controller system whenever its output power is detected as exceeding 125% of its rated power.
E. The power supply shall monitor the incoming line voltage for proper levels. When the power supply is wired to utilize AC input, the system shall function properly within the range of 85 to 265 VAC. In addition, the power supply shall provide surge protection, isolation, and outage carry-over up to 2 cycles of the AC line.

F. Design features of the Programmable Controller power supply shall include a diagnostic indicator mounted in a position to be easily viewed by the user. This indicator shall provide the operator with the status of the DC power applied to the backplane.

G. At the time of power-up, the power supply shall inhibit operation of the processor and I/O modules until the DC voltages of the backplane are within specifications.

H. In addition to the electronic protection described above the power supply shall offer a failsafe fuse that is not accessible by the customer.

2.8 SYSTEM DESIGN

A. The CPU shall be programmable in ladder logic. CPU shall be capable of executing relay logic commands (i.e. contacts, coils, master control relays), timing and counting functions, binary and BCD manipulation, logical functions (i.e. if, and, or), math function (plus, minus, multiplication, etc.), and subroutine executions (i.e. jump).

B. Memory shall be programmable locally or remotely. Program and Data Memory shall be non-volatile regardless of power disturbances and shall have a minimum retention time of one month without power applied.

C. CPU shall support discrete I/O points and analog/word I/O points. CPU shall support timers/counters, PID loops, drum sequencers, and free-form math subroutines callable from ladder logic. Processing time shall be .5 millisecond or less per 1 Kbytes of Boolean scan.

D. The PLC system shall execute status check upon power up and continuously during operation. PLC status information shall be accessible by the Programmer. Information shall indicate running or failure status of the PLC system (i.e. communication port error, scan time error, I/O failure location). The system shall have error indication for parity check. Upon proven parity error, all outputs shall be capable of “last condition” lock in or “all off”. I/Os shall have indicator lamps to determine status.

E. A major consideration of the PLC system shall be its modular, field expandable design. The capability shall exist to allow for expansion of the system by the addition of hardware and/or software.

F. Modules are defined herein as devices that plug into a chassis and are keyed to allow installation in only one direction. The design shall prohibit upside down insertion of the modules as well as safeguard against the insertion of a module into the wrong slot or chassis via an electronic method for identifying a module. Electronic keying performs an electronic check to insure that the physical module is consistent with what was configured.

G. The Programmable Controller shall have downward compatibility whereby all new module designs can be interchanged with all similar modules in an effort to reduce obsolescence.
H. The Programmable controller shall have the ability to be updated electronically to interface with new modules.

I. The Controller shall have the capability of addressing up to 128000 discrete points or 4000 analog points. It shall also have the ability to communicate with up to 250 connections that contain I/O.

J. Each input and output module shall be self-contained and housed within a chassis. These chassis with their respective modules shall contain up to 512 (16 modules x 32pts/module, using a 17 slot chassis) unique points.

K. The Programmable Controller shall use multiple independent, asynchronous scans. These concurrent scans shall be designated for processing of input and output information, program logic, and background processing of other processor functions. Input and output devices located in the same backplane (local I/O) as the CPU will produce at the rate of configured RPI (Requested Packet Interval), and for discrete input modules enabled for Change Of State (COS), at the time any point changes state.

L. The Programmable Controller shall have the ability to communicate with multiple remote (expanded) I/O racks or devices configured with multiple I/O modules. Networks that allow remote (expanded) I/O include “Remote I/O”, EtherNet, and DeviceNet.

M. It shall be possible to communicate with remote (expanded) I/O racks or other PLC’s via fiber optic cable by inserting fiber optic converters into the links. The fiber link shall support distances between converters up to 6500 cable feet on “RIO”

N. The Programmable Controller shall have the ability to support multiple data communications links by using DeviceNet, Ethernet, and MVI (RS232) modules.

O. The Programmable Controller shall have one dedicated serial port, which supports RS-232-C signals. It shall be accessible in control logic and provide support for, DF1 Point to point, and DH-485 (messaging only, no programming) communication protocols. Alternatively, it shall be usable for programming and data monitoring purposes. The serial port will also provide support for ASCII communications.

P. Real Time data Producer/Consumer Connections can be made and data seamless exchanged between multiple large and small capacity PLC’s

2.9 CONTROLLER DESIGN

A. The CPU shall be a self-contained unit, and will provide control program execution and support remote or local programming. This device will also supply I/O scanning and inter-processor and peripheral communication functions.

B. The user program and data shall be contained in battery backed memory. The operating system firmware shall be contained in non-volatile memory.

C. The operating system firmware can be updated via a separate update tool to allow for easy field updates. The controllers shall allow the operating system to be updated using a suitably configured CompactFlash card.
D. Controller user memory shall be available in increments between 750 Kbytes and 8 Mbytes.

E. In a single chassis system all system and signal power to the Controller and support modules shall be distributed on a single backplane. No interconnecting wiring between these modules via plug-terminated jumpers shall be acceptable.

F. The CPU within the system shall perform internal diagnostic checking and give visual indication to the user by illuminating a “green” (OK) indicator when no fault is detected and a “red” (FAULT) indicator (Blinking or Solid) when a fault is detected.

G. The front panel on the Controller shall include color indicators showing the following status information:

1. Program or Run mode of the controller
2. The fault status of the controller
3. I/O status
4. RS-232 activity
5. Battery status
6. Force LED

H. The Controller shall include a mounted keyswitch. The key shall select the following Controller modes: RUN – No control logic edits possible, program always executing; PROGRAM – Programming allowed, program execution disabled; and REMOTE – Programming terminal can make edits and change processor mode, including test mode, whereby the logic executes and inputs are monitored, but edits are not permanently active unless assembled.

I. The Controller shall include a holder and a connector for a lithium battery. The battery shall provide power backup for user programs and data when the main power supply is not available.

J. The front panel of the Controller shall include a 9-pin D-shell serial RS232 port, which supports DF1, DH-485 (messaging only no programming) and ASCII protocols.

K. All system modules and local and remote chassis shall be designed to provide for free airflow convection cooling. No internal fans or other means of cooling, except heat sinks, shall be permitted.

L. All system modules including the processor may be removed from the chassis or inserted into the chassis while power is being supplied to the chassis without faulting the processor or damaging the modules.

M. The Controller shall include an integrated Real Time Clock (RTC). This clock value should be in a form of a predefined tag and should be accessible via logic or remotely.

2.10 COMMUNICATIONS MODULES

A. Communications modules shall enable the PLC system to communicate between PLC CPU’s and with other devices such as the SCADA system, Operator Interface Terminals, expanded I/O, etc. Modules shall be powered from the PLC backplane.
B. PLC’s shall have communication interface modules for Ethernet, DeviceNet, Remote I/O (RIO), and RS232.

C. The Ethernet interface shall support the following:

1. Standard TCP/IP communications
2. Standard Ethernet media (10base2, 10base5, 10baseT, fiber)
3. CSMA/CD access method
4. Subnet masking
5. Standard repeaters, bridges, routers, host computers, peer PLC’s
6. RJ-45 and AUI ports
7. Manual configuration using standard off the shelf software
8. Programmable controller messaging to peer controllers and workstations
9. I/O Control
10. Common Industrial Protocol (CIP), the protocol that provides real-time I/O messaging and information/peer-to-peer messaging
11. 10/100M/Baud auto sensing and auto switching
12. DHCP Utility
13. I/O data, Real-time interlocking, and Information
14. Full or Half-Duplex communication
15. Built-in web server capability
16. Built-in Email capability
17. Supports the open, standard EtherNet Protocol. EtherNet uses the producer/consumer network model, like DeviceNet which also use CIP.
18. The Ethernet interface shall not support bridging between Ethernet links within a PLC chassis.
19. The Ethernet interface shall support bridging to DeviceNet. Bridging allows for configuration (program up/download) and data collection.
20. The Programmable Controller shall have a standard programming instruction that allows peer-to-peer messaging with other controllers over the EtherNet network. The instruction shall be able to address any valid EtherNet node and also provide a simple path input for messages that need to be routed to other networks.

2.11 INPUT/ OUTPUT (I/O) SYSTEM

A. General: The system shall consist of individual modular plug-in input and output modules or cards. Any number of remote discrete and analog I/O points (up to the system capacity) shall be available.

B. Analog Input/Output

1. Analog I/O modules shall be available to convert analog control signals to minimum 12 bit binary numbers and vice-versa. Resolution shall be 1 part in 1,000 or smaller. Accuracy shall be 1.25 percent or better for Analog Inputs.
2. Analog input modules shall have 8 inputs capable of being configured as either 4-20 mA or 1-5 VDC. Isolated inputs shall be available.
3. Analog output modules shall have 4 outputs capable of driving a 4-20 mA signal into a maximum of 500 ohms. Isolated outputs shall be available.
C. Discrete Input/Output
   1. Each discrete input and output shall be capable of accepting two #14 AWG stranded wires under a single terminal screw on the front of the chassis mounted I/O card. Front of card mounted LED indicator lights shall indicate I/O point status (light on when point is energized).
   2. Discrete input modules (120 VAC and 24 VDC) shall have 16 inputs in two groups of 8 with a common neutral or return. Inputs shall be “on” when voltage is supplied to the input point.
   3. Discrete voltage outputs shall have 16 sourcing outputs in two groups of 8 with a common power bus, and have a minimum output rating of 1 Amp at 120 VAC, 24 VAC, or 24 VDC.
   4. Relay outputs shall have 8 Form C (1 – NO, 1 – NC) outputs, and shall be individually isolated, and have a minimum output rating of 0.5 amp continuous at 24 VDC or 120 VAC.

D. I/O Diagnostics
   1. Diagnostic lights shall be provided for the I/O communication system. Lights shall be available to indicate power, and operation status for the I/O system.

2.12 PLC PROGRAMMING SOFTWARE AND CABLES
   A. Software shall be a standard programming, documentation, and diagnostics tool for the PLC. Software shall be capable of uploading and downloading programs to the PLC as well as allowing the user to monitor and troubleshoot the program while in operation. The software shall also be able to make “on-line” edits to the PLC program without compiling and downloading the entire program. Software shall be used for entering and editing programs as well as accessing programming utilities such as “cut and paste” block operations and entering program comments. Software shall enable the Programmer to enter relay ladder logic, special functions, and PID loop programs.
   B. One copy of the PLC programming software with license and any necessary programming cables shall be provided for the overall plant. Programming software licenses shall not be required to be provided for packaged systems.

2.13 PLC PROGRAM DEVELOPMENT AND STORAGE
   A. The program storage medium shall be battery backed RAM type.
   B. Memory capacity shall be configurable to allow for the most economical match to the intended application. It shall be possible to upgrade to a processor with a larger memory size simply by saving a program, installing a memory expansion card, and downloading the program to the new system without having to make any program changes.
   C. Memory shall provide battery back-up capable of retaining all stored program data through a power failure. A low battery condition shall be detectable in ladder logic, but shall not automatically generate a major fault that will halt the execution of a running program.
battery condition will generate a minor fault and will be detectable in ladder logic. Processor shall provide a low battery LED.

D. Compact Flash card shall be available as a processor option for nonvolatile memory storage. The Compact Flash card shall be available as an industrial rated device suitable for use in the same environment as the controller. The Compact Flash shall support a Windows file system allowing multiple files to be stored on the card. The user can manually trigger the controller to save or load from Compact Flash and also configure the controller to load from Compact Flash on power up or when an issue is detected with the data in RAM. Additionally when memory is restored, a user selectable option to be restored in Run mode or Program mode shall be provided

E. The operator should be able to backup volatile memory, including data and program logic onto a personal computer storage disk.

F. All user memory in the processor not used for program storage shall be allocable from main memory for the purpose of data storage. Any data can be displayed in ASCII, Binary, Octal, Hexadecimal, or Decimal radices. Function-specific data types such as PID, Axis, Axis Group or Message shall have dedicated displays available annotating the meaning of specific control bits and words within them and allowing for selective control where appropriate.

G. If contacts or entire rungs are intentionally deleted from an existing logic program, the remaining program shall be automatically repositioned to fill this void. Whenever contacts or entire rungs are intentionally inserted into an existing program, the original program shall automatically be repositioned to accommodate the enlarged program. All rung comments shall maintain their original links.

H. It shall be possible to program application logic more than once into memory.

I. The number of times a normally open (N.O.) and/or normally closed (N.C.) contact of an internal output can be programmed shall be limited only by the memory capacity to store these instructions.

J. The number of times a timer or counter can be programmed shall be limited only by the memory capacity to store these instructions.

K. Control logic programs shall have immediate access to the sub elements of control structures by address and sub element mnemonic, such as timer accumulator value, timer done bit, or PID Process Variable value.

L. Data in the controller should be user defined and tag based and not restricted to any fixed data register format

2.14 PLC PROGRAMMING UTILITIES AND TECHNIQUES

A. The programming format shall be IEC 1131-3 compliant Ladder Diagram (LD), Function Block Diagram (FBD), Sequential Function Chart (SFC), and Structured Text (ST) languages.

B. The controller shall organize user applications as Tasks, which can be specified as continuous, periodic, or event based.
C. Periodic tasks shall run via an interrupt at a user-defined interval in one microsecond increments from 1 millisecond to 2000 seconds.

D. The interrupt mechanism of periodic and event tasks shall adhere to the IEC 1131-3 definition of pre-emptive multitasking.

E. The controller shall be able to accommodate a maximum of 32 individual tasks of which one can be continuous.

F. The periodic and event tasks shall have an associated, user assignable priority from one to fifteen (one being the highest priority), which specifies that task’s relative execution priority in the multitasking hierarchy.

G. The event task can be triggered by hardware events (an input point) or software events (event instruction).

H. Each task shall have a user settable watchdog timeout which is unique to that task.

I. Each task can include a maximum of 32 programs, which can be ordered for execution within the task.

J. Each program can include routines programmed in LD, FBD, SFC, or ST languages. One of the routines can be specified as the main routine and one can be specified as an optional fault routine. All routines shall be capable of being edited when on-line. The number of routines which can be contained in a program is limited only by memory.

K. Variables within the controller shall be referenced as unique, default or user defined tags.

L. Tags may be created off-line, on-line and at the same time the routine logic is entered.

M. The system shall have the capability to store a description for each tag.

N. Tags shall be available to all tasks in the controller (Controller Scoped) or limited in scope to the routines within a single program (Program Scoped) as defined by the user.

O. Any tag shall have the ability to be aliased by another tag, which is defined and has meaning to the user.

P. The ability to program control logic via tags of the Programmable Controller shall exist.

Q. It shall be possible to program ladder diagram rungs with the following restrictions:
   1. Series instruction count limited only by user memory
   2. Branch extensions limited only by user memory
   3. Branch nesting to six levels

R. The capability shall exist to interleave input and output instruction types on the same contiguous rung in the ladder diagram rungs.

S. The capability shall exist to change a contact from normally open to normally closed, add instructions, change referenced tags, etc. It shall not be necessary to delete and reprogram the entire ladder diagram rung.
It shall be possible to insert ladder diagram rungs anywhere in the program, even between existing rungs, insofar as there is sufficient memory to accommodate these additions.

A single program command or instruction shall suffice to delete an individual ladder diagram rung from memory. It shall not be necessary to delete the rung contact by contact.

A clock/calendar feature shall be included within the CPU. Access to the time and date shall be from the programming terminal or user program.

Latch functions shall be internal and programmable.

The system shall have the capability to address software timers and software counters in any combination and quantity up to the limit of available memory. All management of these instructions into memory shall be handled by the CPU. Instructions shall permit programming timers in the "ON" or "OFF" delay modes. Timer programming shall also include the capability to interrupt timing without resetting the timers. Counters shall be programmable using up-increment and down-increment.

Timer instructions shall have a time base of 1.0 milliseconds. The timing range of each timer shall be from 0 to 2,147,483,648 increments. It shall be possible to program and display separately the timer's preset and accumulated values.

The Programmable Controller shall use a signed double integer format ranging from -2,147,483,648 to +2,147,483,648 for data storage of the counter preset and accumulated values.

The Programmable Controller shall store data in the following formats:

1. Boolean values (0 or 1).
2. Short Integer Numbers ranging from -128 to +127.
3. Integer Numbers ranging from -32,768 to +32,767.
4. Double Integer Numbers ranging from -2,147,483,648 to +2,147,483,647.
5. Floating Point Numbers consisting of eight significant digits. For numbers larger than eight digits, the CPU shall convert the number into exponential form with a range of plus/minus $1.1754944 \times 10^{-38}$ to plus/minus $3.402823 \times 10^{38}$.

The capability shall exist to organize data in the form of User Defined Data Structures. All aforementioned data types, as well as others, can be used in such structures along with embedded arrays and other User Defined Structures.

The Programmable Controller shall have support for integer and floating point signed math functions consisting of addition, subtraction, multiplication, division, square root, negation, modulus, and absolute value.

Trigonometric instructions supported shall include Sine, Cosine, Tangent, Inverse Sine, Inverse Cosine, and Inverse Tangent. These instructions shall fully support floating-point math.

Additional floating point instructions supported shall include Log 10, Natural Log, and Exponential.

It shall be possible to complete complex, combined calculations in a single instruction, such as flow totalizing or equations of the format $((A+((B-C)*D))/E)$. 
GG. File function instructions supported shall also include Sort, Average and Standard Deviation.

HH. Value arrays shall be limited in size only by the amount of available memory.

II. Arrays shall be configurable with one, two or three dimensions.

JJ. The CPU shall support indexed addressing of array elements.

KK. Array element manipulation instructions shall be provided to execute "array copy", "array fill", "array to array move", "element to array move", "array to element move", and "first in-first out" (FIFO) operations shall be supported by the system. Math instructions and instructions for performing "logical OR", "logical AND", "exclusive OR", and comparison instructions such as "less than", "greater than", and "equal to" shall be provided. All instructions shall execute on either single words or array elements.

LL. For any module specifically associated with the Programmable Controller, it shall be possible to query the current status of all channels through controller scoped tags without any programming.

MM. The system shall contain instructions, which will construct word shift registers. Additional instructions shall be provided to construct synchronous bit shift registers.

NN. The Programmable Controller shall have a jump instruction which will allow the Programmer to jump over portions of the user program to a portion marked by a matching label instruction.

OO. It shall be a function of the CPU to automatically manage all data types. For example, if a word stored in an Integer tag is transferred into a Floating Point tag, the CPU shall convert the integer value into floating point prior to executing the transfer.

PP. In applications requiring repeatable logic it shall be possible to place such logic in a subroutine section. Instructions which call the subroutine and return to the main program shall be included within the system. It shall be possible to program several subroutines and define each subroutine by a unique program file designator. The processor will support nesting of subroutines up to available stack capacity at the moment of the call. It shall be possible to pass selected values (parameters) to a subroutine before its execution. The number of these parameters is limited only by available memory. This allows the subroutine to perform mathematical or logical operations on the data and return the results to the main program upon completion. These subroutines will be accessed by jump-to-subroutine instructions.

QQ. The program format shall display all instructions on a programming panel with appropriate mnemonics to define all data entered by the Programmer. The system shall be capable of providing a "HELP" utility which when invoked by the Programmer will display on the programming panel a list of instructions and all data and keystrokes required to enter an instruction into the system memory.

RR. At the request of the Programmer, tags contained in system memory shall be displayed on the programming panel. This monitoring feature shall be provided for all tags regardless of format or scope.

SS. The system shall have the capability to enter rung comments above ladder diagram rungs. These comments may be entered at the same time the ladder logic is entered.
TT. The capability shall exist for adding, removing, or modifying logic during program execution in routines of LD, FBD, SFC, and ST languages. When changes to logic are made or new logic is added it shall be possible to test the edits of such logic before removal of the prior logic occurs.

UU. It shall be possible to manually set (force) either on or off all hardwired discrete input or output points from the programming panel. It shall also be possible to manually set (force) an analog input or output to a user specified value. Removal of these forced I/O points shall be achieved either individually or totally through selected keystrokes. The programming terminal shall be able to display forced I/O points.

VV. A means to program a fault recovery routine shall exist. When a major system fault (Controller Fault) occurs in the system, the controller fault recovery routine shall be executed and then the system shall determine if the fault has been eliminated. If the fault is eliminated, program execution resumes. If the fault still exists, the system will shut down.

WW. The capability shall exist for each program to have its own fault routine for program fault recovery. Each having the same features as the controller based fault routine.

XX. An instruction shall be available to give the control program diagnostic information, state control, and sequencing of a process simultaneously, while allowing the capability of user-friendly state programming techniques.

YY. An instruction shall be supported to incorporate closed loop control systems. The "proportional", "integral", and "derivative" elements shall be accessible to the user in order to tune a closed loop system. This instruction shall fully support floating-point math.

ZZ. The system shall support both bit and word level diagnostic instructions.

AAA. To facilitate conditional event detection programming, output instructions shall include "one shot" instructions, which may be triggered on either low-to-high (rising) or high-to-low (falling) rung conditions.

BBB. To facilitate debugging, an "always false" instruction shall exist which may be utilized to temporarily inhibit the execution of control logic.

CCC. The processor shall support Master Control Reset (Relay) type functionality to selectively disable sections of logic.

DDD. The processor shall include direct support of FOR-NEXT loop constructions.

2.15 INTERFACING AND PERIPHERALS

A. The programming software shall operate on a Microsoft Windows PC. To be further known as “workstation”.

B. The workstation shall have the capability to be remotely located from the PLC processor. The workstation shall connect via Ethernet or RS232 for remote access.
C. The means to indicate contact or output status shall be by intensification of the contact or output on the computer display. Each element's status shall be shown independently, regardless of circuit configuration.

D. The Programmable Controller system shall be able to interface with a data terminal, which is RS-232-C compatible (up to 38400 baud) to generate hard copy messages.

E. The PLC system shall provide the capability to load a user program into, or record the contents of the processor's memory to a floppy disk and/or a hard disk on the programming workstation. It shall be possible to load or record the entire contents of memory.

F. The workstation should be able to edit and modify logic without having to take the controller off-line. Provide the ability for changes to be tested and verified prior to merging with existing logic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install PLC Systems complete with ladder logic programming.

B. Program the PLC System[s] to provide local equipment monitoring, local equipment control and serve as an interface between the facility systems and the plant SCADA System.

C. Install all equipment in strict accordance with the manufacturer’s recommendations. Installation requirements shall include, but are not limited to, the following:

1. Maintain a minimum 6-inch vertical spacing between the bottom of the enclosure and the bottom-most PLC chassis.
2. Maintain a minimum 6-inch vertical spacing between the top of the enclosure and the top-most PLC chassis.
3. Maintain a minimum 6-inch vertical spacing between PLC chassis.
4. Maintain a minimum 4-inch horizontal spacing between power supply and side of enclosure.
5. Center wiring ducts between the PLC chassis.
6. Provide a grounding wire for each PLC chassis. Connect the grounding wire between one of the chassis grounding screws and the main grounding bus of the power system. This wire shall be green and the AWG rating shall be sized to meet the fuse rating of the supply circuit.
7. Ground each power supply mounted in the PLC chassis to one of the chassis grounding screws.

D. Install the PLC equipment in new and existing enclosures as shown on the Drawings.

E. Program each Operator Interface panel for monitoring and control as described in Section 409635 “Programming.”

F. Install, configure and test the interface to the plant SCADA system.
3.2 TESTING

A. Perform testing as specified in Sections 409000 “Instrumentation and Control Systems” and 409002 “Testing and Commissioning.”

3.3 SERVICE

A. The Contractor shall provide manufacturers literature pertaining to the following:

1. System specifications
2. Electrical power requirements
3. Application considerations
4. Assembly and installation procedures
5. Power up procedures
6. Troubleshooting procedures
7. Programming procedures
8. Explanation of internal fault diagnostics
9. Shut down procedures
10. Recommended spare parts list

B. The PLC manufacturer shall provide field support personnel located within 100 miles of the owner. The PLC manufacturer shall also provide a field service department with experienced representatives stationed within 100 miles of the owner with the capability to provide telephone consultation, prompt on-site service, and field replacement stock.

C. The PLC manufacturer shall provide product application assistance by trained and experienced engineers to assist the customer with developed programs and systems through telephone consultation, on-site check-out, debug, and start-up assistance.

D. The PLC manufacturer shall provide a customer training program designed to teach the customer's personnel in the understanding and application of the programmable controller. The training program shall include training manuals and "hands-on" programming experience on a Programmable Controller of a type similar to that provided by the Contractor.

E. The PLC manufacturer shall have the capability to conduct on-site training programs at a location provided by the customer.

F. The PLC manufacturer shall be capable of providing troubleshooting software.

G. The PLC manufacturer shall be able to provide 24-hour technical support in the Pacific Northwest, including training and service support. The Contractor shall submit a list that includes PLC manufacturer’s business name, telephone numbers and addresses of technical support personnel in Washington, Oregon, and Idaho.

H. The PLC manufacturer may provide the above mentioned services under this Contract through its vendor's, Suppliers, or Subcontractors but the Contractor remains responsible for the execution of these services.

END OF SECTION 409443
SECTION 409513 – PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for panels for instrumentation and communication equipment. Additional requirements are specified in sections specifying the various instrumentation and communication systems.

B. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more stringent requirements shall prevail.

1. FED STD 595A  Federal Standard Colors
2. IEC 60947-7-1  Low Voltage Switchgear and Control gear - Terminal blocks for copper conductors
3. NEMA 250  Enclosures for Electrical Equipment (1000 Volts Maximum)
4. NFPA 79  Electrical Standards for Industrial Machinery
5. UL 94  Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
6. UL 508A  Industrial Control Panels

B. Listing:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS

A. Per Section 409000 “Instrumentation and Control Systems.”

B. Dimensioned front view drawings.
C. Dimensioned internal equipment layout drawings

D. Panel assembly drawings shall include sections showing clearances between face and rear mounted equipment with items keyed to the bills of materials

E. Nameplate engraving schedule showing engraving by line, character size, and nameplate size

F. Enclosure manufacturers' drawings

G. Panel seismic calculations

H. Panel wiring diagram for each panel. The diagram shall meet the requirements as set forth in the NFPA 79 Electrical standards for industrial machinery.

I. Calculations of percentage wire fill for wire ways including factory wiring and allowance for field wiring

J. Panel load calculations

K. UPS hold up time calculations

1.4 DESIGN REQUIREMENTS

A. Enclosures shall be limited to the following NEMA 250 types:

1. NEMA 12  Control rooms, switchgear rooms, MCC rooms
2. NEMA 4X SS  All other locations and applications except outdoor
3. NEMA 7D  Classified Locations
4. NEMA 3R/12  Outdoor locations

B. Panel Design:

1. General:
   a. Section 409004 “Schedules” specifies major panels and equipment on those panels.
   b. Additional panels may be specified on the Drawings.
   c. Panel size and equipment layout requirements may be specified on the Drawings.

2. No panel mounted operator interface devices, such as selector switches, will be mounted greater than 72” or less than 36” above the finished plant floor, with the exception of annunciators.

3. No panel mounted instruments, such as recorders, will be mounted greater than 66” or less than 40” above the finished plant floor, with the exception of the annunciator panel as described below.

4. Panelboards: each panel containing 120-volt powered equipment with an aggregate load greater than 1200 watts shall be provided with a panelboard per Section 16470.

5. Annunciators: Annunciators shall not be mounted with the top frame in excess of 90” above the finished plant floor.
6. Power supplies:
   a. The control panels shall contain a dual redundant DC power supply system where indicated.
   b. The DC power supply system shall be per Section 409515 “Power Supply and Conditioning Equipment.”

C. Labeling:
   1. Panels shall be manufactured and labeled in accordance with UL 508A and shall bear the UL label.
   2. Design shown on Drawings is functional in nature and is for reference and shall be altered as required to make the panels UL 508A compliant.

PART 2 - PRODUCTS

2.1 MATERIALS AND QUALITY

A. General:
   1. Panel work shall be designed for seismic requirements per Section 016100.
   2. Cutouts for future equipment shall be blanked off with suitable metal covers.
   3. Instrument tag numbers shall be identified on the panel rear per paragraph 409513 “Panels.”
   4. Nameplates shall identify face-mounted instruments per paragraph 409513 “Panels.”
   5. Instruments shall be mounted in a manner that allows ease of access to components and ease of removal.
   6. Face-mounted instruments that are more than six inches deep, weigh more than 10 pounds, or exert more than a 4 ft-lb moment force on the face of the panel shall be supported underneath at the rear by a 1-inch x 1/8-inch thick steel angle.
   7. Face-mounted equipment shall be flush or semi-flush with escutcheons.
   8. Floor mounted cabinets without touch screen operator interface panels or panel mounted computers that are less than 60 inches high shall be provided with floor stands to raise the top of the panel to at least 60 inches above the floor or work platform. Wall mounting may be used in lieu of a floor stand if panel weighs less than 100 pounds and wall space is available.
   9. Panels with touch screen operator interface or panel mounted computers shall be configured and installed so that center of screen is 60” AFF.

B. Fabrication of NEMA Type 12 Industrial Use, Indoor Cabinets with Front Doors:
   1. Enclosure fabricated from 16-gauge minimum thickness sheet steel for enclosures smaller than 24”x24”, and 14-gauge minimum for larger enclosures. Face-mounted instruments shall be mounted in the door.
   2. Interior frame or otherwise formed so as to provide a rigid structure
   3. Doors shall be hung on full-length continuous (piano-type) hinges and equipped with vault-type latch capable of accepting a 3/8-inch-shackle padlock
   4. Three-point latch hardware shall be provided for doors exceeding 48 inches height. Door width shall not exceed 34 inches.
C. Fabrication of NEMA Type 4X Cabinets:
   1. NEMA 250, Type 4X requirements
   2. Fabricated from 14 gauge (minimum thickness) Type 316L stainless steel (or fiberglass when specifically specified) and provided with an interior frame or otherwise formed to provide a rigid structure.
   3. Where face-mounted instruments are specified mount on an interior sub-panel
   4. Doors:
      a. Vault-type latch and, if greater than 48 inches high, three-point latch hardware
      b. Latch shall accept a 3/8-inch shackle padlock.
      c. Unless shown otherwise, door width shall not exceed 36 inches.
   5. For cabinets located outdoors, equip with rain and sun shields

D. Fabrication of NEMA 7D Cabinets: NEMA 250, Type 7 suitable for Class 1, Division 1, Group D classified area and assembled and installed to maintain this rating.

E. Fabrication of NEMA Type 3R Outdoor Cabinets:
   1. NEMA 250, Types 3R and 12 requirements except dust test.
   2. Fabricated from 14 gauge (minimum thickness) Type 316L stainless steel and shall be provided with an interior frame or otherwise formed to provide a rigid structure.
   3. Where face-mounted instruments are specified, they shall be mounted on an interior hinged subpanel arranged to swing completely out of the enclosure.
   4. Door and shall be provided with vault-type latch and, if greater than 30 inches high, three-point latch hardware. Door latch shall accept a 3/8-inch shackle padlock. Door width shall not exceed 36 inches.

2.2 HEATING AND VENTILATING

A. Cooling shall be provided to maintain the internal panel temperature below 104 degrees F (40 °C) when all equipment is operating at its maximum heat load and the ambient temperature is 86 degrees F (30 °C). Filtered forced air ventilation shall be provided for NEMA 12 cabinets and either closed glycol loop heat exchange system or a mechanical refrigeration system for NEMA 4X and NEMA 7 enclosures.

B. Fans shall be equipped with UL-approved washable filters and provide at least 240 CFM. Noise level at three feet from exterior wall and 30 degrees off axis shall not exceed 60 db.

C. Outdoor or below grade cabinets shall not be insulated and shall be provided with thermostatically controlled space heaters.

D. Heater wattage shall to maintain the air temperature inside the cabinet above the dew point or 50 degrees F (10 °C), whichever is higher, at all times.

E. If space heater surface temperature exceeds 122 degrees F (50 °C), an expanded metal guard shall be provided.
F. When a strip type heater is used, the heater shall be a 240 VAC heater and connected to 120 VAC and sized to produce the required heat at 120 VAC.

G. Thermostat Acceptable Manufacturer:
   1. Honeywell T631B1013
   2. Penn Controls A28AA-4
   3. Approved equal.

2.3 NAMEPLATES
   A. Machine engraved laminated white phenolic nameplates with black lettering shall be provided for panel mounted equipment.
   B. Nameplate engraving shall be as specified and shall carry the instrument tag number in 3/32-inch minimum size lettering on the bottom line, or engraved as shown on the Drawings.
   C. Nameplates shall be attached to the panel with a minimum of two self-tapping 316 stainless steel screws.
   D. Wording may be changed if changes are made prior to commencement of engraving.
   E. Machine-printed laminated adhesive labels shall identify tag number of instruments and equipment inside panels.
   F. Attach nameplates and labels to panel surfaces, not to instruments.
   G. Machine embossed, adhesive backed nameplates shall identify the tag number of equipment inside cabinets.

2.4 INTERCONNECTION WIRING AND ELECTRICAL DEVICES
   A. Interconnection Wiring:
      1. Power, control, and signal wiring inside panels:
         a. Conductor insulation shall be rated for 600 volts and 90 degrees C in dry locations.
         b. All conductors shall be stranded copper.
         c. Power and control conductors in panels shall have insulation type MTW, minimum 16 AWG.
         d. Wiring for instrumentation analog signals shall be minimum 18 AWG; aluminum foil twisted shielded pairs, Belden type 8760, or approved equal. Wiring for instrumentation analog signals shall be run continuously from measuring instrument to control cabinet terminal strips without splices.
         e. Conductor size vs. fuse rating for conductors inside panels shall be as follows UNO:
            18 AWG  < 1 AMP
            16 AWG  5 AMPS
            14 AWG  15 AMPS
            12 AWG  20 AMPS
2. Support wiring independent of terminations by slotted flame retardant plastic wiring channels
3. Wiring channels shall comply with UL94, Type V. Wiring channel fill shall not exceed 40 percent.

B. Wire Naming and Tagging

1. Wiring shall be tagged at terminations with machine printed plastic sleeves.
2. Wire numbers shall consist of three parts, or as shown on the Drawings.
3. Unless shown otherwise, the prefix of the wire number shall be the instrument loop number.
4. If an instrument loop number is not available, the lowest mechanical equipment number of all final drives in the circuit shall be used.
5. Following the prefix shall be a code letter. The third part of the wire number shall be a number that identifies wires in a circuit that are electrically identical.
6. Label each control and instrumentation wire as follows:
   LLL-CC-NNN, Where:
   LLL = equipment, panel or loop number
   CC = wire code from table
   NNN= wire number

C. Color Coding

1. Color coding of wires within control panels shall be as follows (subject to restriction by UL 508A):

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Color</th>
<th>Use</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>TSP</td>
<td>BLACK</td>
<td>SIGNAL (+)</td>
<td>5-24 VDC</td>
</tr>
<tr>
<td>S2</td>
<td>TSP</td>
<td>WHITE or CLEAR</td>
<td>SIGNAL (-)</td>
<td>5-24 VDC</td>
</tr>
<tr>
<td>SG</td>
<td>TSP</td>
<td>BARE</td>
<td>SHIELD DRAIN</td>
<td>5-24 VDC</td>
</tr>
<tr>
<td>S1</td>
<td>TRIAD</td>
<td>BLACK</td>
<td>SIGNAL</td>
<td>0-24 VDC</td>
</tr>
<tr>
<td>S2</td>
<td>TRIAD</td>
<td>WHITE</td>
<td>SIGNAL</td>
<td>0-24 VDC</td>
</tr>
<tr>
<td>S3</td>
<td>TRIAD</td>
<td>RED</td>
<td>SIGNAL</td>
<td>0-24 VDC</td>
</tr>
<tr>
<td>SG</td>
<td>TRIAD</td>
<td>BARE</td>
<td>SHIELD DRAIN</td>
<td>0-24 VDC</td>
</tr>
<tr>
<td>24P</td>
<td>SINGLE</td>
<td>BLUE</td>
<td>POWER (+)</td>
<td>24 VDC</td>
</tr>
<tr>
<td>24C</td>
<td>SINGLE</td>
<td>WHITE/BLUE</td>
<td>COMMON (-)</td>
<td>24 VDC</td>
</tr>
<tr>
<td>D</td>
<td>SINGLE</td>
<td>BLUE</td>
<td>CONTROL</td>
<td>24 VDC</td>
</tr>
<tr>
<td>125P</td>
<td>SINGLE</td>
<td>BLUE</td>
<td>POWER</td>
<td>125 VDC</td>
</tr>
<tr>
<td>125C</td>
<td>SINGLE</td>
<td>WHITE/BLUE</td>
<td>COMMON</td>
<td>125 VDC</td>
</tr>
<tr>
<td>B</td>
<td>SINGLE</td>
<td>BLUE</td>
<td>CONTROL</td>
<td>125 VDC</td>
</tr>
<tr>
<td>L</td>
<td>SINGLE</td>
<td>BLACK</td>
<td>POWER</td>
<td>120 VAC</td>
</tr>
<tr>
<td>N</td>
<td>SINGLE</td>
<td>WHITE</td>
<td>NEUTRAL</td>
<td>120 VAC</td>
</tr>
<tr>
<td>C</td>
<td>SINGLE</td>
<td>BLACK</td>
<td>CONTROL</td>
<td>120 VAC</td>
</tr>
<tr>
<td>PG</td>
<td>SINGLE</td>
<td>GREEN</td>
<td>POWER GND</td>
<td>ELECTRIC GND</td>
</tr>
<tr>
<td>SG</td>
<td>SINGLE</td>
<td>GREEN/YELLOW</td>
<td>SIGNAL GND</td>
<td>ELECTRIC GND</td>
</tr>
<tr>
<td>UL</td>
<td>SINGLE</td>
<td>BLACK/WHT</td>
<td>UPS POWER</td>
<td>120 VAC</td>
</tr>
<tr>
<td>UN</td>
<td>SINGLE</td>
<td>WHITE/GREY</td>
<td>UPS NEUTRAL</td>
<td>120 VAC</td>
</tr>
<tr>
<td>EX</td>
<td>SINGLE</td>
<td>YELLOW</td>
<td>EXTERNAL</td>
<td>120 VAC</td>
</tr>
<tr>
<td>EXN</td>
<td>SINGLE</td>
<td>WHITE/YELLOW</td>
<td>EXTERNAL NEUTRAL</td>
<td>120 VAC GND'D</td>
</tr>
<tr>
<td>A</td>
<td>SINGLE</td>
<td>BLACK OR BLUE</td>
<td>ANNUNCIATOR</td>
<td>120 VAC/24VDC</td>
</tr>
<tr>
<td>IO</td>
<td>SINGLE</td>
<td>BLACK OR BLUE</td>
<td>ISOL I/O</td>
<td>120 VAC/24VDC</td>
</tr>
<tr>
<td>R</td>
<td>SINGLE</td>
<td>BLUE</td>
<td>RTU</td>
<td>12 VDC</td>
</tr>
<tr>
<td>IS</td>
<td>SINGLE</td>
<td>LIGHT BLUE</td>
<td>INTRINSIC SAFE</td>
<td>&lt;12 VDC</td>
</tr>
</tbody>
</table>
2. Power and control wiring shall be carried in covered wiring channels separate from low voltage analog signal circuits.
3. All control wiring in control panels or other enclosures that is powered from an external source and is not disconnected by the control panel disconnect shall be terminated at a disconnecting terminal block (with energization indicator light upon entering the enclosure.) The color of the wire shall then be changed to yellow to identify it as being powered from an external source. Provide identification nameplate on exterior of enclosure to indicate sources of external power.

D. Terminal blocks and accessories:

1. UL listed
2. DIN rail mounted. Compliant with IEC 60947-7-1
3. Compression clamp type terminal rated for 600 volts and 30 Amperes
4. 22 AWG to 12 AWG copper wire size range
5. Mark using marker carrier and preprinted marker bars for the terminal numbers
6. Acceptable manufacturers:

   a. Entrelec Series: Typical Entrelec catalog numbers are the following:
      1) Terminal Block: Type MS 4/6
      2) Switch Block: Type M 4/6.SNT
      3) Fuse Block: Types M 4/8.SFL, M 4/8.SFD, M 4/8.SFD1

   b. Phoenix Contact Series UK IEC Terminal Blocks
   c. Allen-Bradley Series 1492 IEC Terminal Blocks
   d. Approved equal.

7. Field connections shall be to separate terminal blocks. Terminal blocks for field terminations shall be in a separate part of the panel close to where the field cables enter the panel.
8. External circuits shall be fused. Fuses shall include blown fuse indicator lamps.
9. Comply with UL 508A requirements in construction.

2.5 PANEL GROUNDING

A. Each panel shall be provided with two copper ground bars. One bar shall be bonded to the panel frame or sheet metal and to the station ground system. The second (signal) ground bar shall be mounted on insulated stand-offs and shall be bonded to the frame ground bar at one point only.

B. Signal circuits, signal cable shields, and low-voltage DC power supply commons shall be bonded to the signal ground bar.

C. Surge protectors and separately derived AC power supplies shall be bonded to the frame ground bar.
2.6 FUSES

A. Circuits shall be fused. Fuses shall be 1/4 x 1-1/4 inch. Fuses on 120V AC circuits shall be ceramic tube type with 25,000 amperes interrupting capacity at 125 volts and neon blown fuse indicator lamps. Fuses for 24V DC circuits shall be fast acting glass tube type rated 1/8 or 1/10 amp for 4-20 mA loops and 1/2 amp for the power supply to individual instruments. Fuse holders for 120V AC shall be drawout type and molded from melamine plastic.

2.7 SURGE PROTECTION

A. Surge Protection: Per Section 409515 “Power Supply and Conditioning Equipment.”

2.8 PANEL LIGHT, SWITCH, AND CONVENIENCE OUTLET

A. Provide a light with a door actuated switch in control panels that contain a PLC rack, relays, or other equipment that would require troubleshooting or operator access for normal operation. Provide a duplex outlet, 120VAC 15A, in all panels that require a computer or other maintenance tools that may need a power source. These shall be on a separate dedicated circuit.

2.9 PANEL DISCONNECT SWITCH

A. All control panels shall be provided with a main power disconnect switch. Label panels with multiple power sources and identify power sources.

PART 3 - EXECUTION

3.1 GENERAL

A. Wired as shown on the wiring diagrams.

B. Control room cabinets:

1. Mount on channel iron sills as specified.
2. Sills shall be leveled so panel structures will not be distorted.
3. Panels shall be shimmed to precise alignment so doors operate without binding.
4. Sealant shall be provided under panels not located in dry control or electrical equipment rooms.
5. Mount field panels and cabinets in compliance with Paragraph 409000.
6. Floor-mounted cabinets except in dry control rooms or electrical equipment rooms shall be mounted on 3-1/2-inch minimum height concrete pads or grouted bases as specified
7. Mount record drawings for wiring, connection and interconnection diagrams behind a piece of Plexiglas on the inside of one (or more) door(s).

C. Terminals and terminal blocks shall be sprayed with a silicone resin, similar to Dow Corning R-4-3117 conformal coating, after all terminations have been completed.
3.2 COATING

A. Except for stainless steel and fiberglass panels, all panels and cabinets shall be painted inside and out. Exterior finish shall be an enamel meeting ANSI 61 gray. Interior panel finish shall be an enamel meeting Federal Standard 595: 27880 white.

B. Treat cutouts to prevent corrosion.

C. Except for stainless steel enclosures, the metal surfaces of panels, cabinets, and consoles, shall be prepared, primed, and finish coated per Section 099600 “High-Performance Coatings,” System F-2.

D. Except for stainless steel enclosures, the metal edges of cutouts for instruments, switches, lights, etc., in panels, cabinets, and consoles shall be prepared, primed, and finish coated per Section 099600 “High-Performance Coatings,” System F-2.

END OF SECTION 409513
SECTION 409515 – POWER SUPPLY AND CONDITIONING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for power supply and conditioning equipment required to power instrumentation and communication devices and systems.

B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.

1. Section 409000 “Instrumentation and Control Systems.”

C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete.

D. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more stringent requirements shall govern.

1. NFPA 70 National Electrical Code (NEC)
2. UL 1012 Power Units other than Class 2
3. UL 1283 Electromagnetic Interference Filters
4. UL 1449 Transient Voltage Surge Suppressors

B. Listing:

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.
C. Labeling: power supply equipment shall bear a UL or other label acceptable to the inspection authority having jurisdiction for the specified application.

1.3 SUBMITTALS
A. Per Section 409000 “Instrumentation and Control Systems.”

1.4 PLANT ELECTRICAL SUPPLY SYSTEM
A. Electric power for instrumentation and communication systems shall be obtained from the power distribution system specified in Division 26. This power is not regulated, waveforms may be distorted, and significant amounts of electrical noise may be present.

B. Unless otherwise specified, provide all necessary power supply and conditioning equipment for all required voltages and current capacities and of adequate quality to ensure reliable operation of the instrumentation and communication systems.

C. Unless otherwise specified, assume that the power supply for instrumentation systems is 120 volts plus or minus 15 percent, 60 hertz plus or minus 3 hertz, and 5 percent harmonic distortion.

PART 2 - PRODUCTS

2.1 GENERAL
A. Except for power supply units that form an integral part of an individual piece of equipment:
   1. Comply with UL 1012.
   2. Approved by UL, CSA, or FM for the application.

B. Provide diode isolation for redundant direct current supply units.

C. Connect the DC power supply negative output terminal to the signal ground bus at a single point.

2.2 ALTERNATING CURRENT (AC) VOLTAGE REGULATORS
A. Solid-state tap-changing type, insensitive to line frequency variations between 47 and 63 hertz. Ferro resonant units are not acceptable.

B. Output regulation for input voltage variation from 85 to 125 volts shall not exceed 4 percent.

C. Output regulation for load variation from 0 to 100 percent shall not exceed 1.0 percent.

D. Response time shall be 1.0 cycles or less.
E. Voltage regulators serving panel boards and control panels shall have a load capacity not less than 200 percent of the connected load.

F. Voltage regulators serving individual instruments shall have a load capacity not less than 125 percent of the connected load.

G. Power loss shall not exceed 2 percent of the regulator capacity, and harmonic distortion introduced by the regulator shall not exceed 0.1 percent.

H. Regulator output shall be fully protected against internal faults, external overloads, and short circuits.

I. Three-phase units shall be 4-wire, wye-connected, and capable of supporting 100 percent unbalanced load.

2.3 NOISE-SUPPRESSION ISOLATION TRANSFORMERS

A. For AC powered instrumentation loads containing solid-state circuitry where such is not included within the instrument.

B. Triple box shield type.

C. Each coil shall be completely enclosed in a grounded conductive faraday shield, and the overall transformer enclosed in a faraday shield.

D. Common mode noise attenuation between primary and secondary shall exceed 140 dB at 1.0 kHz.

E. Dielectric strength shall be 2500 volts minimum.

F. Serving panel boards and control panels shall have a load capacity not less than 200 percent of the connected load.

G. Serving individual instruments shall have a load capacity not less than 125 percent of the connected load.

H. Power loss shall not exceed 2.0 percent of the maximum load rating.

I. Harmonic distortion introduced by the isolation transformer shall not exceed 0.1 percent.

J. Three-phase units shall be 4-wire, wye-connected, and capable of supporting 100 percent unbalanced load.

K. Acceptable manufacturer:
   1. Topaz T1.
   2. Approved equal.
2.4 DIRECT-CURRENT POWER SUPPLIES

A. Switching DC Power Supply: UL 508 labeled, regulated switching power supply with the following features:

1. Barrier block terminals for all wiring connections
2. Input voltage: 90-264 VAC, 47-63 Hz
3. 24 VDC output voltage with accessible adjustment for a minimum of plus or minus 2.0 volts
4. Floating output allowing either output terminal to be connected to system ground
5. Line regulation: shall not exceed plus or minus 0.5 percent for line voltage variation from 105 to 125 volts.
6. Load Regulation: shall not exceed plus or minus 1.5 percent for load variation from zero to full load.
7. Noise and ripple: shall not exceed 2.0 percent p-p, including switching noise.
8. Minimum efficiency: 80%
9. Electronic current limiting: 105-110% of full load, with automatic recovery
10. Enclosure: Fully enclosed and suitable for mounting on DIN rail
11. Output current: Output current rating shall provide 50% spare capacity at peak load, derated to 50 degrees C
12. Acceptable manufacturers:
   a. Acromag series PS5R
   b. Idec series PS5R
   c. Lambda series DPP or DLP
   d. Sola series SFL
   e. Approved equal.

2.5 UNINTERRUPTIBLE POWER SYSTEM (UPS)

A. UPS shall provide continuous duty protection and complete power conditioning. UPS shall consist of a power conditioner, a battery charger, a battery, an inverter, system control, and a surge suppression network. UPS shall be UL or CSA labeled and shall meet IEEE 587-80 standards. UPS capacity shall be a minimum of 150% of full load. UPS shall provide the following functions and features:

1. Performance when the power line is absent:
   a. Output voltage: 120VAC ± 3%, sinewave
   b. Total harmonic distortion: 5% maximum
   c. Battery: Provide sufficient batteries for 20 minutes of full load operation

2. Performance when the power line is present:
   a. Input voltage range: 120V ± 20%
   b. Total harmonic distortion: 2% maximum added to incoming line distortion
   c. Surge protection: Per ANSI C62.41-80 (6000V peak, 500 nanosecond rise time, 100kHz damped ring wave)
   d. Output regulation band: +6% to -8% of nominal for all conditions of line and load
e. Correction time: 2 cycles maximum
f. Common mode noise attenuation: 100dB at 100 kHz
g. Normal mode noise attenuation: 70dB at 100 kHz
h. Efficiency: 93% minimum
i. Transfer time AC line to inverter: 4 milliseconds maximum
j. Transfer time inverter to AC line: No interruption
k. Transfer points power conditioning to inverter: -8% or +6% of nominal voltage
l. Transfer points inverter to power conditioning: -11% or +13% of nominal voltage
m. Input Frequency tolerance: ±5%
n. Load Power Factor: 0.9 leading to 0.9 lagging, linear load, 0.6 non-linear load
o. Operating Temperature: -29 to +40 degrees C

3. Acceptable Manufacturers:
   a. APC
   b. Topaz
   c. Approved equal.

2.6 SURGE PROTECTION

A. For protection against line generated transients for both normal and common mode protection: The unit shall be a non-degrading, solid state, series low pass filter with transient protection having the following features:

   1. UL compliant for UL categories 1283 and 1449
   2. Input voltage: 120 VAC single-phase, 47-63 hertz
   3. Load current: 20 amperes minimum
   4. Barrier type terminal blocks for line and load hard-wired connections
   5. Response time: less than 1 nsec normal mode and 5nsec common mode
   6. HF noise suppression: -25 dB at 100 KHz and -55 dB at 5-10 MHz
   7. Transient suppression (per IEEE C62.41): Line-neutral, line-ground, neutral-ground - 15,000 Amps (8 x 20 usec); Category A Ringwave: Normal mode: 6V, Common mode: 330V.
   8. Operating temperature: -40 degrees C to +45 degrees C
   9. Acceptable manufacturer and model:
      a. Control-Concepts Islatrol IC+130
      b. Control-Concepts Islatrol IE+120
      c. Eaton/Cutler Hammer AEGIS HW
      d. Approved equal.

B. For Isolation Transformers: Surge arrestors and capacitors shall be provided on the primary winding of isolation transformers supplying power to solid state systems. Surge protectors shall be mounted in a separate, NEMA 1 enclosure adjacent to the transformer and the incoming line passed through this enclosure. Surge arrestors shall be General Electric 9L15EC or equal. Surge capacitors shall be General Electric 9L18B, or equal.

C. For Panel External Terminal Blocks: Surge protectors shall be provided at panel external terminal blocks and according to the equipment manufacturer’s instructions for types c,d,e,f,g
and i signal circuits as defined in Section 409000 “Instrumentation and Control Systems,” which extend outdoors. Surge protectors shall be:

1. For Panel: MTL Zone Defender or MTL Zone Sentinel or equal
2. For 2 wire transmitters: MTL TP48 or equal
3. For 4 wire transmitters: MTL SD Series or MTL 375/377 or equal
4. For Antennas: Polyphaser or equal

2.7 BACKUP POWER SUPPLY (BPS)

A. BPS shall provide continuous duty protection and complete power conditioning. BPS shall consist of a power conditioner, a battery charger, a battery, system control, and a surge suppression network. The BPS will provide 12VDC and 24VDC with sufficient wattage to run telemetry and associated equipment for a minimum of 4 hours.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Unless otherwise specified, mount and connect in compliance with the manufacturer's instructions.

B. Provide line side disconnect switches.

C. Provide line and load side overcurrent protection in compliance with NFPA 70.

D. Disconnect switches per Section 262800 “Low Voltage Circuit Protection Devices”

E. Small power supply and conditioning equipment may be mounted in the panel served. Larger units shall be mounted adjacent to the equipment served.

F. Where unconditioned power is brought into control panels, it shall be enclosed in metallic raceways within the panel.

G. When larger than 5 KVA load capacity supported from surfaces other than concrete provide with sound isolators.

H. Final raceway connections shall be a flexible conduit in compliance with Section 260553 “Identification for Electrical Systems.”

I. When not designed for exposed mounting, house in panels per Section 409513 “Panels.”

END OF SECTION 409515
SECTION 409517 – MISCELLANEOUS PANEL INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for panel mounted devices for operator interface and internal controls.

B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.

C. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE

A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the most demanding requirements shall govern.

1. EIA RS-310C Racks, Panels, and Associated Equipment
2. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
3. UL 508 Industrial Control Equipment

B. Listing

1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBmittals

A. Per Section 409000 “Instrumentation and Control Systems.”
PART 2 - PRODUCTS

2.1 GENERAL

A. Unless otherwise specified or shown, devices covered by this Section shall comply with all requirements for installation in a control panel bearing the UL 508 label.

B. Unless otherwise specified, all like equipment specified in this Section shall be the product of a single manufacturer.

C. Requirements for devices are specified in this Section are listed on INSTRUSPEC sheets in Part 3.

D. Application requirements are specified in Section 409004 “Schedules,” and/or on the Drawings.

E. All operator interface devices mounted on the panel front shall be rated for the environment in which they will be located. Unless specified otherwise devices mounted on indoor panels shall be NEMA 13 rated. Operator devices mounted outdoors, or in wet or corrosive environments, shall be NEMA 4X rated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Devices shall be installed in panels per Section 409513 “Panels” and in compliance to EIA RS-310C.

3.2 TESTING

A. Testing requirements per Section 409000 “Instrumentation and Control Systems.”

3.3 INSTRUSPEC SHEETS

A. INSTRUSPEC sheets provide detailed requirements for the listed devices. The following INSTRUSPEC sheets are included in this Section.

<table>
<thead>
<tr>
<th>INSTRUSPEC Symbol</th>
<th>Instrument Description</th>
<th>Instrument Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR</td>
<td>Control Relay</td>
<td>Control Logic</td>
</tr>
<tr>
<td>TR</td>
<td>Timer Relay</td>
<td>Control Logic</td>
</tr>
<tr>
<td>POT</td>
<td>Potentiometer</td>
<td>Operator Interface</td>
</tr>
</tbody>
</table>
**Instrument Identification:** CR1, CR2, CR3, CR4  
**Instrument Description:** Control Relay  
**Instrument Function:** Control Logic  
**Power Supply:** Dependent on application  
**Signal Input:** 120 VAC or 24 VDC  
**Signal Output:** Contacts  
**Process Connection:** N/A  

**Product Requirements:**

1. General: All relays shall have indicator lights and 4 Form C contacts except for Types 3 & 4, which shall have 3 Form C contacts. Submit relay types appropriate to the application.

2. CR1: Dry circuit relay. (0 to 100 mA DC). Hermetically sealed with miniature blade terminals.
   a. Potter Brumfield KHS Series with bifurcated gold crossbar
   b. Omron model MY4ZH
   c. Approved equal.

3. CR2: Low level relay (10 mA DC to 1A DC). Miniature blade terminals
   b. Allen-Bradley Bulletin 700-HC14
   c. Approved equal.

4. CR3: Intermediate level relay (50 mA DC to 5 amps AC). Octal tube base.
   a. Idec series RR with silver contacts.
   b. Allen Bradley Bulletin 700-HA.
   c. Approved equal.

5. CR4: Low power relay (10 amps at 120 VAC). Square base with blade terminals.
   a. Potter-Brumfield KU Series with silver cadmium-oxide contacts
   b. Allen-Bradley Bulletin 700-HB
   c. Approved equal.

**Installation:**

1. Mount and connect in panels per Section 409513 “Panels” and in accordance with manufacturer's instructions to the specified functional requirements.

**Application/Calibration:**

1. NA
Instrument Identification: **TR1, TR2**
Instrument Description: Timer Relay
Instrument Function: Control Logic
Power Supply: NA
Signal Input: 120 VAC or 24 VDC
Signal Output: Contacts
Process Connection: N/A

Product Requirements:

1. **TR1:** Time delay “on” relay.
   a. DPDT contacts rated 3 A at 30 VDC or 220 VAC
   b. Repeatability: +/- 0.2% maximum
   c. Setting error: +/- 10% maximum
   d. Temperature error: +/- 3% maximum
   e. Range: As specified, 0.1 - 3600 seconds
   f. Lifetime:
      i. electrical: 200,000 operations
      ii. mechanical: 50,000,000 operations
   g. Coil voltage: As specified
   h. Approved Manufacturers:
      i. Allen-Bradley 700-HR series
      ii. Omron H3CR-A series
      iii. Approved equal.

2. **TR2:** Time delay "off" relay.
   a. "True off" delay: timed contact remains energized after power is removed from coil terminals up to 600 seconds.
   b. DPDT contacts rated 24 VDC or 240 VAC at 5A
   c. Repeatability: +/- 0.4% maximum
   d. Setting error: +/- 10% maximum
   e. Temperature error: +/- 0.2% maximum
   f. Range: As specified, 0.1 - 600 seconds
   g. Lifetime:
      i. electrical: 100,000 operations
      ii. mechanical: 20,000,000 operations
   h. Coil voltage: As specified
   j. Approved Manufacturers:
      i. Idec GT-3F series
      ii. Allen-Bradley 700-HRQ series
      iii. Omron H3CR-H series
      iv. Approved equal.

Installation:

1. Mount and connect in panels per Section 409513 “Panels” and in accordance with manufacturer’s instructions to the specified functional requirements.

Application/Calibration:

1. NA
**Instrument Identification:** POT

<table>
<thead>
<tr>
<th>Instrument Identification:</th>
<th>POT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument Description:</td>
<td>Rotary Potentiometer</td>
</tr>
<tr>
<td>Instrument Function:</td>
<td>Operator Interface</td>
</tr>
<tr>
<td>Power Supply:</td>
<td>0-15 VDC, as specified</td>
</tr>
<tr>
<td>Signal Input:</td>
<td>N/A</td>
</tr>
<tr>
<td>Signal Output:</td>
<td>0 - Full Scale Volts</td>
</tr>
<tr>
<td>Process Connection:</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Product Requirements:**

1. 30.5 mm diameter mounting hole, heavy-duty, water-tight/oil-tight, NEMA 13 or 4X, rated to match enclosure type.
2. Single-turn operation with 312-degree rotation
3. Electrical rating: 300 VAC/DC, 2 Watts, resistance as specified.
4. Escutcheon legend: 0 - 100; or as shown on drawings
5. Acceptable Manufacturers:
   a. Allen-Bradley Series 800T
   b. Square-D class 9001 Type K
   c. Approved equal

**Installation:**

1. Mount and connect in panels per Section 409513 and in accordance with manufacturer's instructions to the specified functional requirements.

**Application/Calibration:**

1. Application, calibration, and set points shall be per Section 409004.

END OF SECTION 409517
SECTION 409543 – NETWORKING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. This section specifies requirements for network components and systems.
B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.
C. Not all products listed are required for all applications. Submit only products required for the application.

1.2 QUALITY ASSURANCE
A. Listing
   1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
   2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
   3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.3 SUBMITTALS
A. Per Section 409000 “Instrumentation and Control Systems.”

1.4 SERVICE REQUIREMENTS
A. Service environment is described in Section 409000 “Instrumentation and Control Systems.”

PART 2 - PRODUCTS

2.1 GENERAL
A. Network systems hardware shall be standard commercial off-the-shelf products that have not been customized in any way for the project to meet the specified requirements.
B. The specified component descriptions are to be considered as minimum required performance benchmarks for each component. Submit the most recent component from the listed manufacturers.

C. Provide the number of ports required by the application. Provide multiple items if one item does not provide the required number of ports.

D. Provide the number of patch panels required by the application but not less than the quantity shown on the drawings.

E. Contractor shall install and configure all equipment, devices, cards, accessories, etc., supplied.

2.2 EQUIPMENT RACK:

A. Electronic equipment racks shall be manufactured by B-Line, Dell, or approved equal, and shall provide the following features:

1. Vertical Equipment Rack ~84” high
2. Smoked Plexiglas removable front locking door
3. Top/bottom louvered removable rear locking door
4. Push button lift-off locking side panels (louvered).
5. Perforated top panel with fan and mounting.
6. Caster feet with stop lock
7. Removable cable entry panels on base, sides and back.
8. Interior cable and power wiring management
10. Power strip(s) as required.
11. Shelves as required.
12. Provide all connection cables, cable management accessories, and other accessories as required to provide a reliable, neat, orderly, and fully functional installation.
15. Racks shall accommodate equipment as shown on the Drawings.
16. Contractor shall review and coordinate equipment rack configuration requirements with actual site conditions and spaces provided. Contractor shall ensure equipment rack is optimal for the actual spaces provided and allows free and easy installation and removal of equipment and free and easy access to all cabling, jacks, ports, etc, as required for efficient and easy maintenance of equipment.

2.3 ETHERNET UTP PATCH PANEL

A. UTP patch panels shall provide the following features and characteristics:

1. 1 U rack height for 19” equipment rack.
2. 24 each RJ45 ports.
3. Complete front and rear panel labeling.
4. Supports category 6 requirements.
5. Provide field replaceable 6 port modules.
6. 110 IDC punch down rear terminations.
7. T568A/B wiring configuration.
8. Provide all needed installation and connection accessories, patch cables, etc.
9. Provide the number of patch panels required by the application but not less than shown on the drawings.
10. UTP patch panels shall be ADC # ADCPP24C6 or approved equal.

2.4 RACK MOUNTED FIBER OPTIC CABLE PATCH PANELS

A. Fiber optic cable patch panels shall provide the following features and characteristics:
   1. 2 U rack height for 19” equipment rack.
   2. 24 available connector positions.
   3. Provide all needed installation and connection accessories, patch cables, blank plates, etc.
   4. Provide adapter plug in modules as required by the application.
   5. Provide the number of patch panels required by the application but not less than shown on the drawings.
   6. Fiber optic patch panels shall be ADC # FL1-E or approved equal.

2.5 RACK MOUNTED UPS SYSTEMS

A. Rack mounted UPS systems shall meet the performance specifications of Section 409515 “Power Supply and Conditioning Equipment.” The UPS shall be as manufactured by APC or approved equal and shall have the following additional features:
   1. Remote UPS enterprise integration and management application software
   2. Rack mounted external battery packs needed to meet holdup requirements
   3. UPS network management card
   4. 1 hour holdup time at full rack load. Submit hold up time calculations.

2.6 ETHERNET SWITCHES FOR PROCESS EQUIPMENT

A. Fiber Optic Ethernet Switches: Fiber optic switches shall be capable as follows:
   1. Full IEEE 802.3 and 1613 Compliance
   2. Minimum six 10/100 Base TX RJ-45 Ports
   3. Two 100 Base FX Ports, ST connectors
   4. Extended Environmental Specifications
   5. Auto Sensing 10/100BaseTX, Duplex, and MDIX
   6. Store-and-forward Technology
   7. Up to 2.6 Gb/s Throughput
   8. Rugged Industrial DIN-Rail Enclosure
   9. Redundant Power Inputs (10-30 VDC)
   10. Bi-Color LED’s For Link, Speed, Activity & Duplex Status
   11. IGMP Snooping - Internet Group Management Protocol to forward multicast traffic intelligently.
   12. VLAN - Virtual Local Area Network to segment the switch in order to create two or more separate local area network domains.
13. QoS - Quality of Service to provide prioritization of network traffic for real-time and other interactive applications.
14. Trunking - Port trunking (aggregation) enables multiple physical ports to be linked together and function as one uplink to another switch configured in the same increasing the bandwidth between switches.
15. Port Mirroring - To allow the traffic on one port to be duplicated and sent to a designated mirror port.
16. OPC Switch Monitoring to add network traffic monitoring, trending and alarming to any popular HMI software packages
17. Units shall be suitable for use in a fiber-optic ring configuration as required.
18. Switch shall be N-Tron 7012FX2-A Industrial Ethernet Switch or approved equal.

B. Managed Process Switches: Provide managed version of the listed manufacturers Ethernet switch, or approved equal, if required for reliable communications as applied with PLC's. Coordinate requirements with PLC manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Equipment shall be mounted, connected, and configured in compliance with the manufacturer’s instructions and recommendations unless specifically noted otherwise.
B. The Contractor shall configure all specified devices and equipment to function according to the Contract Documents unless specifically noted otherwise.
C. Owner’s standard networking components specified shall be provided and configured by the Contractor.

3.2 WARRANTY:
A. Warranty shall be per Section 409000 “Instrumentation and Control Systems.” All warranties shall be registered to the Owner.

3.3 TESTING:
A. Testing shall be per Section 409000 “Instrumentation and Control Systems” and 409002 “Testing and Commissioning.”

3.4 OPERATION AND MAINTENANCE DATA:
A. O&M data shall be per 409000 “Instrumentation and Control Systems.”

END OF SECTION 409543
SECTION 409600 – SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM SOFTWARE

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies software components of the Supervisory Control and Data Acquisition system.

B. The SCADA system shall include the following software components:
   1. SCADA application software
   2. Data acquisition software if not integral to the SCADA software
   3. Process data historian and associated report generation software
   4. Microsoft SQL Server data base management system software and client access licenses
   5. Remote alarm notification system software
   6. Remote SCADA access software

1.2 QUALITY ASSURANCE

A. All products shall be commercial off the shelf products. All products shall be provided by manufacturers with the highest possible reputation in the industry for the application. Custom products are not acceptable. All products supplied shall be either provided by a single manufacturer or shall be endorsed by all the manufacturers for integration into a complete, fully functional, and reliable system. All components, if not the product of a single manufacturer, shall be recommended by all of the component manufacturers for integration with all other provided software products supplied.

B. It shall be the CSI's responsibility to verify that all submitted software components of the system meet the support requirements of all of the system software vendors. This applies particularly to computer operating system compatibility.

C. Acceptability of submitted products shall be entirely at the discretion of the project.

1.3 SUBMITTALS

A. Per Section 409000 “Instrumentation and Control Systems.”

B. Submit manufacturer’s product information for all items supplied.

C. Software license list.

D. A copy of this specification section with all items either check marked to indicate full compliance or otherwise notated with explanations of less than full compliance.
PART 2 - PRODUCTS

2.1 GENERAL

A. All software components shall be commercial off the shelf type components which have not been customized for the application. All components, programs, configurations, etc, shall be non proprietary with no legal restrictions on their use or modification.

B. All software licensing requirements are specified by the functions they must enable and by the number of concurrent running instances of the software they allow. The contractor shall submit software licenses which meet the listed functional requirements as a minimum. The functionality of the submitted licenses shall be greater than or equal to the specified functionality.

C. The Contractor shall provide any and all ancillary or related software and licensing required to support the specified functionality of the core software components. These items shall be considered incidental to and included in the contract.

2.2 SCADA APPLICATION SOFTWARE:

A. General: SCADA software core components shall be Wonderware Intouch, most current version at the time of purchase to match the software being provided by the MBR supplier. All licenses required to provide the defined functionality shall be provided. It shall be the CSI's responsibility to determine, submit, and supply the required licenses. SCADA software licenses provided shall license a minimum of 5000 tags and 200 screens.

B. SCADA HMI development licenses: The contractor shall provide sufficient software licenses to support 1 development session with IO and 1 run time only session with IO.

C. Data Acquisition: The contractor shall provide data acquisition server software licenses. Data acquisition software shall be OPC server software and shall be KEPware, TOP Server or approved equal as recommended by the selected SCADA software manufacturer. Data acquisition software must provide connectivity to PLC’s supplied, contractor shall coordinate associated details.

D. Process Data Historian Software: The data historian shall support data storage, trending, advanced calculations, and historical reporting and analysis of system data. Data historian software shall be Wonderware Historian, most current version at the time of purchase. Contractor shall provide full function license that support 2000 tags each unless noted otherwise in the contract documents. The contractor shall determine, submit, provide, install, and configure any and all additional related software licenses such as Microsoft SQL Server database software needed to fully implement the data historian. The contractor shall provide client access (CAL) or other needed licenses for 5 concurrent connections to the historian and database software. The historian must provide advanced calculation functionality which provides the ability to do advanced calculations on Historian tag data and store the results in the historian. These features must include pre-configured and extendable business rules and calculations that allow users to manipulate collected raw data and store the calculated values in the historian.
E. Data Reporting Utilities: The Contractor shall provide reporting utilities that are either directly integrated with, ship with, or are shipped separately but integrate with the historian software. The reporting utility software shall be the software most highly recommended by the process data historian software manufacturer. Reporting software shall be Wonderware Dream Report software, or approved equal. Provide client access or other needed licenses for 5 concurrent connections to the historian and data base software.

F. Remote Alarm Notification Software: Software shall integrate with the SCADA software and provide greater than 3 levels of alarm annunciation including the use of voice, phone, pager, e-mail, and support of alarm groups with common acknowledgement indication across all SCADA nodes. Software shall be WIN911, or approved equal, most current version at the time of purchase. The alarm software shall be the software product most highly recommended by the SCADA software manufacturer. Contractor shall provide each license which support a minimum of 1000 alarm tags.

G. Support: All supplied software shall be provided with one year of the most comprehensive support contract available from each manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall install all software supplied unless specifically noted otherwise.

B. Packaged equipment vendors shall install all software they supplied.

C. Third party programmers shall install contractor provided software where specifically noted.

3.2 SOFTWARE DELIVERY

A. Where applicable, software shall be delivered to third party system programmer 4 months prior to the anticipated date of factory testing.

3.3 PROGRAMMING AND CONFIGURATION:

A. Contractor shall install, configure, program, and test all SCADA application and related software per 409000, 409635 and 409002, unless specifically noted otherwise.

B. Packaged equipment vendors shall install, configure, program, and test all SCADA application and related software for their systems per 409000, 409635 and 409002.

C. Both the contractor and the packaged equipment suppliers shall proactively coordinate the integration of the packaged equipment suppliers local SCADA components with the contractors overall plant SCADA components.

D. When specifically noted, third party programmers shall install, program, and test the SCADA software. The contractor and CSI shall provide integration, testing, and commissioning support as requested by the Engineer.
3.4 TESTS AND INSPECTIONS

A. Per Section 409002 “Testing and Commissioning.”

3.5 OPERATION AND MAINTENANCE DATA

A. The Contractor shall provide complete sets of documentation for all software components supplied. Documentation sets shall include installation manuals, user manuals, technical manuals, trouble shooting manuals, etc. Original documents or copies of originals shall be required. Internet or web page printouts shall not be accepted. High volume documentation may be provided on electronic storage media. Provide index of documentation.

B. The contractor shall develop and provide a comprehensive and detailed SCADA system user’s manual per Section 409000 “Instrumentation and Control Systems” unless SCADA software is configured and programmed by a third party programmer in which case the programmer will provide the manual for the programs they supply.

END OF SECTION 409600
SECTION 409635 – PROGRAMMING

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: This Section specifies requirements for programming software, programmable devices, and programmable systems. Provide fully operational, fully programmed, and fully tested programs for all supplied programmable devices, software, and systems unless specifically noted otherwise. Programming for controlled processes shall operate as specified in the Contract Drawings, the Control Strategies, and needs of the application and equipment in the case of packaged systems. This section applies to but is not limited to the components listed below:

1. PLC's
2. OIT's
3. Data acquisition servers
4. SCADA system components
5. Data Historian and reporting software
6. Remote alarm notification software

B. Experience: Programmers responsible for performing the detailed software design and programming of programmable equipment on the project shall have a minimum of five (5) years experience in similar projects. The Contractor shall assume full responsibility for software system design, programming, and operation unless specifically noted otherwise.

C. Acceptable Programmers: All programming on the project shall be provided by either a direct employee of the CSI, packaged equipment control system suppliers. CSI employees providing programming services to the project shall have a minimum of 1 year of employment with the CSI. Packaged equipment suppliers shall provide programming for supplied programmable packaged control system components.

1.2 SUBMITTALS

A. General: Per 409000

B. Progress Submittals: All programming elements shall be submitted to the Engineer for review at all required submittal levels.

C. Format: Submit as hard copy printed program and configuration listings as well as programming software file format on CD-ROM.

D. Submittals: Submittals shall include the following as they apply to this project and the submittal level:

1. PLC logic block diagrams
2. PLC I/O and data file listings
3. PLC program listings
4. PLC program files
5. OIT screen samples from recent similar projects
6. OIT Tag database listing
7. OIT screen shots
8. OIT program files
9. Data Acquisition Server configuration listing
10. Data Acquisition Server configuration files
11. SCADA HMI screen and functionality samples from recent similar project
12. SCADA database listing
13. SCADA HMI screenshots
14. SCADA HMI program files
15. Process data historian database listing
16. Process data historian configuration files
17. Process data historian report format
19. Remote alarm notification software database listing
20. Remote alarm notification software configuration files
21. Proposed color code for OIT and HMI screen presentation
22. Proposed common graphic elements and functions for OIT and HMI screen presentation
23. P&ID drawings with programmed elements check marked up too indicate element is programmed. Provide explanations for unchecked elements. Provide progress updates at 30, 60, 90, and 100% progress submittal level.

E. PLC programs: Provide block diagrams of logic sequence referenced to the control strategy specifications. PLC programs shall provide fully commented ladder logic. All instructions and all rungs shall be commented. Provide overall control sequence comments at the start of each program file and at the start of each major logic block. Reference logic descriptions to the control strategy specifications. Indicate registers used to communicate between PLC’s and operator interface.

F. OIT and SCADA: Submit color "screen shot" images of each proposed operator interface and SCADA screen. Describe color schema, mouse button use, function key controls, animation, and communication protocol with PLC’s. Provide screen navigation flow diagram. Include sample event and alarm log screens. All HMI screen elements shall be identified by tag number, equipment description, and system description.

G. Data Acquisition and Trending: Submit details of data structures, communications protocols, data exchange formats, sampling intervals, file storage space management, etc. Provide "screen shot" images of historical trending.

1.3 PROGRAMMING SOFTWARE

A. PLC programming software as specified in Section 409443 “Programmable Logic Controllers.”

B. SCADA programming software as specified in Section 409600 “Supervisory Control and Data Acquisition (SCADA) System Software.”
C. Process data historian and reporting software as specified in Section 409600 “Supervisory Control and Data Acquisition (SCADA) System Software.”

D. Remote alarm notification software as specified in Section 409600 “Supervisory Control and Data Acquisition (SCADA) System Software.”

1.4 PLC PROGRAMMING

A. General: All programmed process and equipment control logic shall be executed in PLC’s. The Contractor shall have full and complete knowledge of ladder logic programming.

B. Ladder Logic: Program all PLC functions in Ladder Logic. Submit requests to program functions in any other language. Function Block, Structured Text, and Sequential Function Chart programming may be allowed on an exception basis with written permission from the Engineer. Time spent by the Contractor to correct programming that is not compliant with the programming software and programming language defined in this section will be at the Contractor's expense and shall not affect the project schedule or milestone dates.

1.5 SOFTWARE REVISIONS

A. Revision Tracking: Provide a formal revision tracking procedure for all software being developed and submitted to the Engineer. The revision tracking procedure shall contain information necessary to track all changes, and ensure revisions are properly tested, documented, and incorporated into the final program. The revision tracking procedure shall track submitted programs, reference Engineer's comments, show date program was saved, date of all revisions, and reference to material used for the program revisions. The revision tracking procedure shall ensure that only fully tested, fully documented, and properly revised software is loaded into the PLC for delivery. Track incorporation of reviewers comments.

1.6 COMMUNICATIONS

A. EHTERNET: PLC, OIT, and SCADA components shall communicate over the plant process control Ethernet network.

1.7 PROGRAM DEVELOPMENT AND COMMISSIONING RESPONSIBILITY

A. General: The contract documents include depictions and descriptions of the functional requirements of control system component programming. Unless specifically noted otherwise the contractor shall configure and program all programmable equipment on the project. The contractor shall in all cases be responsible for the proper functioning or all programmable hardware they supply. The contractor shall in all cases be responsible for the process control network, communication systems, media, and infrastructure on which proper process control programming functionality depends.

B. Programming Elements not Supplied by the CSI: The project includes control system equipment and programming provided by the CSI, packaged system suppliers where noted, and third party programming of contractor supplied equipment where noted. Packaged systems may be either
submitted by the contractor or may be preselected prior to bid award and assigned to the contractor. Where specifically noted, programs shall be developed, installed, and tested by responsible entities other that the CSI. The CSI shall not be required to provide supervision, development, submittal, installation, testing, documentation, commissioning, delivery, and warrantee support for programs provided by others except as noted in the SUPPORT paragraph below. Integration and overall project commissioning responsibilities shall be shared by the Contractor, packaged equipment suppliers, and third party programmers as directed by the Engineer or the Owner.

C. Packaged Equipment: Suppliers of packaged equipment control systems shall configure, program, test, commission, and provide thorough documentation for all equipment they supply. Packaged equipment shall be understood to include preselected as well as contractor supplied packaged systems. Suppliers of these systems shall provide all services related to programming development, documentation, and testing including coordination, submittals, user manuals, training, warrantee support, etc. These system suppliers shall provide all programming and related services for all equipment they supply including but not limited to the items listed below:

1. PLC’s supplied with packaged equipment
2. Operator interface terminals supplied with packaged equipment
3. SCADA HMI supplied with packaged equipment
4. Final configuration and commissioning of VFD’s associated with vendor provided equipment
5. Configuration and calibration of all instruments supplied by the vendor
6. Configuration and programming of all devices required to support communications between the Vendors PLC and other devices at the site as required by the contract documents

D. Third Party Programmers: Designated third party programmers shall program contractor supplied equipment as specifically noted. Third Party Programmers shall be understood to include any organization other than the CSI or packaged equipment suppliers who provide programming services to the project such as the design consultant. These parties shall provide all services related to program development, documentation, and testing including coordination, submittals, user manuals, training, warrantee support, etc.

E. Contractor Support: The contractor and CSI shall provide coordination and support to packaged equipment vendors and third party programmers. The CSI and the Contractor shall support these other parties in the development, submittal, testing, integration, and commissioning of their individual scopes of supply to the extent that the programs supplied by others interface with or otherwise interact with contractor supplied equipment and functions. The Contractor shall be responsible to provide services, support, and assistance to support the testing and verification of responses of their supplied equipment to the programming provided by others. The contractor shall provide this coordination and support at the request of, in the manner, and on the schedule dictated by the Engineer.
PART 2 - PRODUCTS

2.1 PROGRAMS

A. General: Provide fully functioning programs that are without error, do not perform abnormal stops or actions, and are fully documented.

B. Security: Provide three levels of access to OIT and SCADA screen functions. Secure two of the levels with login requiring user name and password. The three access levels shall allow the following:

1. Read Only User: This user will be able to navigate and view all system data but will not be able to enter any data. This user shall automatically log in on system startup or inactivity time out for higher level users.
2. Full Read Write User: This user will have full access to all administrative and data entry functions. This user shall automatically log out after 30 minutes of inactivity.
3. Read Limited Write User: This user will not have access to administrative functions. This user will have access to a subset of the data entry functions. Write capabilities for this user will be defined during development. This user shall automatically log out after 30 minutes of inactivity.

C. Graphic Screen Content: Operator Interface and HMI display screens shall provide the following types of information:

1. System Overview. The system overview shall include but not limited to: All flows and levels, all major elements on drawing G006 as well as any other major elements of the system (pumps, fans, motors, analytical devices, etc.). Change of state (on/off/fault) shall be indicated on the System Overview screen as a color change. Color code standards shall be coordinated with the owner.
2. Sub process detailed information
3. Equipment Status
4. Set point and Data Entry
5. Alarm History with time/date stamp
6. Control Modes and logic state
7. Maintenance information
8. Trends
9. Navigation

D. Graphic Screen Layout: Graphic displays shall include static and animated text and graphical representations of the facility, the equipment, and the process. Graphic HMI displays shall be logical, well organized, and intuitive to the operators. Do not overpopulate and congest screens. Create a sufficient number of screens to provide easy to read and understand screens which logically separate process information. Graphic elements shall resemble the facilities, equipment, and devices they represent. Use manufacturer provided graphic elements where available. All items on the P&ID drawings shall be represented on graphics screens. The general layout and content of graphics screens shall correlate with the P&ID drawings however duplication of the P&ID drawings in the graphic screens will not meet presentation requirements. Provide a minimum number of process graphics screens equivalent to the number of P&ID drawings in the contract documents, in addition to any needed pop up's, trends, alarm
lists, process overview screens, navigation screens, text data screens, numeric data entry screens, etc.

2.2 SOFTWARE FUNCTIONS

A. P&ID Drawings & Control Strategy Specs: Provide all features, characteristics, functions, and presentations required by control strategy specification and the P&ID drawings.

B. PLC Programs: Provide PLC programs capable of performing the following general functions at a minimum:

1. Analog input processing and conversion to engineering units
2. Discrete input processing for alarms and interlocks
3. Discrete output processing for Alarm generation
4. Equipment Sequence selection
5. Equipment Start/Stop and Speed control
6. Proportional + Integral + Derivative (PID) control algorithm processing, with setpoints entered locally or transmitted from the OIT or SCADA system
7. Analog Output processing for control loop outputs
8. Real-time clock for scheduling of control functions and tasks
9. Display of process data on Operator Interface and SCADA HMI
10. Provide alarm timers for all required alarms.

C. HMI: Provide Operator Interface and SCADA HMI programming that allows adjustment of loop set points, timer and counter presets, loop tuning parameters, etc.

D. Packaged Equipment: Provide all programmed operator interface/HMI presentations and logic functions required to monitor and control the process and equipment within the system supplier's scope of supply.

2.3 PROGRAM DOCUMENTATION

A. General: Provide complete documentation of all programs. Utilize all available documentation services available through the Programming Software. All application programs shall be fully documented. Program databases shall be fully expanded and documented and shall include a populated comments field. Documentation shall be sufficiently thorough to enable reviewers to review and understand all submitted programs without extensive reverse engineering efforts, and to enable trained staff of the owner to review, understand, maintain, and modify all programs supplied without extensive reverse engineering efforts. All programming components required to be complete for each progress submittal level shall be fully documented.

B. PLC Programs: All PLC programs shall be fully documented. All program blocks, sub programs, ladder rungs, and instructions shall be commented. Provide descriptive program block, sub program, and rung comments which relate the programming to the control sequence specifications. Provide sufficiently detailed comments to enable reviewers to understand the logic flow and functions of the programs. Use sub program and rung comments to explain how the code performs the all functions including those specified in the control strategy specification sections. Provide revision history of programs. Submit complete printouts and files demonstrating compliance to documentation requirements. PLC documentation shall include:
1. Log Book of revisions and their authors
2. Tags
3. Descriptors
4. Program, sub program, Task, Routine, rung, and instruction Comments
5. Titles
6. CPU Memory Configuration
7. I/O Rack configuration

C. Tag Names: Provide consistent tag names in PLC, OIT, SCADA, process data historian, and remote alarm notification software. Tags shall be descriptive and correlate to the loop, equipment, or function to which they are associated per the P&ID drawings and control strategy specifications. Include device or equipment tag number in register tag names, instruction comments, and rung comments at every available opportunity where the application of the element is specific to an individual tag number.

D. Descriptor Fields: Fully utilize all descriptor fields provided by the programming software including the following:
   1. Tags and Aliases
   2. Descriptions
   3. Comments
   4. Titles

E. Data Communications:
   1. Packaged Equipment: Provide documentation detailing data structures communicated between vendor and contractor provided PLC's and SCADA. Provide correlated tag lists from vendor provided PLC's or SCADA which exchange data with contractor provided PLC's or SCADA.
   2. Other Data Comm IO: Submit instrument and device configurations for all instruments, devices, scanners, modules, etc., which exchange IO data with PLC's via communications protocols such as devicenet, Foundation Fieldbus, Profibus, Modbus, Remote I/O, etc. Provide all instrument, scanner, and other communications device tag lists and configurations.

2.4 OWNERSHIP OF SOFTWARE LICENSES AND PROGRAMS

A. All operating software, programming software, etc. shall become the property of the Owner upon completion of the project. Suppliers and contractors shall make no claims of ownership, copyright, or other licensor upon final acceptance of the system. All “Commercial” software licenses required shall be licensed to the Owner at the time of the original purchase.
PART 3 - EXECUTION

3.1 PROGRAM DEVELOPMENT

A. Schedule: Provide a schedule showing program development tasks including milestones. Include all software programs developed by the contractor. The schedule shall include the following steps as a minimum:

1. Predevelopment coordination submittal
2. Preliminary Software Submittal (30%)
3. Intermediate Software Submittal (60%)
4. Pre Operational Software Submittal (90%)
5. Factory Acceptance Test software (100%)
6. Final Software Submittal with O&M manuals
7. Submittal review meetings

B. Pre development coordination: The programmer shall coordinate with the project prior to the start of detailed program development. The programmer shall provide the project with examples of proposed conventions, function implementation, and data presentations as requested by the project. The Project may at their discretion provide the programmer with samples of software functions and data presentations, conventions, etc. The programmer shall incorporate requested software functions, data presentations, conventions, etc into the programs they develop.

C. Submittals: Provide submittals listed below. Submit in programming software configuration and program file format and hardcopy format. Hard copy shall be produced with utilities provided with the programming software or format shall be compatible with Microsoft Word/Excel 2013. All program and configuration files shall be represented at each submittal level and shall be submitted simultaneously for each submittal level. Resubmittal of any programming submittal level may be required or may be deferred to the next submittal level at the discretion of the owners Engineer. Resubmittals shall be provided upon the request of the owners Engineer until the owners Engineer approves all elements of the programming and configuration submittals.

1. Predevelopment submittal: Submit OIT and HMI screen samples from recent similar projects. Submit proposed standard screen element color code and proposed standard graphic elements for interface screen presentations.
2. 30% Software Submittal: Submit all items listed under submittals developed to a 30% level of completion. All unique functional and presentation elements shall be identified. All functional and presentation elements shall be identified and associated with a defined unique functional element. Tag databases shall be complete for all unique functional and presentation elements at the 30% level. A list shall be provided which identifies the duplication of the developed tags required to complete the tag databases. Programming for 50% of all unique functional and presentation elements shall be complete at the 30% submittal level. Programming for 30% of all functional and presentation elements shall be complete at the 30% submittal level. A list shall be provided which indicates all remaining functional and presentation elements to be developed and identifies which block of common tags and programming will be duplicated to complete the programming. Include tag lists and communications device configurations for data acquired via Devicenet, Foundation Fieldbus, vendor-provided PLC’s or SCADA, etc.
3. 60% Software Submittal: Submit all items listed under submittals developed to a 60% level of completion. All tag databases shall be 100% complete at the 60% submittal level.
Programming for all unique functional and presentation elements shall be complete at the 60% submittal level. Programming for 60% of all functional and presentation elements shall be complete at the 60% submittal level. Include tag lists and communications device configurations for data acquired via Devicenet, Foundation Fieldbus, vendor-provided PLC's or SCADA, etc. Update and submit list of elements remaining to be developed.

4. 90% Software Submittal: Submit all software listed under submittals developed to a 90% level of completion. Include proposed test plan for Factory Acceptance Test of Software. All program development shall be 100% complete and documented by the 90% submittal. All that should remain to be done to reach the 100% submittal is bench testing, debugging, and incorporation of 90% review comments. Include tag lists and communications device configurations for data acquired via Devicenet, Foundation Fieldbus, vendor-provided PLC's or SCADA, etc.

5. 100% Submittal: Submit completed programs to be used for factory acceptance testing.

6. O&M Submittal: Submit final programs and documentation as part of O&M manuals.

D. Submittal Review: The programmer shall provide progress submittals listed above to the project in the specified formats, color screen shots, and as requested by the project for review by the project. The project will provide review comments to the programmer. The programmer shall incorporate all project submittal review comments into the development of the subsequent submittal as requested by the project. The contractor shall attend a submittal review and coordination meeting following each submittal. The meetings shall be at a time and place and of a duration required by the project. The project may, at its discretion, waive any or all of the submittal review meetings.

E. Contractor Response to Submittal Review Comments: The contractor shall provide individual written responses to each submittal review comment on a file copy of the submittal review comments and shall submit these responses and the updated and corrected files with the subsequent submittal. Responses to submittal review comments shall describe the action taken to correct or otherwise address the issue identified by each submittal review comment. Responses such as "comment noted", "will review and correct as needed", etc., are not acceptable. The review comment responses shall identify all specific areas of the program and configuration files that have been modified in response to the review comments. The review comment responses shall be accompanied by the updated programming and configuration files which contain the corrections as referenced by the review comment responses and as required by the submittal level requirements.

F. Coordination of Display Screen Development:

1. General: Coordination of all HMI and OIT devices and programming shall be within the Contractors scope of supply UNO. This includes CSI provided systems and bid and assigned Vendor provided systems. The development of display screens for these systems shall be coordinated with the Engineer to ensure consistency of functionality and the look and feel of the systems at the plant.

2. Screen Content: Display screens shall include the data indicated on the P&ID drawings and the control strategy specification sections. Screens shall provide navigation functions. Automatic fault messages shall appear upon alarm conditions. System operating and alarm information shall be displayed on screens in both graphical and text format. Alarm icons shall flash on the screen until the alarm has been manually or automatically cleared.

3. Screen Conventions: Display screens shall follow the owners conventions for color usage, function, navigation, alarm display, graphic symbols, animation, etc. if requested. The Contractor shall coordinate display screen presentation development with the
Engineer and shall submit tag lists, alarm lists, PLC I/O lists, sample screens, color code, etc., to the Engineer for approval.

3.2 PROGRAM INSTALLATION

A. Install the application program.

B. Edits by the Contractor to software installed in a PLC in production operation at the facility shall comply with the following:

1. Coordinate the changes, edits or reloading of the programs with the Engineer. Make changes to the program to correct deficiencies or incorrect operation.
2. The Engineer shall approve all changes before loading the program into the PLC.
3. All programming changes shall be downloaded locally.
4. Contractor shall provide complete record documents. All applicable documentation, drawings, copies of the program, and narratives shall be revised by the Contractor to reflect the edits to the programs and the operation of the process.

C. Programs developed by packaged system suppliers and third party programmers will be installed by these parties.

3.3 PROGRAM TESTING

A. Test programs in accordance with Section 409000 “Instrumentation and Control Systems” and 409002 “Testing and Commissioning.”

3.4 TRAINING

A. Provide training per Section 409000 “Instrumentation and Control Systems.”

B. Provide 16 hours of training for the owner’s personnel on all aspects of design, operation and maintenance of the programs and software provided.

C. Provide training on site at a time mutually agreed between the Contractor and the Engineer.

D. Notify the Engineer at least four weeks prior of the proposed training date.

END OF SECTION 409635
SECTION 409715 - PRESSURE GAGES

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes pressure gages for both water and sewer systems.

1.2 SUBMITTALS
   A. Product Data: For each component of gage assembly.
   B. Include scale range and ratings for gages.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      1. Pressure Gages:
         a. AMETEK, Inc.; U.S. Gauge Div.
         c. Dresser Industries, Inc.; Instrument Div.; Weksler Instruments Operating Unit.
         d. Ernst Gage Co.
         e. Marsh Bellofram.
         f. Noshok, Inc.
         g. Trerice: H. O. Trerice Co.
         h. Weiss Instruments, Inc.
         i. WIKA Instruments Corp.
         j. Winter's Thermogauges, Inc.

2.2 PRESSURE GAGES
   A. Provide all pressure gages shown on Process and Instrumentation Drawings.
   B. Description: ASME B40.1, phosphor-bronze bourdon-tube type with bottom connection; liquid-filled-case type.
   C. Case: Drawn steel, brass, or aluminum with 4-1/2-inch- diameter, clear acrylic plastic lens.
   D. Connector: Brass, NPS 1/4.
E. Scale: White-coated aluminum with permanently etched markings.

F. Range: Pressure gage scales shall be selected so that the normal operating pressure falls between 50 and 80 percent of full scale.

G. Accuracy: Grade B, plus or minus 2 percent of middle 50 percent of scale.

2.3 DIAPHRAGM SEALS

A. General: Diaphragm seals shall be provided and installed for all pressure gauge. Seal shall be Terice, Type M, Model 516 or approved equal.

B. Diaphragm seal shall have stainless steel process flange.

C. Diaphragm seal shall have flushing connection.

D. Seal flanges shall have 1/2-inch threaded connections.

PART 3 - EXECUTION

3.1 GAGE INSTALLATION, GENERAL

A. Install pressure gages on pipe vertically, at the most readable position.

B. Provide removable/portable diaphragm seal/gage assemblies.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other specification Sections. Drawings indicate general arrangement of piping and specialties.

3.3 ADJUSTING AND CLEANING

A. Adjust faces of gages to proper angle for best visibility.

B. Clean windows of gages and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 409715
SECTION 412223 – MONORAIL AND DAVIT CRANES

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes:
   1. Wire Rope Hoist and Trolley (HST 230010)
   2. Davit Crane.

B. The Contractor shall supply the labor, materials, and equipment necessary to design, fabricate, test, deliver and provide installation assistance for the crane assemblies specified in this Section.

C. Related sections include the following:
   1. Division 46 Section 460513 “Common Motor Requirements for Water and Wastewater”

1.2 GENERAL

A. Like items of equipment provided hereunder shall be the end products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer’s service. Equipment shall be manufactured by a firm normally engaged in the fabrication of this type of equipment and shall have documentation of installation of similar design and application.

1.3 SUBMITTALS

A. Procedures: Submit in accordance with Division 1, Section 013300 “Submittal Procedures.”

B. Submittals shall be made in accordance with Division 1 “Submittals Procedures”. In addition, the following specific information specified hereinafter shall be provided.
   1. Drawing showing complete dimensional data.
   2. Manufacturer’s data including materials of construction and weight.
   4. Exceptions to these Specifications.

1.4 STANDARDS, SPECIFICATIONS, AND CODES

A. Bottom running single girder overhead traveling cranes shall conform to the latest edition of Crane Manufacturers’ Association of America (CMAA) Specification No. 70, except as specified herein. CMAA specification hereinafter shall mean CMAA Specification No. 70.

B. Bottom running single girder cranes shall be designed for services as Class C and as described in CMAA Specification No. 70.
C. All trolleys shall be designed for services as Class C and as described in CMAA Specification No. 70.

D. All hoists shall be designed for service Class H3 as described in Hoist Manufacturer’s Institute (HMI) Specifications.

E. All electrical components shall be furnished in accordance with the applicable requirements of the National Electrical Code (NEC), state and local regulations, and standards of the National Electrical Manufacturer’s Association (NEMA).

F. Electrical equipment and material shall be tested and labeled for the purpose for which it is designed by Underwriters Laboratories, Factory Mutual, CSA, ETL or equivalent nationally recognized testing laboratory acceptable to the local Electrical Inspection Authorities.

PART 2 - PRODUCTS

2.1 Wire Rope Hoists and Trolleys (HST 230010)

A. General

1. All crane equipment shall be designed to occupy the space provided, as shown on the Drawings.
2. Examine the Drawings and modify as required for equipment clearances, interferences, and obstructions which might impose limitations upon the equipment or do not meet safety requirements.
3. All building clearances shall be as specified in CMAA Specifications.
4. All materials shall be properly selected for the stresses to which they will be subjected. Design stresses and safety factory shall be in accordance with CMAA Specifications.
5. All apparatus covered by this specification shall be constructed with due regard to safety of operation, accessibility, interchangeability, durability of parts, and shall conform to ANSI B30.2.0 safety code and all applicable OSHA regulations.
6. Runway rails and stops shall be located as shown on the Drawings.
7. Latch type hook to meet OSHA requirements.
8. Provide required festoon or other cable system per manufacturer recommendation.

B. Manufacturers

1. STAHL
2. Budgit
3. Yale
4. Wright
5. Approved Equal.
C. System Requirements

1. Electric wire rope.
2. Headroom: See Drawings for minimum clearance.
3. Trolley travel range: See Drawings for trolley range of travel.
4. Design and supply rail to resist all vertical, lateral and torsional forces.
5. Operating Requirements:

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runway beam</td>
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<tr>
<td>Trolleys, wheels, hook</td>
<td>Steel, ASTM A36</td>
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</table>

D. Materials:

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<td>Runway beam</td>
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<td>Steel, ASTM A36</td>
</tr>
</tbody>
</table>

E. Equipment

1. Beam: standard beam section of a proper size for the monorail supplied with suitable splices and accessories.
2. Trolley: Motorized trolley with be hardened steel wheels, mounted on permanently lubricated anti friction bearings.
3. Hoist:
   a. Hoist shall be double reeved. The hoisting drums shall be grooved and designed for one layer of wire rope. Hoist gearing shall be heat-treated hardened steel, running in an oil bath. Gear bearings shall be the oil-lubricated anti-friction type, and all bearings shall be designed for a Class M2 (20,000 hour) bearing life.
   b. A geared upper and lower limit switch and plugging upper limit switch shall be provided to assure safe operation and positive stopping under all conditions. The geared limit switch shall automatically stop the motor and engage the hoist brake when the hook reaches either its upper or lower limit of travel. The hoist shall be provided with a load limiting device adjusted not to exceed 125 percent of rated capacity.
   c. Each load hook shall be mounted on ball thrust bearings to swivel without twisting the wire rope. The lifting tackle shall be of the safety type, and the hook shall be of hardened steel equipped with a safety catch. Sheaves shall be properly guarded and shall be heavy pattern, deep flanged, and properly grooved. Sheaves shall either be bronzed, bushed, or fitted with ball bearings, and supported on fixed pins.
   d. Hoist motor brake shall be magnetically operated disc type or shoe type, mounted on the extended pinion shaft, and designed for a torque rating to 150 percent of the motor full load torque. Brake shall be equally effective in both directions of motor rotation and of sufficient size to stop motor and hold rated capacity load. Brake shall be self-adjusting to allow for normal wear of the brake lining.
e. The CONTRACTOR shall furnish and install an identification plate on the hoist housing. The identification plate shall be of clearly legible permanent lettering giving the manufacturer's name, model number, capacity, and other essential information. In addition, the identification plate shall display the equipment number for the hoist that is identified hereinbefore.

4. Drive unit:
   a. Hoist and trolley drive units: provide as an integral part of the equipment as specified above.
   b. Motor: totally enclosed, high torque type suited for Class 1 hoist service.
   c. Ballast resistors to provide slow, cushioned starts.

5. Control:
   a. By push-button pendant suspended from the trolley for all motions.
   b. Hoist and trolley controls shall be by multiple detent push-buttons plus an emergency stop push-button.
   c. Controls: clearly marked with etched or engraved nameplates.
   d. Pendant: attached to a retractable cable which will allow it to be raised above head level when the hoist is not in use and which will allow the pendant to be held in the hand during hoist operation.

6. Electrical Equipment
   a. Hoist motors shall be two-speed adjustable frequency motors. Trolley motion shall be through reversible, two-speed adjustable frequency electric motor.
   b. The Contractor shall furnish and assemble all electrical equipment on the crane including motors, motor starters, pendant control, and conduit. Bridge conductors may be removed for shipment. All conductors on the crane shall be furnished by the crane manufacturer, cut to length and installed, as far as practical, for shipment.
   c. The electrical equipment shall be furnished in accordance with the applicable requirements of Article 610 of the latest issue of the National Electrical Code.
   d. Motors shall be squirrel-cage type and shall be built in accordance with NEMA Standards, rated on not less than a 30-minute basis, with temperature rise in accordance with the latest NEMA Standards for the class of insulation and enclosure used, and shall be provided with antifriction bearings. Squirrel-cage motors shall be NEMA Design D, with high starting torque, low starting current and high slip at full load. Overload relays shall be provided in all phases of polyphase alternating current motors.
   e. Grounding on the equipment and provisions for grounding the equipment to external grounding systems shall be in accordance with the requirements of the NEC and state and local regulations.
   f. Electric hoists shall be equipped with a pendant control having momentary contact pushbuttons, and shall be provided with a device which will disconnect all motors from the line on failure of power and will not permit any motor to be restarted until the controller handle is brought to the OFF position, or a reset switch or button is operated. Undervoltage protection shall be provided as a function of each motor controller, or by a magnetic main line contactor.
   g. Controls shall be fully magnetic of the plain reversing type, or variable frequency controllers, housed in NEMA Type 3X enclosure. Each magnetic control shall
have contactors of sufficient size and quantity for starting, accelerating, reversing and stopping duty for the specified crane service class. Provide upper and lower limiting switches, disc type motor break, and load limiting device.

h. Provide control transformers to supply 120 volts ac to the pushbutton control stations. The pushbutton control stations shall be of heavy-duty, oiltight construction and suspended from the trolley. The pushbutton enclosure shall be supported with chain or wire rope. The control wire cable shall be attached to the enclosure support at not more than 6-foot intervals. The control wire cable shall be of sufficient length to bring the control pendant to the ground floor of the sludge handling facility. The control station shall contain pushbuttons for control of the hoist and an ON/OFF switch to operate a main line contactor which shall remove all power from the control station.

F. Accessories

1. Equipment Identification Plates: A 16-gauge stainless steel identification plate shall be securely mounted on the equipment in a readily visible location. The plate shall bear the 1/4-inch die-stamped equipment identification number indicated in the specification and/or shown on the Drawings. The equipment identification number shall be mounted on each of the separate components of the equipment to facilitate assembly in the field.

G. Coatings

1. Per manufacturer’s recommendation appropriate for outdoor condition.

2.2 DAVIT CRANES

A. General:

1. Manufacturers:

   a. Thern Incorporated (Model 5110)
   b. Or equal

2. Cranes shall have telescopic boom with adjustable height, 500 pound capacity with horizontal boom position and 66 inch hook reach from mast, hand winch with spur gear and automatic disk brake, 36 feet of 1/4-inch diameter stainless steel wire rope and stainless steel hook with latch.

3. Crane shall be portable and break down for transport. Socket base shall allow 360 degree rotation. Crane, winch and socket base shall be stainless steel construction.

   a. Provide 2 pedestal-mount socket bases for Influent Pumps PMP 310001, PMP 310002 as shown on the Drawings.
   b. Provide 2 pedestal-mount socket bases for Pre Anoxic Basin Feed Forward Pumps PMP 040102, PMP 040103, PMP 040202 and PMP 040203 as shown on the Drawings.
   c. Provide 6 pedestal-mount socket bases for Pre Anoxic Basin Mixers MXR 040101 and MXR 040102, Pre Aeration Basin Mixers MXR 050101 and MXR 050201, and Post Anoxic Basin Mixers MXR 060101 and MXR 060201, as shown on the Drawings.
d. Provide 3 davit cranes for PMP 310001, PMP 310002, PMP 040102, PMP 040103, PMP 040202, PMP 040203, MXR 040101, MXR 040102, MXR 050101, MXR 050201, MXR 060101 and MXR 060201. The Owner will move the cranes to equipment locations as needed after installation is complete.

PART 3 - EXECUTION

3.1 GENERAL

A. The equipment specified herein shall be installed in accordance with the supplier’s written installation instructions, as approved by the Engineer. Provide a representative of the manufacturer to inspect the installation and make all necessary adjustments to the equipment for satisfactory operation.

3.2 COATING

A. Per manufacturer’s recommendation for outdoor use.

3.3 FACTORY TESTS

A. Motor Test: Motors shall be tested in accordance with NEMA Standards.

B. Factory Test: Monorail shall be factory tested for proper alignment, quiet operation, proper connection, and satisfactory performance.

C. Provide written certification of these tests to the Engineer prior to shipping the bridge crane.

3.4 MANUFACTURER’S SERVICES

A. The manufacturer shall provide a representative for the equipment specified herein to be present at the job site and/or classroom designated by the Owner for the minimum person-days listed for the service below, travel time excluded;

1. One (1) person-day for installation assistance, certification of the installation, startup, testing, and training.

B. Services shall be at such times as requested by the Owner.

3.5 FIELD TESTS

A. Functional Test: Prior to plant startup, all equipment described herein shall be inspected for proper level, proper alignment, proper connection, and satisfactory operation by means of a functional test.

B. The Contractor and manufacturer’s representative shall conduct field tests with the equipment in its installed position. Tests shall include tests to demonstrate to the Engineer that under the
design conditions the equipment will perform satisfactory throughout the complete range of operation.

C. As a minimum, test by operating the equipment through a complete lift and lowering cycle and through a complete travel of the monorail to determine that the equipment performs smoothly and safely without failure.

D. The Contractor and manufacturer’s representative shall perform a load test. The unit shall be load tested per OSHA requirements.

E. Correct or immediately replace any defects.

3.6 MANUFACTURER’S CERTIFICATE

A. Provide manufacturer’s certificate(s) in accordance with Division 1, General Requirements.

3.7 PREPARATION FOR SHIPMENT, SHIPMENT, AND PROTECTION

A. In addition to the requirements of Division 1, General Requirements, equipment shall be prepared and protected for shipment and shipped as follows:

1. All mechanical connections shall be matchmarked or tagged to ensure proper field assembly.
2. The Contractor shall make arrangements for extra protection until final erection if units are to be stored outside.

END OF SECTION 412223
SECTION 420520 - PIPE HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies hangers and supports for all piping systems

1.2 SUBMITTALS

A. Product Data: Manufacturer's catalog data including load capacity.

B. Shop Drawings: Indicate system layout with location - including critical dimensions, sizes, and pipe hanger and support locations - and detail of trapeze hangers, anchors, and guides.

C. Welders' Certificate: Compliance with AWS D1.1, verifying qualification within previous 12 months.

D. Delegated Design Submittals:
   1. Submit signed and sealed Shop Drawings with design calculations and assumptions for load carrying capacity of trapeze, multiple pipe, and riser support hangers.
   2. Indicate calculations used to determine load carrying capacity of trapeze, multiple pipe, and riser support hangers.
   3. Submit calculations sealed by a Professional Engineer registered in the State of Washington.

E. Qualifications Statements:
   1. Qualifications for manufacturer, fabricator, installer, and licensed professional.
   2. Manufacturer's approval of installer.

1.3 OPERATING CONDITIONS:

A. The hangers and supports specified in this section are provided to resist pipe vertical and horizontal gravity and seismic loads.

B. For the purpose of pipe hanger and support selection, this section establishes pipe support classifications based on the operating temperatures of the piping contents. Pipe support classifications are as follows:
   1. Hot Systems:
      a. 120 degrees F to 450 degrees F (not used)
      b. 451 degrees F to 750 degrees F (not used)
      c. Over 750 degrees F (not used)
2. Ambient Systems:
   a. 60 degrees F to 119 degrees F.

3. Cold Systems:
   a. 33 degrees F to 59 degrees F.
   b. -20 degrees F to 32 degrees F (not used)

C. For the purpose of material section, spaces are classified as:
   1. Dry Service Environment including offices, pipe galleries.
   2. Wet/Corrosive Service Environment including wetwells, wastewater tank and channels.

1.4 HANGER AND SUPPORT SELECTION

A. Select pipe hangers and supports as specified. Selections shall be based upon the pipe support classifications specified in this section and the piping insulation thickness specified in Section 424213 “Process Piping Insulation”, and any special requirements which may be specified. Materials shall be based on the service environment.

B. Review the piping layout in relation to the surrounding structure and adjacent piping and equipment before selecting the type of support to be used at each hanger point.

C. Hangers and supports shall withstand all static and specified dynamic conditions of loading to which the piping and associated equipment may be subjected. As a minimum, consideration shall be given to the following conditions:

1. Weights of pipe, valves, fittings, insulating materials, suspended hanger components, and normal fluid contents.
2. Weight of hydrostatic test fluid or cleaning fluid if normal operating fluid contents are lighter.
3. Reaction forces due to the operation of safety or relief valves.
4. Wind, snow or ice loadings on outdoor piping.
5. Seismic loadings per Section 420520.1 “Seismic Anchorage and Bracing”.

D. Hangers and supports shall be sized to fit the outside diameter of pipe, tubing, or, where specified, the outside diameter of insulation.

E. Where negligible movement occurs at hanger locations, rod hangers shall be used for suspended lines, wherever practical. For piping supported from below, bases, brackets or structural cross members shall be used.

F. Hangers for the suspension of size 2-1/2 inches and larger pipe and tubing shall be capable of vertical hanger component adjustment under load.

G. The supporting systems shall provide for and control the free or intended movement of the piping including its movement in relation to that of connected equipment.
H. Where there is horizontal movement at a suspended type hanger location, hanger components shall be selected to allow for swing. The vertical angle of the hanger rod shall not, at any time, exceed 4 degrees.

I. There shall be no contact between a pipe and hanger or support component of dissimilar metals. Prevent contact between dissimilar metals when supporting copper tubing by use of copper-plated, rubber, plastic or vinyl coated, or stainless steel hanger and support components.

J. Unless otherwise indicated, existing pipes and supports shall not be used to support new piping.

K. Unless otherwise indicated, pipe support components shall not be attached to pressure vessels.

L. Stock hanger and support components shall be used wherever practical.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pipe support components shall conform to the requirements of MSS SP-69 and FEDSPEC WW-H-171e.

B. Pipe support materials shall conform to the requirements of MSS SP-58.

C. Metal framing system components shall conform to the Metal Framing Manufacturer's Association standard MFMA-2.

D. For system compatibility, support clips and attachments shall be compatible with the following:

   1. Acceptable manufacturer:
      2. B-Line.
      3. Unistrut.
      4. Approved equal.

2.2 MATERIALS

A. Service Environment: Pipe hangers and supports, structural attachments, fittings and accessories:

   1. Dry Service Environment: Zinc plated or mechanically galvanized after fabrication. Nuts, bolts and washers: galvanized or zinc-plated.
   2. Wet or Corrosive Environment: type 304 or 316 stainless steel. Nuts, bolts and washers: stainless.

B. Pipe Hangers and Supports:

   1. Type 1 - Clevis Pipe Hanger: Carbon steel with configuration and components equivalent to MSS and FEDSPEC Type 1.

      a. Steel pipe (uninsulated):
1) B-Line B3100.
2) Grinnell Fig. 260.
3) Approved equal.

b. Steel pipe (insulated):

1) Clevis pipe hanger shall be as described in this Section, with insulation shield.

c. Cast and ductile iron pipe:

1) B-Line B3102.
2) Grinnell Fig. 590.
3) Approved equal.

d. Copper pipe (uninsulated):

1) B-Line B3104 CT.
2) Grinnell Fig. CT-65.
3) Approved equal.

e. Copper pipe (insulated):

1) Clevis pipe hanger shall be as described in this Section, with insulation shield.

f. Plastic pipe:

1) B-Line B3100 C.
2) Carpenter & Patterson Fig. 100PVC.
3) Approved equal.

2. Type 2 - “J” Pipe Hanger: Carbon steel with configuration and components equivalent to MSS Type 5. This hanger shall be used only on uninsulated pipe.

a. Steel pipe: (uninsulated)

1) B-Line B3690.
2) Grinnell Fig. 67.
3) Michigan model 418.
4) Approved equal.

b. Copper and plastic pipe:

1) Michigan model 419.
2) Unistrut J 1205N series.
3) Approved equal.

3. Type 3 - Double Bolt Pipe Clamp: Carbon steel, with configuration and components equivalent to MSS and FEDSPEC Type 3.

a. Steel pipe (uninsulated):
1) B-Line B3144.
2) Grinnell Fig. 295.
3) Approved equal.

b. Steel pipe (insulated):

1) Double bolt pipe clamp shall be as described in this Section, with insulation shield. Insulation shield is optional for hot and ambient systems.

c. Copper pipe (insulated only):

1) Double bolt pipe clamp shall be as described in this Section, with insulation shield.

4. Type 4 - Adjustable Roller Hanger: Rollers shall be cast iron. Yoke and cross bolt shall be carbon steel. Configuration and components shall be equivalent to MSS Type 43 and FEDSPEC Type 44.

a. Steel pipe (uninsulated):

1) B-Line B3110.
2) Grinnell Fig. 181.
3) Approved equal.

b. Steel pipe (insulated):

1) Adjustable roller hanger shall be as described in this Section, with insulation shield.

c. Copper pipe (insulated only):

1) Adjustable roller hanger shall be as described in this Section, with insulation shield.

d. Plastic pipe:

1) B-Line B3110.
2) Grinnell Fig. 181.
3) Approved equal.

5. Type 5 - Single Pipe Roll: Rollers and sockets shall be cast iron. Cross rod shall be steel. Configuration and components shall be equivalent to MSS Type 41 and FEDSPEC Type 42.

a. Steel pipe (uninsulated):

1) B-Line B3114.
2) Grinnell Fig. 171.
3) Approved equal.

b. Steel pipe (insulated):

1) Single pipe roll shall be as described in this Section, with insulation shield.
c. Plastic pipe:
   1) B-Line B3114.
   2) Grinnell Fig. 171.
   3) Approved equal.

6. Type 6 - Framing Channel Pipe Clamp: Pipe clamps shall be steel with galvanized finish.
   a. Steel pipe (uninsulated):
      1) Material thickness:

<table>
<thead>
<tr>
<th>Pipe size</th>
<th>Material thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch and 1/2 inch</td>
<td>16 gage</td>
</tr>
<tr>
<td>3/4 inch through 1-1/4 inches</td>
<td>14 gage</td>
</tr>
<tr>
<td>1-1/2 inches through 3 inches</td>
<td>12 gage</td>
</tr>
<tr>
<td>3-1/2 inches through 5 inches</td>
<td>11 gage</td>
</tr>
<tr>
<td>6 inches and 8 inches</td>
<td>10 gage</td>
</tr>
</tbody>
</table>

   2) Acceptable manufacturer:
      a) Michigan model 431.
      b) Powerstrut PS 1100.
      c) Unistrut P 1109 series.
      d) Approved equal.

   b. Steel pipe (insulated):
      1) Pipe clamp shall be as described in this Section with insulation shield.

   c. Copper (uninsulated) and plastic pipe:
      1) Material thickness:

<table>
<thead>
<tr>
<th>Pipe size</th>
<th>Material thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch and 1 inch</td>
<td>16 gage</td>
</tr>
<tr>
<td>1-1/4 inches and 1-1/2 inches</td>
<td>14 gage</td>
</tr>
<tr>
<td>2 inches through 3 inches</td>
<td>12 gage</td>
</tr>
<tr>
<td>4 inches</td>
<td>11 gage</td>
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</tbody>
</table>

   2) Clamp shall be copper-plated, plastic coated or lined with dielectric material.
   3) Acceptable manufacturer:
      a) Michigan model 432.
      b) Powerstrut PS 1200.
      c) Unistrut P 2024C and P 2024PC series.
      d) Approved equal.
d. Copper pipe (insulated):
   1) Pipe clamp shall be as described in this Section with insulation shield.

7. Type 7 - U-Bolt: Carbon steel with configuration equivalent to MSS and FEDSPEC Type 24.

   a. Steel pipe (uninsulated):
      1) Grinnell Fig. 137.
      2) B-Line B3188.
      3) Approved equal.

   b. Steel pipe (insulated):
      1) U-bolt shall be as described in this Section with insulation shield.

   c. Cast and ductile iron pipe:
      1) Grinnell Fig. 137.
      2) B-Line B3188.
      3) Approved equal.

   d. Copper pipe (uninsulated):
      1) Carpenter & Patterson Fig. 222 CT.
      2) B-Line B3501 CT.
      3) Approved equal.

   e. Copper pipe (insulated):
      1) U-bolt shall be as described in this Section with insulation shield.

   f. Plastic pipe:
      1) Grinnell Fig. 137C.
      2) Michigan model 151.
      3) B-Line B3188 C.
      4) Approved equal.

8. Type 8 - Adjustable Pipe Roll Support: Rollers and sockets shall be cast iron. Cross rod and support rods shall be carbon steel.

   a. Steel pipe (uninsulated):
      1) B-Line B3122.
      2) Grinnell Fig. 177.
      3) Approved equal.
b. Steel pipe (insulated):
   1) Adjustable pipe roll support shall be as described in this Section with insulation shield.

c. Copper pipe (insulated only):
   1) Adjustable pipe roll support shall be as described in this Section with insulation shield.

d. Plastic pipe:
   1) B-Line B3122.
   2) Grinnell Fig. 177.
   3) Approved equal.

9. Type 9 - Welded Pipe Stanchion: Minimum material thickness shall be standard schedule carbon steel pipe, cut to match contour of the pipe elbow. Use of this support shall be limited to ambient systems only.

10. Type 10 - Pipe Stanchion Saddle: Saddles and yokes shall be carbon steel and comply with MSS Type 37 and FEDSPEC Type 38.

   a. Steel pipe (uninsulated):
      1) Carpenter & Patterson Fig. 125.
      2) B-Line B3090.
      3) Approved equal.

   b. Steel pipe (insulated):
      1) Pipe stanchion saddle shall be as described in this Section with insulation shield.

   c. Cast and ductile iron pipe:
      1) Carpenter & Patterson Fig. 125.
      2) B-Line B3090 NS.
      3) Approved equal.

   d. Copper pipe (uninsulated):
      1) Pipe stanchion saddle shall be as described in this Section with insulation shield or lined with dielectric material.

   e. Copper pipe (insulated):
      1) Pipe stanchion saddle shall be as described in this Section with insulation shield.

   f. Plastic pipe:
      1) Carpenter & Patterson Fig. 125.
2) B-Line B3090.
3) Approved equal.

11. Type 11 - Offset Pipe Clamp:

a. Shall be carbon steel with configuration and components as specified. Shall be of standard design manufactured by a pipe hanger component manufacturer.

1) Steel pipe (uninsulated):
   a) B-Line B3148.
   b) Grinnell Fig. 103.
   c) Approved equal.

2) Steel pipe (insulated):
   a) Offset pipe clamp shall be as described in this Section, with insulation shield.

3) Cast and ductile iron pipe:
   a) B-Line B3148 NS.
   b) Grinnell Fig. 103.
   c) Approved equal.

4) Copper pipe (insulated):
   a) Offset pipe clamp shall be as described in this Section, with insulation shield.

5) Copper pipe (uninsulated):
   a) Offset pipe clamp shall be as described in this Section, lined with dielectric material.

6) Plastic pipe - shall be B-Line B3148, Grinnell Fig. 103, or equal.
   a) B-Line B3148.
   b) Grinnell Fig. 103.
   c) Approved equal.

b. Vertical pipe support applications shall be as specified above except that insulation shields shall not be used for insulated pipe.

12. Type 12 - Riser Clamp: Shall be carbon steel with configuration and components equivalent to MSS and FEDSPEC Type 8.

a. Steel pipe (insulated):
   1) B-Line B3373.
   2) Grinnell Fig. 261.
   3) Approved equal.
b. Steel pipe (uninsulated):
   1) B-Line B3373.
   2) Grinnell Fig. 261.
   3) Approved equal.

c. Cast and ductile iron pipe:
   1) B-Line B3373.
   2) Grinnell Fig. 261.
   3) Approved equal.

d. Copper pipe (insulated):
   1) B-Line B3373 CT.
   2) Grinnell Fig. CT-121.
   3) Michigan model 511.
   4) Approved equal.

e. Copper pipe (uninsulated):
   1) B-Line B3373 CT.
   2) Grinnell Fig. CT-121.
   3) Michigan model 511.
   4) Approved equal.

f. Plastic pipe:
   1) B-Line B3373.
   2) Grinnell Fig. 261c.
   3) Approved equal.

13. Type 13 - Framing Channel Pipe Strap: Shall be carbon steel, with configuration equivalent to MSS Type 26.

   a. Steel pipe (uninsulated):
      1) Superstrut No. C-708-U.
      2) Powerstrut PS 3126.
      3) Kin-Line No. 477.
      4) Approved equal.

   b. Steel pipe (insulated):
      1) Framing channel pipe strap shall be as described in this Section with insulation shield.

   c. Copper pipe (uninsulated):
      1) Framing channel pipe strap shall be as described in this Section with insulation shield or lined with dielectric material.
d. Copper pipe (insulated):

1) Framing channel pipe strap shall be as described in this Section with insulation shield.

e. Plastic pipe:

1) Superstrut No. C-708-U.
2) Powerstrut PS 3126.
3) Kin-Line No. 477.
4) Approved equal.

C. Rack and Trapeze Supports:

1. General: Unless otherwise indicated, trapeze and pipe rack components shall have a minimum steel thickness of 12 gage, or a minimum fiberglass thickness of 0.200 inch, with a maximum deflection 1/240 of the span.

2. Type 20 - Trapeze Pipe Support: Trapeze pipe support cross members shall be framing channel, or fiberglass where specified, as specified in this Section E.5. Flat plate fittings shall be 1-5/8 inch square carbon steel of standard design manufactured by framing channel manufacturer.

a. Acceptable manufacturer:

1) Unistrut P2471.
2) B-Line B202-2.
3) Aickinstrut 2000 series.
4) Approved equal.

3. Types 21 and 22 - Pipe Rack Supports: Post and cross members shall be framing channel as specified in this Section. Pipe rack fittings shall be carbon steel, of standard design manufactured by framing channel manufacturer. Ninety-degree fittings shall be gusseted. Post base fittings shall be as specified in this Section.

a. Acceptable manufacturer:

1) Unistrut P2484.
2) B-Line B844.
3) Approved equal.

D. Structural Attachments:

1. Type A - Malleable Iron Concrete Insert: Concrete inserts shall be malleable iron and comply with MSS and FEDSPEC Type 18.

a. Acceptable manufacturer:

1) Grinnell Fig. 282.
2) Carpenter & Patterson Fig. 108.
3) Approved equal.
2. Type B - Side Beam Bracket: Bracket shall be malleable iron and comply with MSS Type 34 and FEDSPEC Type 35.
   a. Acceptable manufacturer:
      1) Grinnell Fig. 202.
      2) B-Line B3062.
      3) Approved equal.

3. Type C - Malleable Beam Clamp With Extension Piece: Clamp and extension piece shall be malleable iron. Tie rod shall be steel. Beam clamp shall comply with MSS and FEDSPEC Type 30.
   a. Acceptable manufacturer:
      1) Grinnell Fig. 218 with Fig. 157 extension piece.
      2) B-Line B3054.
      3) Approved equal.

4. Type D - Steel Beam Clamp With Eye Nut: Beam clamp and eye nut shall be forged steel. Configuration and components shall comply with MSS and FEDSPEC Type 28.
   a. Acceptable manufacturer:
      1) Grinnell Fig. 292.
      2) Carpenter & Patterson Fig. 297.
      3) Approved equal.

5. Type E - Framing Channel Post Base: Post bases shall be carbon steel, and of standard design manufactured by framing channel manufacturer.
   a. Single channels:
      1) Unistrut P 2072A.
      2) B-Line B280.
      3) Approved equal.
   b. Double channels:
      1) Unistrut P 2073A.
      2) B-Line B281.
      3) Approved equal.

6. Type F - Welded Beam Attachment: Beam attachment shall be carbon steel and comply with MSS and FEDSPEC Type 22.
   a. Acceptable manufacturer:
      1) B-Line B3083.
      2) Grinnell Fig. 66.
      3) Approved equal.
7. Type G - Welded Steel Bracket:
   a. Bracket shall be carbon steel.
   b. Medium welded bracket shall comply with MSS Type 32 and FEDSPEC Type 33.
   c. Heavy welded bracket shall comply with MSS Type 33 and FEDSPEC Type 34.

8. Type H - Cast Iron Bracket:  Bracket shall be cast iron.
   a. Acceptable manufacturer:
      1) Carpenter & Patterson Fig. 340.
      2) Grinnell.
      3) Approved equal.

9. Type J - Adjustable Beam Attachment: Beam attachment shall be carbon steel.
   a. Acceptable manufacturer:
      1) Carpenter & Patterson Fig. 151.
      2) B-Line B3082.
      3) Approved equal.

10. Type K - Double Channel Bracket:
    a. Wall channel shall be single framing channel, or fiberglass where specified, as specified in this Section.
    b. Cantilever bracket shall be a carbon steel double framing channel assembly.
       1) Acceptable manufacturer:
          a) Unistrut P2542 through P2546.
          b) B-Line B297-12 through B297-36.
          c) Aickinstrut 2000 series.
          d) Approved equal.

11. Type L - Single Channel Bracket:
    a. Wall channel shall be single framing channel, or fiberglass where specified, as specified in this Section.
    b. Cantilever bracket shall be a carbon steel single framing channel assembly.
       1) Acceptable manufacturer:
          a) Unistrut P2231 through P2234.
          b) B-Line B198-6, B198-12, B196-18 and B196-24.
          c) Aickinstrut 2000 series.
          d) Approved equal.

12. Type M - Wall Mounted Channel: Wall channel shall be single framing channel, or fiberglass where specified, as specified in this Section.

13. Type N - Pipe Stanchion Floor Attachment: Baseplate shall be carbon steel with 1/2 inch minimum thickness. Anchor bolt holes shall be 1/16 inch larger than the anchor bolt
diameter. The space between the baseplate and the floor shall be filled with nonshrink grout.

E. Accessories:

1. Hanger Rods: Rods shall be carbon steel or as specified on the Drawings, threaded on both ends or continuous threaded and sized as specified.

2. Weldless Eye Nut: Eye nut shall be forged steel and shall comply with MSS and FEDSPEC Type 17.
   
   a. Acceptable manufacturer:
      
      1) Grinnell Fig. 290.
      2) B-Line B3200.
      3) Approved equal.

3. Welded Eye Rod: Eye rod shall be carbon steel or as specified on the Drawings with eye welded closed. Inside diameter of eye shall accommodate a bolt diameter 1/8 inch larger than the rod diameter.
   
   a. Acceptable manufacturer:
      
      1) Grinnell Fig. 278.
      2) B-Line B3211.
      3) Approved equal.

4. Turnbuckle: Turnbuckle shall be forged steel or as specified on the Drawings and shall comply with MSS and FEDSPEC Type 15.
   
   a. Acceptable manufacturer:
      
      1) Grinnell Fig. 230.
      2) B-Line B3202.
      3) Approved equal.

5. Framing Channel:
   
   a. Framing channel shall be 1-5/8 inches square, roll formed, 12-gage carbon steel or as specified on the Drawings. Channel shall have a continuous slot along one side with in-turned clamping ridges.
      
      1) Single channel:
         
         a) Unistrut P 1000.
         b) B-Line B22.
         c) Approved equal.

      2) Double channel:
         
         a) Unistrut P 1001.
         b) B-Line B22A.
         c) Approved equal.
3) Triple channel:
   a) Unistrut P 1004A.
   b) B-Line B22X.
   c) Approved equal.

b. Embedded concrete insert framing channel shall be 1-5/8 inch wide by 1-3/8 inch deep. Provide end caps or end anchors as recommended by the manufacturer.
   1) Embedded concrete insert framing channel:
      a) Unistrut P 3200 series.
      b) B-Line B32I series.
      c) Approved equal.
   2) End caps or end anchors:
      a) Unistrut P 3280 or P 3704.
      b) B-Line B206 or B3332.
      c) Approved equal.

F. Fiberglass Framing Channel: Framing channel shall be 1-5/8 inches square, pultrusion formed, fiberglass reinforced plastic with 0.200-inch wall thickness. Channel shall have a continuous slot along one side with in-turned clamping ridges, as manufactured by Aickin Corporation, Aickinstrut 2000 series.

2.3 THERMAL PIPE HANGER SHIELD

A. General:
   1. Thermal shields shall be provided at hanger, support and guide locations on pipe requiring insulation.
   2. The shield shall consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer.
   3. The thermal shield shall be the same thickness as the piping system insulation specified in Section 15260.
   4. The standard shield shall be used for hot systems and the vapor barrier shield shall be used for cold systems.
   5. Stainless steel band clamps shall be used where specified to ensure against slippage between the pipe wall and the thermal shield.

B. Standard Shield:
   1. Insulation:
      a. Hydrous calcium silicate, high density, waterproof.
      b. Compressive strength: 100 psi average.
      c. Flexural strength: 75 psi average.
      d. K factor: 0.38 at 100 degrees F mean.
      e. Temperature range: 20 degrees F to 500 degrees F.
2. Steel Jacket: Galvanized steel. Gage shall be the manufacturer's standard supplied for the given pipe size.
3. Connection: Shield shall have butt connection to pipe insulation. Steel jacket and insulation shall be flush with end.

C. Vapor Barrier Shield:
   1. Insulation:
      a. Hydrous calcium silicate, high density, waterproof.
      b. Compressive strength: 100 psi average.
      c. Flexural strength: 75 psi average.
      d. K factor: 0.38 at 100 degrees F mean.
      e. Temperature range: 20 degrees F to 500 degrees F.

2. Steel Jacket: Galvanized steel. Gage shall be the manufacturer's standard supplied for the given pipe size.
3. Connection: Shield shall have butt connection to pipe insulation. Insulation shall extend 1 inch each side of steel jacket for vapor tight connection to pipe insulation vapor barrier.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT LOCATIONS

A. Locate hangers and supports as near as possible to concentrated loads such as valves, flanges, etc. Locate hangers, supports and accessories within the maximum span lengths specified in the Drawings to support continuous pipeline runs unaffected by concentrated loads.

B. Locate at least one hanger or support within 2 feet from a pipe change in direction.

C. For any valve 6 inches in size and greater, locate at least one hanger or support within 2 feet in either direction of the valve.

D. Locate hangers and supports to ensure that connections to equipment, tanks, etc., are substantially free from loads transmitted by the piping.

E. Where piping is connected to equipment, a valve, piping assembly, etc., which require removal for maintenance, the piping shall be supported in such a manner that temporary supports are not necessary for this procedure.

F. Pipe shall not have pockets formed in the span due to sagging of the pipe between supports caused by the weight of the pipe, medium in the pipe, insulation, valves and fittings.

G. Pipes shall be supported from the ceiling wherever practical and walkways below kept clear.
3.2 INSTALLATION

A. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of AISC M011. Unless otherwise indicated, do not drill or burn holes in the building structural steel.

B. Do not use hanger components for purposes other than that for which they were designed. Do not use them for rigging and erection purposes.

C. Install items to be embedded before concrete is poured. Fasten embedded items securely to prevent movement when concrete is poured.

D. Inserts:
   1. Install inserts for placement in concrete forms.
   2. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
   3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 in and larger.
   4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
   5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

E. Use embedded anchor bolts instead of concrete inserts for support installations in areas below water surface or areas normally subject to submerging.

F. Install thermal pipe hanger shields on insulated piping at required locations during hanger and support installation. Make butt joint connections to pipe insulation at the time of insulation installation in accordance with the manufacturer's recommendations.

G. Hanger and support components in contact with plastic pipe shall be free of burrs and sharp edges.

H. Rollers shall roll freely without binding.

I. Prior to grouting, rough finished floor beneath Type N structural attachments and framing channel post bases. Grout between base plate and floor shall be free of voids and foreign material.

J. Cut and drill baseplates to specified dimensions prior to welding stanchions or other attachments and prior to setting anchor bolts.

K. Provide plastic or rubber end caps at the exposed ends of all framing channels that are located up to 7 feet above the floor.
3.3 ADJUSTMENTS

A. Adjust hangers and supports to obtain required pipe slope and elevation. Shims made of material that is compatible with the piping material may be used. Adjust stanchions prior to grouting their baseplates.

END OF SECTION 420520
SECTION 420520.1 - SEISMIC ANCHORAGE AND BRACING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies the seismic anchorage and bracing requirements for mounted and suspended piping and equipment over 200 pounds.

B. This Section specifies engineered design requirements for seismic anchorage and bracing for installation of piping equipment over 400 pounds.

1.2 QUALITY ASSURANCE

A. Reference Standards: This Section incorporates by reference the latest revisions of the following documents. They are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBC</td>
<td>International Building Code</td>
</tr>
<tr>
<td>ASCE 7-05</td>
<td>Minimum Design Loads for Building Structures</td>
</tr>
<tr>
<td>SBC</td>
<td>Seattle Building Code</td>
</tr>
<tr>
<td>SMACNA</td>
<td>Seismic Restraint Manual Guidelines for Mechanical Equipment</td>
</tr>
</tbody>
</table>

1.3 SUBMITTALS

A. List of freestanding equipment weighing 200 pounds or more.

B. Anchorage details for all equipment and freestanding items weighing between 200 and 400 pounds.

C. Sway bracing for elevated or suspended items such as ceiling systems, ducting, conduits, cable trays and piping.

D. Engineered design:

1. Anchorage and bracing drawings and calculations prepared, stamped, dated and signed by a Professional Engineer licensed in the state of Washington.

2. Criteria used to determine seismic coefficients and forces applied to the equipment.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

A. In accordance with IBC and local code, whichever is more stringent, all equipment shall be anchored and braced to resist seismic forces prescribed in the code and ASCE 7.

B. Design of seismic anchorage and bracing for equipment shall use site-specific seismic criteria.
1.5 SITE SEISMIC CRITERIA

A. Per Drawings.

B. Component Amplification Factor: ASCE 7, Table 13.6-1.

C. Component Response Modification Factor: ASCE 7, Table 13.6-1.

END OF SECTION 420520.1
SECTION 420553 – IDENTIFICATION FOR PROCESS PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES
   A. This Section includes the following Process identification materials and their installation:
      1. Equipment nameplates.
      2. Equipment markers.
      3. Equipment signs.
      4. Access panel and door markers.
      5. Pipe markers.

1.2 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Valve numbering scheme.
   C. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.3 QUALITY ASSURANCE

1.4 COORDINATION
   A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
   B. Coordinate installation of identifying devices with location of access panels and doors.
   C. Install identifying devices before installing acoustical ceilings and similar concealment.
PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:
   a. Manufacturer, product name, model number, and serial number.
   b. Capacity, operating and power characteristics, and essential data.
   c. Labels of tested compliances.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.
2. Data:
   a. Equipment Name or identifying number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.

C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Data: Instructions for operation of equipment and for safety procedures.
2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
3. Thickness: 1/8 inch, unless otherwise indicated.
4. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

D. Access Panel and Door Markers: 1/16-inch-thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

A. Plastic coding markers:
1. Plastic markers for coding pipe shall comply with ASME A13.1. Markers shall be the pre-coiled type that is easily removable. Markers shall be resistant to petroleum based oils and grease and shall meet criteria for humidity, solar radiation, rain, salt, fog and leakage fungus as specified by MIL-STD-810 and shall withstand a continuous operating temperature range of -40 to 250 degrees F. Markers shall not be the individual letter type but shall be manufactured and applied in one continuous length of plastic including directional arrows. Legends and arrows shall be subsurface printed on polyester and over-laminated with Tedlar. Marking Services Style MS-995, Brady Style B-915 or approved equal.

2. Minimum marker lengths and letter heights:

<table>
<thead>
<tr>
<th>Outside Diameter of Pipe or Covering</th>
<th>Minimum Length of Marker</th>
<th>Minimum Height of Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1-1/2-inch</td>
<td>8 inches</td>
<td>1/2-inch</td>
</tr>
<tr>
<td>1-1/2-inch through 3 inches</td>
<td>8 inches</td>
<td>1-1/8 inches</td>
</tr>
<tr>
<td>Greater than 3 inches</td>
<td>12 inches</td>
<td>2-1/4 inches</td>
</tr>
</tbody>
</table>

* Outside diameter shall include insulation and protective wrapping.

3. In addition, pipe markers shall include uni- and bidirectional arrows in the same sizes and colors as the legend.

4. Pipe Color:
   a. Color shall as specified in Section 422700 “Process Piping – General”.
   b. Legends and arrow color shall match existing or shall be white on blue or red backgrounds; black on all other backgrounds.

B. Tracer tape:
   1. Tracer tape shall be 6 inches wide, and made of inert plastic material suitable for direct burial.
   2. Magnetic tracer tape shall be 2 inches wide, and made of inert plastic material suitable for direct burial.
   3. A message shall be printed on the tape.
      a. The message shall read “Caution Caution Caution – Pipe Buried Below” with bold letters approximately 2 inches high for tracer tape and approximately 1 1/4 inches high for magnetic tracer tape.
      b. The blank shall be filled with the name of particular system fluid.
      c. The message shall be printed at maximum intervals of 2 feet.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in Division 42, 43 and 46 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.
3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of Plumbing equipment that does not have nameplate nor has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Pumps and similar motor-driven units.
2. Heat exchangers, coils, and similar equipment.
3. Tanks and pressure vessels.
4. Strainers and similar equipment.

B. Install equipment markers with permanent adhesive on or near each major item of Plumbing equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
   a. Main control and operating valves, including safety devices.
   b. Meters, gages, thermometers, and similar units.
   c. Pumps and similar motor-driven units.
   d. Tanks and pressure vessels.
   e. Strainers, filters, water heaters, water-treatment systems, and similar equipment.

C. Install equipment signs with screws or permanent adhesive on or near each major item of Plumbing equipment. Locate signs where accessible and visible.

1. Identify Plumbing equipment with equipment markers in the following color codes:
   a. Blue: For domestic water equipment and components.
   b. Brown: For process equipment.

2. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
4. Include signs for the following general categories of equipment:
   a. Main control and operating valves, including safety devices.
   b. Pumps and similar motor-driven units.
c. Heat exchangers, coil, and similar equipment.
d. Tanks and pressure vessels.
e. Strainers and similar equipment.

D. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, Less Than 6 Inches: Pretensioned pipe markers. Use appropriate size to ensure a tight fit for self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:

1. Near each valve and control device.
2. Near each branch connection and intersection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. East side of penetrations through walls, floors, ceilings, and nonaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

3.4 ADJUSTING

A. Relocate Plumbing identification materials and devices that have become visually blocked by other work.

3.5 CLEANING

A. Clean faces of Plumbing identification devices and glass frames of valve schedules.

END OF SECTION 420553
SECTION 422700 – PROCESS PIPING - GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

2. Table A - Piping Schedule

1.2 RELATED SECTIONS

A. General Requirements:

1. This section includes general requirements for all piping. See individual piping Specification for piping material and additional requirements.

B. Related Specification Sections:

1. Section 420520 “Pipe Hangers and Supports”
2. Section 420553 “Identification for Process Piping”
3. Section 422702 “Process Piping Specialties”
4. Section 424213 “Process Piping Insulation”
5. Section 424214 “Electric Heat Trace”
6. Section 099600 “High-Performance Coatings”

1.3 SUBMITTALS

A. Product Data: Manufacturer's catalog information on pipe materials and fittings. Individual submittals shall be marked to indicate each system where the piping item is to be used.

B. Shop Drawings: Piping layouts and layout schedule by area showing pipeline locations for all piping systems in that area with respect to structures, other piping and utilities (ductwork, conduits, etc.) and details and location of joints, anchors, supports, fittings, connections, penetrations, supports, valves, piping appurtenances, flexible couplings, manholes, and cleanouts as applicable. Drawings shall be original layouts by the Contractor; photocopies of contract drawings are not acceptable. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

C. Field Measurements: Verify field measurements prior to fabrication of pipe and fittings. Indicate field measurements on Shop Drawings.

D. Manufacturer's Certificate: Products meet or exceed specified requirements.
E. Source Quality-Control Submittals: Indicate results of shop or factory tests and inspections. Include certified copies of all tests required by the standards for the manufacture of pipe, fittings, coatings, valves, and pipe supports.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Qualifications Statements: Qualifications for manufacturer, installer, and licensed professional.

H. Delegated Design for Joint Restraint: Provide restrained joint anchorage calculations where restrained joints are required.

I. Installation Instructions: Manufacturer’s printed instructions for installation of each type and size of pipe, fitting, and appurtenance.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents:
   1. Record actual locations of piping, valves and other appurtenances, connections, and invert elevations.
   2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Tools: Provide special tools as required for Owner to maintain.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Pipe schedule, including system legend of each service are specified in Table A – Piping Schedule. See Drawings for pipe size.

B. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings and coatings, shall be selected from those listed on the piping system specification sheets. Piping materials shall conform to detailed specifications for each type of pipe.

C. Where temporary piping and valving are required, piping material and accessories shall be selected by the Contractor. Such piping shall be suitable for operation at the test pressure and maximum range of operating service temperature of the permanent piping system which the temporary piping is replacing, as specified in Table 1 – Piping Schedule. Plastic, steel, RCP, ductile iron, and polyethylene pipe may all be used at the Contractor's discretion. Temporary piping shall be provided with supports at intervals which prevent sagging or liquid accumulation.
PART 3 - EXECUTION

3.1 PIPING IDENTIFICATION

A. Pipe coding and marking shall be as specified in Section 420553 “Identification for Process Piping and Equipment.”
   1. Plastic coding markers: Provide for all piping.
   2. Pipe color: Per Table A – Piping Schedule
   3. Tracer tape: Provide for all buried piping.

3.2 EXAMINATION

A. Verify that field dimensions are as indicated on Drawings.
B. Inspect existing flanges for nonstandard bolt hole configurations or design, and verify that new pipe and flange mate properly.

3.3 CONTRACT DRAWINGS

A. The contract drawings indicate the general design, arrangement and extent of piping systems. The indicated positions shall be followed as closely as possible. Do not scale drawings for roughing in measurements nor use as shop drawings. Prepare shop drawings per “Submittals,” specified herein. The exact location of various items are subject to building construction, and the actual materials and equipment furnished. Verify the location of items to be furnished, installed, or connected. Coordinate work with other specification sections and divisions.
B. Piping systems shall be located from dimensions given on drawings or implied locations shall be determined at the building site after field measurements have been taken.
C. Should interferences or discrepancies prevent the installation of any part of the work, the Engineer shall be notified and the Engineer will determine the steps necessary to complete the true development of the intent of the drawings and specifications.

3.4 INSTALLATION

A. General: The types and sizes of pipes to be used shall be as specified and shown. Where sizes or locations of small pipe are omitted from the drawings and not mentioned in the specifications, the sizes to be used shall correspond to the latest edition of the Uniform Plumbing Code requirements. In any event, undesignated pipe shall be proper for the functions to be performed and as accepted by the Engineer. Installation shall be in accordance with the manufacturer's written manual.
   1. Location: Piping shall be provided as specified except for adjustments to avoid architectural and structural features and shall be coordinated with electrical construction. Piping installed adjacent to equipment and machines shall be located to allow for service and maintenance.
2. Joint: Takedown couplings shall be provided for all piping systems. Takedown couplings shall be provided both around equipment and at standard pipe lengths for all straight runs of pipe. Continuous welding for straight runs of pipe is acceptable only where the individual Specification allows welding as a connection option. Where connections are shown, the connections shall be specifically where shown; however, if several connection options are allowed for the particular piping system on the individual pipe Specification, then any option may be consistently used; i.e., if flanged or grooved are acceptable and flanged are shown, then grooved may be substituted. Integrity of rigid, non-rotating connections must be maintained at all valves and other equipment.

3. Provide flanged coupling adapters where indicated on Drawings, and where needed for assembly.

4. Unless otherwise specified, the crowns of all buried pipe shall be at least 30 inches below finished grade. Pipes with less than 30 inches of cover at roadways and driving surfaces shall be encased in concrete.

5. All pipe shall be carefully placed and supported at the proper lines and grades, and where possible shall be sloped to permit complete drainage. Piping runs shown on the drawings shall be followed as closely as possible, except for minor adjustments to avoid equipment, architectural, and structural features. If major relocations are required, they shall be acceptable to the Engineer.

6. In erecting the pipe a sufficient number of screw unions, flanged or grooved end type joints shall be used to allow any section or run of pipe to be disconnected without taking down adjacent runs. Flanged and mechanical pipe coupling joints shall be employed on pipelines 3 inches in diameter and larger. The provision of an adequate number of appropriate take-down fittings must be rigidly adhered to whether or not such fittings are indicated on the drawings. Take-down fittings shall also be provided for removal of valves and other appurtenances. Where piping passes through concrete or masonry walls, take-down fittings shall be employed as near the wall as possible. Dielectric unions shall be used at all locations to join pipe or equipment of dissimilar metals. Eccentric reducers shall be used to keep the top of piping at pump suction level.

7. Unless otherwise specified, all pipes passing from concrete or steel to earth shall be provided with a flexible coupling. Wherever a metallic pipe 1 inch in diameter or larger passes from concrete to earth horizontally, 2 flexible pipe couplings spaced from 2 feet to 4 feet apart depending on pipe size shall be installed, whether shown or not. Only one flexible pipe coupling is required on vertical runs from the Structure. One coupling shall be within 1 foot of the structure. Particular care shall be taken to ensure a full support of the pipe in the earth between and beyond the joints.

8. All pressure taps on the suction and discharge sides of all pumps, blowers, and compressors shall be provided with ball valves unless otherwise shown. Provide taps in all piping for flow switches, pressure switches, etc., as required, to match instrumentation drawings. Taps to be a minimum diameter of 3/4 inch with bushings for smaller sizes. For taps larger than 3/4 inch, tap actual size to be coordinated with electrical instrumentation.

9. Unless otherwise specified, the suction and discharge of all pumps, blowers, fans, and compressors shall be provided with flexible couplings suitable for the intended service.

B. Pipe supports

1. See Section 420520 “Pipe Hangers and Supports”

C. Installation at concrete walls and footings
1. Whenever a pipeline of any material terminates at, or extends through, a structural wall or sump, the Contractor shall install in advance of pouring of concrete the fittings, sleeves or special casting required for the particular installation.

2. Unless otherwise shown on the drawings, no pipe other than ductile iron, steel, PVC, and concrete shall be cast in concrete or masonry walls.

3. Pipe other than concrete to be cast in water-bearing walls or more than 4 feet below grade shall have water-stop rings. Water stop rings shall be cast integrally with pipe or fabricated. If fabricated, they shall be at least 6 inches larger diameter than pipe, 1/4-inch thick, and continuous welded all around on both sides.

D. Piping through walls and slabs: Unless otherwise indicated, pipes passing through walls and slabs shall be installed in accordance with the standard details shown on the drawings. Care shall be taken to ensure no contact between embedded sleeves or pipes and reinforcing steel. Pipe must be isolated from reinforcing steel.

E. Pipe welding: All welding of steel pipe shall be by the shielded arc method. All welders must be qualified for pipe welding in all positions and for the materials to be welded in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section IX. The Contractor shall provide the Engineer with welding certificates specifically validated for this project. This certification supersedes all other certification requirements of other specifications noted herein.

1. All butt welding of stainless steel shall be by the MIG or TIG method. Fillet welds at slip-on flanges shall be by MIG, TIG or SMA method. Qualification, certification shall be as noted above for steel piping.

2. Gas purging of the backside of the weld during the initial root pass is required. Purge gas shall be the same composition as the shielding gas supplied to the welding gun.

3. Fill and cover passes on butt welds are required to provide a cross section of weld metal equal to, or greater than, the parent metal.

4. All welding, weld testing, and weld repair shall be in accordance with ANSI B31.1 and B31.3, as applicable.

5. All pipe welding on system not previously noted shall be per AWWA C206, and all weld repairs shall be in accordance with AWWA C206.

F. Pipe cutting: The Contractor shall perform all work of cutting pipe and fittings or special castings necessary to the proper and accurate assembly, erection, and completion of the work. All pipe shall be cut to fit accurately with smooth edges and faces.

G. Pipe threads: Pipe ends shall be reamed to the full bore of the pipe. Threads shall conform in dimension and limits of size to ANSI B2.1, tapered pipe thread. In making up threaded joints, an accepted thread lubricant shall be applied to the male threads only.

H. Flanged joints shall be made up square with even pressure upon the gaskets and shall be watertight.

I. Solder joints: Solder to be used in copper piping shall be 95% tin and 5% antimony. All pipe and fittings to be joined with solder shall be free from all burrs and wire brushed or steel wool cleaned. After cleaning, a paste flux shall be evenly and sparingly applied to the surfaces to be joined. Solder shall then be applied and flame passed toward the center of the fitting until the solder disappears. All excess solder shall be removed while it is still plastic. Absolutely no acid flux or acid wipe shall be used in making solder joints.
J. Grooved and shoulder-type joints shall be in accordance with AWWA C606.

K. Pressure piping

1. Anchorage: Buried pressure pipe shall have restrained joints. Concrete thrust blocks may be allowed at locations approved by the Engineer.

2. Manual air vents and pipe drains: Manual air vents shall be installed at the high points of all pipelines carrying liquid, except acids, caustics, or other dangerous liquids, as instructed by the Engineer, of any service class which cannot be vented through service connections or vent cocks provided with equipment. Manual air vents for liquid pipelines 2-1/2 inches and larger shall consist of a 1/2-inch valve as specified for flushing and for smaller piping shall be 3/8-inch size consisting of bronze cock and short copper tubing return. Vents shall include piping to floor level with valve located 4 feet above floor.

   a. All exposed liquid lines 4 inches and larger shall be provided with a tap or guided nipple and valve drain on the bottom of the pipe. This drain connection shall be provided at all low points with a spacing not to exceed that in the table and where shown. Size and minimum spacing shall be as follows:

   
<table>
<thead>
<tr>
<th>Size</th>
<th>Water and Other Liquids</th>
<th>Sewage and Sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot; through 12&quot;</td>
<td>1&quot; at 200 feet</td>
<td>2&quot; at 200 feet</td>
</tr>
<tr>
<td>14&quot; and larger</td>
<td>2&quot; at 100 feet</td>
<td>2&quot; at 100 feet</td>
</tr>
</tbody>
</table>

   b. Drain piping and isolating valves shall be the size noted above unless otherwise shown and shall be the same as shown in the Piping Specification Sheets. Drains shall be piped to a sump, gutter, floor drain, or other collection point.

   c. Vent and drain provisions do not apply to buried or encased pipe except where shown.

3. Laying and jointing of buried piping

   a. Pipe laying: Laying of ductile-iron, cast-iron, and steel pressure pipelines shall conform to applicable portions of Sections 6, 7, and 10 of AWWA C600. Laying of high density polyethylene pipe shall conform to Plastic Pipe Institute standards.

      1) Anchorage shall be provided for fittings where there is a possibility of pulling the joint under pressure. Anchors shall be in accordance with applicable portions of AWWA C600, except as otherwise shown.

      2) Pipe shall be handled with canvas slings or devices to prevent damage to the pipe exterior. Each piece of pipe shall be laid in such a manner as to prevent any sudden offsets in the flow line. As the work progresses, the interior of the pipe shall be cleared of all dirt and debris of every description. Pipe shall not be laid when the condition of the trench or the weather is unsuitable. At times when work is not in progress, open ends of pipe and fittings shall be closed.

      3) Unless otherwise indicated or directed by the Engineer, pipe shall be placed on bedding material at least 6 inches deep below the barrel of the pipe. The bedding and backfill material shall be as specified in Section 312000 “Earth Moving.”
b. Pipe jointing

1) Restrained joints and fittings shall be installed in accordance with the manufacturer's recommendations. Grooved and shoulder type couplings shall not be used for buried services.

L. Gravity pipelines

1. General: The types and sizes of pipe to be used shall be as specified and shown. Bell-and-spigot pipe laying shall proceed upgrade with the spigot ends of pipe pointing in the direction of flow. Each piece shall be laid true to line and grade and in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets in the flow line. As the work progresses, the pipe interior shall be cleared of all dirt and debris of every description. Where cleaning after laying is difficult because of small pipe size, a suitable swab or squeegee shall be kept in the pipe and pulled forward past each joint immediately after jointing has been completed. Pipe shall not be laid when the condition of the trench or the weather is unsuitable. At times when work is not in progress, open ends of pipe and fittings shall be closed.

a. Dewatering, excavation, backfill, bedding, etc., shall be in accordance with the contract drawings and other sections of these specifications.
b. Gravel or crushed rock required to stabilize a soft, wet, or spongy foundation shall be provided at the Contractor's expense.

M. Temporary piping and pipelines: All temporary piping shall conform to the appropriate Piping Specification Sheet and shall be cleaned and tested as specified herein. All buried temporary lines shall be filled with sand, capped and abandoned in place or shall be removed. Temporary lines on the ground surface shall be removed and salvaged.

N. The Contractor shall have on the site at all times three inflatable pipe plug for each size pipe up to and including 12 inches in diameter and one inflatable plug for all pipes greater than 12 inches in diameter. The plugs shall be used to exclude dirt and debris from pipelines during construction. Temporary blocking of pipe with anything other than inflatable plugs (unless all are in use) will not be allowed.

O. Pipes buried with less than 30-inches of cover shall be concrete encased.

3.5 PIPELINE TESTING

A. General: All piping, both gravity and pressure pipelines, shall be subject to acceptance tests. The Contractor shall provide all necessary utilities, labor, and facilities for testing and shall dispose of all waste, including water.

1. All piping including valves, fittings, hydrants, etc., shall be pressure tested prior to backfill or connection to equipment such as pumps. Perform tests sections between isolation valves or structures. Test all pipe penetrations with clean water in wet wells.

2. All exposed piping shall be pressure tested and flushed in accordance with these specifications before they are either painted or insulated. Furthermore, no concrete or concrete slabs shall be poured over or around any piping (except wall penetrations) until the pipe has been tested for acceptance. If a piping system (or portion thereof) fails to
meet an acceptance test, repairs shall be made at the Contractor's expense. The repair method used shall be subject to the Engineer approval and the unacceptable portion shall be retested until it meets these testing specifications.

3. Any equipment which may be damaged by the specified test shall be isolated.

4. All joints which will later be encased in concrete or insulated, whether buried or not, shall be tested prior to encasement. Pipe with leakage greater than allowed herein shall be repaired and retested at the Contractor's expense.

5. Liquid system: Leakage for all unburied liquid piping shall be zero throughout the duration of the test. Leakage for buried piping conveying chemicals shall be zero throughout the duration of the test. Leakage for other buried liquid piping shall not exceed the allowable leakage as set forth in APWA Standard Specifications Section 7-11.3 Hydrostatic Pressure Test.

   a. All cleansing liquid circulated through piping shall first be filtered with a 20-micron filter of the cleanable disc type. Cleansing liquid shall not be circulated through valves, cylinders or pumps to be incorporated in the completed project.

   b. Liquid piping system less than 36 inches in diameter shall be cleaned by the sewer ball method. Pipes 36 inches in diameter and larger shall be cleaned by flushing as long as the pipe is first visually inspected to assure that no physical obstructions exist. Flush at a velocity sufficient to remove all welding slag, dirt and other foreign material and shall be a minimum of 2.5 fps. Pump suction lines shall be flushed prior to connection to pumps or compressors, and temporary strainers shall be installed during system testing to protect equipment.

B. Gravity pipelines

1. Obstructions: After backfilling and restoration of surfaces, all gravity pipelines shall be inspected for obstructions and shall be cleaned. Pipes 24 inches in diameter and smaller shall be cleaned using the sewer ball method. Lines larger than 24 inches in diameter may be cleaned by flushing as long as it is first visually inspected to assure that no physical obstructions exist. Flushing shall be such that velocities are at least 2.5 feet per second.

2. Leakage: All gravity pipe drain lines including interior buried and encased lines shall be tested for leakage after backfilling in accordance with Acceptance Test by Pressure Drop Method shown below. The Contractor shall, at its own expense, correct any excess leakage and repair any damage to the pipe and their appurtenances or to any structures resulting from or caused by these tests. No pipe sealant will be allowed in repair. Where required by the Engineer, the line shall be retested at the Contractor's expense to meet the specifications.

   a. Install access tees, valves, temporary caps or plugs, gages, meters and fittings not called out on the Drawings if required to isolate pipe for testing.

3. Acceptance test by pressure drop method:

   a. Plug all pipe outlets with suitable test plugs. Brace each plug securely.

   b. All gauge pressures in the test should be increased by the amount of groundwater pressure at the center of the pipe.

   c. Add air slowly to the portion of the pipe installation under test until the internal air pressure is raised to 4.0 psig.
d. After an internal pressure of 4.0 psig is obtained allow at least 2 minutes for air
temperature to stabilize, adding only the amount of air required to maintain
pressure.

e. After the 2 minute period, disconnect air supply.

f. When pressure has decreased to 3.5 psig, start stop watch. Determine the time in
seconds that is required for the internal air pressure to reach 2.5 psig. This time
interval should then be compared with the time required by specification as
computed below.

g. List size and length of all portions of pipe under test in table similar to the one that
follows. The maximum reach to be tested in one operation shall be the reach
between two consecutive manholes.

h. Compute K and C using the Nomograph provided by the Engineer. Use scales d
and L, read K and C, and enter these values a table (example provided at the end of
this article).

i. Add all values of K and all values of C for pipe under test.

j. If the total of all C values is less than one, enter the total of all K values into the
space for "Time Required by Specification."

k. If the total of all C values is greater than one and less than 1.75, divide the total of
all K values by the total of all C values to get $t_q$.

l. If the total of all C values is greater than 1.75, divide the total of all K values by
1.75 to get "Time Required by Specification" $t_q$.

C. Pressure pipelines

1. Test according to AWWA C600.
2. Test Pressure: Not less than 200 psig, or 50 psi in excess of maximum static pressure,
whichever is greater.
3. Conduct hydrostatic test for at least two hours.
4. Fill section to be tested with water slowly; expel air from piping at high points. Install
corporation cocks at high points. Close air vents and corporation cocks after air is
expelled. Raise pressure to specified test pressure.
5. Observe joints, fittings, and valves under test. Remove and renew cracked pipe, joints,
fittings, and valves showing visible leakage. Retest.
6. Correct visible deficiencies and continue testing at same test pressure for additional two
hours to determine leakage rate. Maintain pressure within plus or minus 5 psi of test
pressure. Leakage is defined as quantity of water supplied to piping necessary to maintain
test pressure during period of test.
7. Compute maximum allowable leakage by following formula:

\[
L = SD \times \sqrt{P}/C
\]

$L =$ testing allowance, in gallons per hour

$S =$ length of pipe tested, in feet

$D =$ nominal diameter of pipe, in inches

$P =$ average test pressure during hydrostatic test, in psig

$C =$ 133,200

When pipe under test contains sections of various diameters, calculate allowable
leakage from sum of computed leakage for each size.
8. When test of pipe indicates leakage greater than allowed, locate source of leakage, make corrections, and retest until leakage is within allowable limits. Correct visible leaks regardless of quantity of leakage.

9. Potable water: Following satisfactory completion of the pressure test, all potable water lines shall be flushed, disinfected, flushed and tested, in accordance with Section 221116 “Domestic and Service Water Piping.”

3.6 FINISHES

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

B. Finish primed surfaces according to Section 099600 “High-Performance Coatings”

C. Coat machined faces of metallic flanges with temporary rust-inhibitive coating.
## PORT HADLOCK WRF
### Table A - Piping Schedule

<table>
<thead>
<tr>
<th>Description</th>
<th>Service Legend</th>
<th>Exposure</th>
<th>Size(s)</th>
<th>Piping Material</th>
<th>Specification Section</th>
<th>Pipe Color &amp; Label</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOT WATER, POTABLE</td>
<td>HW</td>
<td>ALL</td>
<td>ALL</td>
<td>CU</td>
<td>221116</td>
<td>YELLOW</td>
<td>All HW1 piping shall be insulated per Section 424213, unless otherwise indicated.</td>
</tr>
<tr>
<td>WATER, POTABLE</td>
<td>C1, CW</td>
<td>EXP U. SLAB</td>
<td>ALL</td>
<td>CU</td>
<td>221116 221116 422700.03</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>WATER, NONPOTABLE</td>
<td>C2</td>
<td>EXP U. SLAB</td>
<td>ALL</td>
<td>CU</td>
<td>221116 221116 422700.03</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>WATER, NONPOTABLE WASH WATER (PLANT WATER)</td>
<td>C3</td>
<td>EXP BUR</td>
<td>ALL</td>
<td>DI/STL</td>
<td>422700.01 422700.02</td>
<td>NEUTRAL BEIGE</td>
<td>Exposed outdoor C3 piping shall be insulated per Section 424213 and heat traced per Section 424214.</td>
</tr>
<tr>
<td>DEIONIZED WATER</td>
<td>DIW</td>
<td>ALL</td>
<td>ALL</td>
<td>PP</td>
<td>221116</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>STORM DRAIN</td>
<td>SD</td>
<td>BUR</td>
<td>&lt;= 6&quot;</td>
<td>PVC or DI</td>
<td>422700.03 422700.02</td>
<td>NEUTRAL BEIGE</td>
<td>All culverts shall be Ductile Iron Pipe.</td>
</tr>
<tr>
<td>ROOF DRAIN</td>
<td>RD</td>
<td>ALL</td>
<td>ALL</td>
<td>PVC</td>
<td>422700.03</td>
<td>MATCH BUILDING EXTERIOR</td>
<td></td>
</tr>
<tr>
<td>SANITARY SEWER</td>
<td>SS</td>
<td>ALL</td>
<td>ALL</td>
<td>PVC</td>
<td>422700.03</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>SANITARY SEWER (PLUMBING)</td>
<td>SS</td>
<td>ALL</td>
<td>ALL</td>
<td>CISP</td>
<td>221316</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>RAW SEWAGE</td>
<td>RS</td>
<td>ALL</td>
<td>ALL</td>
<td>DI</td>
<td>422700.02</td>
<td>NEUTRAL BEIGE</td>
<td>Exposed outdoor piping shall be insulated per Section 424213.</td>
</tr>
<tr>
<td>SCREENED RAW SEWAGE</td>
<td>SRS</td>
<td>DI</td>
<td>All</td>
<td>DI</td>
<td>422700.02</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>FEED FORWARD</td>
<td>FF</td>
<td>DI</td>
<td>All</td>
<td>DI</td>
<td>422700.02</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>PERMEATE</td>
<td>PRMT</td>
<td>ALL</td>
<td>ALL</td>
<td>PVC STL</td>
<td>422700.03 422700.01</td>
<td>NEUTRAL BEIGE</td>
<td>Permeate piping shall be PVC unless otherwise indicated.</td>
</tr>
<tr>
<td>EFFLUENT</td>
<td>EFL</td>
<td>ALL</td>
<td>ALL</td>
<td>PVC STL</td>
<td>422700.03 422700.01</td>
<td>PURPLE PANTONE C522</td>
<td>EFL piping shall be PVC unless, otherwise indicated.</td>
</tr>
<tr>
<td>FOUL AIR</td>
<td>FA</td>
<td>DI</td>
<td>All</td>
<td>PVC</td>
<td>422700.03</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>PROCESS AIR</td>
<td>PA</td>
<td>EXP</td>
<td>ALL</td>
<td>SS</td>
<td>422700.01</td>
<td>LABEL</td>
<td></td>
</tr>
<tr>
<td>DRAIN</td>
<td>DR</td>
<td>ALL</td>
<td>ALL</td>
<td>DI PVC STL</td>
<td>422700.02 422700.03 221316</td>
<td>NEUTRAL BEIGE</td>
<td>DR shall be DI unless otherwise indicated. Odor system drains shall be PVC FF pipe drains shall be galv. steel</td>
</tr>
<tr>
<td>UNDER DRAIN</td>
<td>UD</td>
<td>ALL</td>
<td>ALL</td>
<td>PERF. PVC</td>
<td>422700.03</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>WASTE ACTIVATED SLUDGE (WAS) DISCHARGE</td>
<td>WAS</td>
<td>BUR</td>
<td>ALL</td>
<td>DI</td>
<td>422700.02</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>RETURN ACTIVATED SLUDGE (RAS) DISCHARGE</td>
<td>RAS</td>
<td>BUR</td>
<td>ALL</td>
<td>DI</td>
<td>422700.02</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>SAMPLING PIPE</td>
<td>SMP</td>
<td>ALL</td>
<td>ALL</td>
<td>PVC</td>
<td>422700.03</td>
<td>NEUTRAL BEIGE</td>
<td>Provide sample tube where indicated.</td>
</tr>
<tr>
<td>CHEMICAL DOSING SYSTEM</td>
<td>CDS</td>
<td>ALL</td>
<td>ALL</td>
<td>PVC</td>
<td>422700.03</td>
<td>SAFETY YELLOW</td>
<td>All CDS piping containing Mg(OH)2 inside tank shall be insulated per Section 424213.</td>
</tr>
</tbody>
</table>
**PORT HADLOCK WRF**

**Table A - Piping Schedule**

<table>
<thead>
<tr>
<th>Description</th>
<th>Service</th>
<th>Exposure</th>
<th>Size(s)</th>
<th>Piping Material</th>
<th>Specification</th>
<th>Pipe Color &amp; Label</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEMICAL DRAIN</td>
<td>CD</td>
<td>ALL</td>
<td>ALL</td>
<td>PVC</td>
<td>422700.03</td>
<td>NEUTRAL BEIGE</td>
<td>All valves in the CDS system shall be plastic.</td>
</tr>
<tr>
<td>VENT</td>
<td>V</td>
<td>ALL</td>
<td>ALL</td>
<td>STL PVC</td>
<td>221316 422700.03</td>
<td>NEUTRAL BEIGE</td>
<td>Vent piping shall be steel unless otherwise indicated. Vent piping on PRMT lines inside building shall be PVC.</td>
</tr>
<tr>
<td>ENGINE EXHAUST</td>
<td>EE</td>
<td>EXP</td>
<td>All</td>
<td>SS</td>
<td>422700.01</td>
<td>LABEL</td>
<td></td>
</tr>
<tr>
<td>FUEL VENT</td>
<td>FV</td>
<td>EXP</td>
<td>All</td>
<td>SS</td>
<td>422700.01</td>
<td>NEUTRAL BEIGE</td>
<td></td>
</tr>
<tr>
<td>FUEL OIL RETURN</td>
<td>FOR</td>
<td>EXP</td>
<td>All</td>
<td>See Comments</td>
<td>231323</td>
<td>NEUTRAL BEIGE</td>
<td>FOR shall be flexible thermoplastic pipe unless otherwise indicated.</td>
</tr>
<tr>
<td>FUEL OIL SUPPLY</td>
<td>FOS</td>
<td>EXP</td>
<td>All</td>
<td>See Comments</td>
<td>231323</td>
<td>NEUTRAL BEIGE</td>
<td>FOS shall be flexible thermoplastic pipe unless otherwise indicated.</td>
</tr>
</tbody>
</table>

**DEFINITIONS**

- **EXP** Exposed piping, includes piping inside building, vaults, and other structures.
- **U.SLAB** (Under slab) Buried piping within 2 feet of slab.
- **BUR** Buried piping, not including piping buried within 2 feet of slab.

**END OF SECTION 422700**
SECTION 422700.01 - STEEL PIPE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Steel Pipe and Fittings
   2. Stainless Steel Pipe and Fittings

1.2 GENERAL

A. See “422700 - Process Piping General” for general requirements.

1.3 ADDITIONAL SUBMITTAL REQUIREMENT

A. Welders' Certificate: Compliance with ASME Section IX or AWS D1.1, verifying qualification within previous 12 months.

1.4 QUALITY ASSURANCE

A. Perform Work according to ASME B31.9 code for installation of piping systems, and ASME Section IX for welding materials and procedures.

B. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.

C. Installer: Company specializing in performing Work of this Section with minimum three years' documented experience.

D. Licensed Professional: Professional engineer experienced in design of specified Work and licensed at Project location in State of Washington.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's packaging, including handling instructions.

B. Inspection: Accept piping and appurtenances on-Site. Inspect for damage.

C. Store piping and appurtenances according to manufacturer's instructions.

D. Protect piping and appurtenances from oxidation by storing off ground.
PART 2 - PRODUCTS

2.1 STEEL PIPE AND FITTINGS

A. Steel Pipe (2” and smaller)

1. Pipe
   b. Type: Type E, electric resistance welded, or Type S, seamless pipe
   c. Minimum wall thickness: Schedule 80

2. Joints
   a. Threaded or flanged at valves and equipment, or grooved end meeting requirements of AWWA C606

3. Thread Lubricant:
   a. Teflon tape or joint compound that is insoluble in water.

B. Steel Pipe (4” through 24”)

1. Pipe (4” through 8”):
   a. Pipe: ASTM A53, Grade B, Black
   b. Type: Type E, electric resistance welded, or Type S, seamless pipe
   c. Minimum wall thickness: Schedule 40

2. Pipe (10” through 24”):
   a. Pipe: ASTM A53, Grade B, Black, or AWWA C200
   b. Seam: Straight or spiral.
   c. Minimum wall thickness: 3/8”

3. Joints
   a. Flanged at valves and equipment, butt-weld, or grooved end meeting requirements of AWWA C606.

4. Coating and Lining
   a. Coating and lining for non-galvanized steel.
   b. Epoxy, AWWA C210 with the following exceptions:
      1) No coal tar products shall be incorporated in the liquid epoxy.
      2) The curing agent may be an amidoamine as well as other curing agents listed in AWWA C210
c. Applied to 16 mils thick minimum in not less than two coats.
d. Field welds, connections and otherwise damaged areas shall be coated and patched according to the manufacturer’s instruction.

C. Butt-welded Joints and Fittings:

1. Shop-welded circumferential butt-weld, ASTM A774, Class 150, of the same material and same thickness as the pipe.

D. Flanged Joints and Fittings:

1. Galvanized forged carbon steel, ASTM A105/105M, ASME B16.5 Class 150, threaded or butt-weld per ASTM A774, 1/16-inch raised face.

E. Grooved End Joints and Fittings:

1. Manufacturers:
   a. Victaulic.
   b. Anvil International Inc.
   c. Gruvlok.

2. AWWA C606 grooved end: malleable iron ASTM A47 or ductile iron ASTM A536, 250 psi working pressure.
3. Provide grooved end flange adapter where required.
4. Grooved end to accept couplings without field preparation.

F. Bolting:

1. Flanges: carbon steel ASTM A307, Grade A hex head bolts and ASTM A563, Grade A hex head nuts.
2. Grooved end couplings: Carbon steel, ASTM A183 bolts and nuts, 110,000 psi minimum tensile strength.

G. Gaskets:

1. Flanges: 1/8-inch thick, SBR, hardness 80 (Shore A), rated to 200 degrees F.

2.2 STAINLESS STEEL PIPE AND FITTINGS

A. Stainless Steel Pipe

1. Pipe:
   a. 2” and smaller: Schedule 40S Type 304L seamless, pickled and passivated.
   b. 2-1/2” through 6”: Schedule 10S Type 304L, ASTM A778, “as-welded” grade, pickled and passivated.
2. Joints
   a. 1-1/2” and smaller: threaded or flanged at equipment as required or shown.
   b. 2” and larger: butt-welded or flanged at valves and equipment.

3. Fittings
   a. 1-1/2” and smaller: threaded: forged 1,000 CWP, ASTM A182/182M Grade 304L.
   b. 2” and 2-1/2”: butt welded: ASTM A403/A403M, Grade 304L, ASME B16.9 and MSS SP 43, annealed, pickled and passivated, fitting wall thickness to match adjoining pipe; long radius elbows.
   c. 3” and larger: butt-welded: ASTM A774/A774M Grade 304L, MSS SP43, “as-welded” grade, pickled and passivated., fitting wall thickness to match adjoining pipe; long radius elbows.

4. Flanges:
   a. Forged stainless steel: 304L ASTM A182/A182M, ASME C16.5 Class 150 or Class 300, slip-on weld neck or raised face.

5. Bolting:
   a. Bolts, nuts and washers for stainless steel flange assemblies and stainless steel couplings.
   b. Forged flanges: Type 304 stainless steel, ASTM A320/320M Grade B8M hex head bolts and ASTM A194/A194M Grade 8M hex head nuts.

B. Gaskets:
   1. EPDM suitable for use at temperatures to 300 degrees F.

2.3 SOURCE QUALITY CONTROL

A. Owner Inspection: Make completed steel pipe available for inspection at manufacturer's factory prior to packaging for shipment. Notify Owner at least seven days before inspection is allowed.

B. Owner Witnessing: Allow witnessing of factory inspections and test at manufacturer's test facility. Notify Owner at least seven days before inspections and tests are scheduled.

C. Certificate of Compliance: When fabricator is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at fabricator's facility conforms to Contract Documents.
   1. Specified shop tests are not required for Work performed by approved fabricator.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field dimensions are as indicated on Drawings.

B. Inspect existing flanges for nonstandard bolt hole configurations or design, and verify that new pipe and flange mate properly.

3.2 PREPARATION

A. Ream ends of threaded pipes and file smooth.

B. Thoroughly clean pipe and fittings before installation.

   1. Surface Preparation:

      a. Touch up shop-primed surfaces with primer as specified in Section 099600 “High Performance Coatings”

      b. Solvent-clean surfaces that are not shop primed.

      c. Clean surfaces to remove loose rust, mill scale, and other foreign substances; prime surface as specified in Section 099600 “High Performance Coatings”

3.3 INSTALLATION

A. Run piping straight along alignment indicated on Drawings with minimum number of joints.

B. Install according to ASME B31.3 and AWWA M11. Weld joints in accordance with AWWA C206.

C. Fittings:

   1. Clean gasket seats thoroughly, and wipe gaskets clean prior to installation.

   2. Install fittings according to manufacturer's instructions.

   3. Tighten bolts progressively, drawing up bolts on opposite sides until bolts are uniformly tight; use torque wrench to tighten bolts to manufacturer's recommendations.

D. Provide required upstream and downstream clearances from devices as indicated.

E. Install piping with sufficient slopes for venting or drainage of liquids and condensate to low points.

F. Support exposed piping as specified in Section 420520 “Pipe Hangers and Supports”

G. Provide expansion joints as specified in Section 422702 “Process Piping Specialties” to compensate for pipe expansion due to temperature differences.
H. Field Cuts: According to pipe manufacturer's recommendations. Apply lining and coatings at field joints.

I. Finish primed surfaces according to Section 099600 “High Performance Coatings”

3.4 CLEANING

A. Keep pipe interior clean as installation progresses.

B. Clean pipe interior of soil, grit, loose mortar, and other debris after pipe installation.

END OF SECTION 422700.01
SECTION 422700.02 – DUCTILE IRON PIPE

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Ductile iron pipe and fittings.
      2. Accessories.

1.2 GENERAL
   A. See “422700 - Process Piping General” for general requirements.

1.3 MAINTENANCE MATERIAL SUBMITTALS
   A. Tools: Special wrenches and other devices required for Owner to maintain fittings and appurtenances.

1.4 QUALITY ASSURANCE
   A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.
   B. Installer: Company specializing in performing Work of this Section with minimum three years' documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING
   A. Deliver materials in manufacturer's packaging, including handling instructions.
   B. Inspection: Accept piping and appurtenances on-Site. Inspect for damage.
   C. Store piping and appurtenances according to manufacturer's instructions.
   D. Protect piping and appurtenances from oxidation by storing off ground.
   E. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.
PART 2 - PRODUCTS

2.1 DUCTILE IRON PIPE AND FITTINGS

A. Piping:
   1. AWWA C150
   2. Diameter per Drawings.
   3. Class: Class 52 unless otherwise indicated.
   4. Nominal Laying Length: 18 or 20 feet.

B. Joints:
   1. Pressure Rating: Same as that of connected piping.
   2. Restrained joints for all exposed and buried piping unless otherwise indicated.
   3. Pipe Restraint on Mechanical Joints:
      a. Where specified, mechanical joints for above or below ground service shall meet the requirements of ANSI/AWWA A21.10/C110 and ANSI/AWWA A21.11/C111.
      b. Gaskets: synthetic rubber compound in which the elastomer is styrene butadiene, comply with AWWA C111.
      c. Where specified, retainer gland type suitable for buried service.
      d. Manufacturer List:
         1) EBAA Iron, Inc. Megalug Series 1100.
         2) Approved equal.
   4. Restrained Push-on Joints:
      a. Where specified shall be rubber ring compression, push-on joint suitable for buried service.
      b. Unless otherwise indicated, joints shall have an allowable deflection of up to 5 degrees at working pressure.
      c. Capable of being deflected after full assembly.
      d. Joint assembly shall be in strict conformance with AWWA C600 and manufacturer’s recommendation.
      e. No field cuts of restrained pipe are permitted without prior approval of the ENGINEER.
      f. Manufacturer List:
         1) American Cast Iron Pipe Company, Flex-Ring or Lok-Ring Joint.
         2) U.S. Pipe, TR Flex Joint or Field Lok Gaskets.
         3) Approved equal.
5. Flanged Assemblies:

a. Unless otherwise indicated, ductile iron, threaded-on flanges conforming to ANSI/AWWA A21.15/C115 or cast on flanges conforming to ANSI/AWWA A21.10/C110
b. Pressure rating: 150 psi
d. Where specified, flanges shall be threaded-on or cast-on flanges conforming to ANSI B16.1, Class 250.
e. Bolts and nuts:
   1) Bolts and nuts: ANSI B18.2.1 standard square or hexagon head bolts with ANSI B18.2.2 standard hexagon nuts.
   2) Threads: ANSI B1.1 standard coarse thread series; bolts shall be Class 2A, nuts shall be class 2B.
   3) Length: In conformance with ANSI B16.5
   4) Unless otherwise specified, carbon steel machined bolts with hot pressed hexagon nuts.
   5) Bolts and nuts for submerged service: Type 316 stainless steel in conformance with ASTM F593 and ASTM F594, marking F593F and 594F.
   6) Bolts and nuts for buried service: Noncorrosive high-strength, low alloy steel per ANSI/AWWA C111/A21, regardless of other protective coating.

f. Gaskets:
   1) Gaskets: synthetic rubber compound in which the elastomer is styrene butadiene, comply with AWWA C111
   2) Plain faced flanges: full face type.
      a) Pipe 10 inches and less in diameter: 1/16 inch.
      b) Pipe 12 inches and larger: 1/8 inch.
   3) Raised faced flanges: match raised face, unless otherwise indicated
      a) Pipe 3-1/2 inches and less in diameter: 1/16 inch.
      b) Pipe 4 inches and larger: 1/8 inch.

C. Fittings:

1. AWWA C110 or C153, ductile iron
3. Flanged Fittings:
   a. AWWA C110, ASME B16.1.
   b. Pressure Rating: 150 psig
2.2 FINISHES

A. Cement-mortar lining, AWWA C104; standard thickness; ASTM C150, Type II or V, low alkali cement, containing less than 0.60 percent alkalis.

B. Outside Coating:
   1. Buried: Asphaltic; 0.04 in thick.
   2. Exposed: As specified in Section 099600 “High-Performance Coatings”

2.3 ACCESSORIES

A. Gaskets: Rubber

B. Dielectric Fittings: Provide between dissimilar metals.

C. Bolts and nuts: Corrosion resistant, high strength, low alloy steel as specified in ANSI/AWWA C111/A21.11. Corrosion resistance, stainless steel bolts and nuts for use with ductile iron joints are an acceptable substitute. Galvanized or cadmium-plated steel bolts are not acceptable substitutes.

D. Transition Coupling.
   1. Manufacturer List:
      a. Dresser Inc. Style 128
      b. Smith Blair Style 912
      c. Romac FCA 501
      d. Approved equal.

E. Flexible Coupling
   1. Manufacturer List:
      a. ROMAC: Style 501
      b. Approved equal.

2.4 SOURCE QUALITY CONTROL

A. Certificate of Compliance: When fabricator is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at fabricator's facility conforms to Contract Documents.
   1. Specified shop tests are not required for Work performed by approved fabricator.
PART 3 - EXECUTION

3.1 EXAMINATION
   A. Verify that field dimensions are as indicated on Drawings.
   B. Inspect existing flanges for nonstandard bolt hole configurations or design, and verify that new pipe and flange mate properly.

3.2 PREPARATION
   A. Thoroughly clean pipe and fittings before installation.
   B. Surface Preparation:
      1. Touch up shop-primed surfaces with primer as specified in Section 099600 “High-Performance Coatings”
      2. Solvent-clean surfaces that are not shop primed.
      3. Clean surfaces to remove loose rust, mill scale, and other foreign substances; prime surface as specified in Section 099600 “High-Performance Coatings.”

3.3 INSTALLATION
   A. Buried Service:
      1. Install pipe as specified in Section 422700 “Process Piping General”
   B. Exposed Service:
      1. Run piping straight along alignment indicated on Drawings with minimum number of joints.
      2. Install according to ASME B31.3.
      3. Fittings:
         a. Clean gasket seats thoroughly, and wipe gaskets clean prior to installation.
         b. Install fittings according to manufacturer's instructions.
         c. Tighten bolts progressively, drawing up bolts on opposite sides until bolts are uniformly tight; use torque wrench to tighten bolts to manufacturer's recommendations.
      4. Provide required upstream and downstream clearances from devices as indicated.
   C. Make taps to ductile iron piping only with service saddle, tapping boss of a fitting or valve body, or equipment casting.
   D. Install piping with sufficient slopes for venting or drainage of liquids and condensate to low points.
E. Support piping as specified in Section 420520 “Pipe Hangers and Supports”

F. Provide expansion joints as specified in Section 422702 “Process Piping Specialties” to compensate for pipe expansion due to temperature differences.

G. Field Cuts: According to pipe manufacturer's recommendations.

H. Finish primed surfaces according to Section 099600 “High-Performance Coatings”

3.4 FIELD QUALITY CONTROL

A. Inspect for damage to pipe lining or coating, or other defects that may be detrimental as determined by Engineer. Repair damaged piping, or provide new undamaged pipe.

B. After installation, inspect for proper supports and interferences.

3.5 CLEANING

A. Keep pipe interior clean as installation progresses.

B. Clean pipe interior of soil, grit, loose mortar, and other debris after pipe installation.

END OF SECTION 422700.02
SECTION 422700.03 – PLASTIC PIPE

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. PVC pipe and fittings.

1.2 GENERAL
   A. See “422700 - Process Piping General” for general requirements.

1.3 QUALITY ASSURANCE
   A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' experience.
   B. Installer: Company specializing in performing Work of this Section with minimum three years' experience.

1.4 DELIVERY, STORAGE, AND HANDLING
   A. Deliver materials in manufacturer's packaging according to ASTM D3892.
   B. Protect piping and tubing from puncture, abrasion, moisture, and ultraviolet radiation by storing according to manufacturer's recommendations.

1.5 AMBIENT CONDITIONS
   A. Temperature: Do not install pipe when temperature is below 40 degrees F or above 90 degrees F if pipe is exposed to direct sunlight.
   B. Ultraviolet (UV) Protection: Provide pipe installed above ground or outside with UV protection.
PART 2 - PRODUCTS

2.1 PVC PIPE, TUBE, AND FITTINGS

A. PVC Schedule 80
   1. Services: All PVC piping shall be Schedule 80 PVC, unless otherwise indicated.
   2. Pipe: ASTM D1785, Schedule 80
   3. Fittings: ASTM D2467, Schedule 80
   4. Joints, unless otherwise noted: Socket, solvent-welded, ASTM D2855
   5. Joints for chemical dosing system (CDS) containing sodium hypochlorite: Socket, solvent weld 724 CPVC cement.

B. PVC C900/C905
   1. Services: Effluent (EFL) piping.
   2. Pipe and fittings: AWWA C900 DR 25/C905 DR 25
   3. Joint: Integral bell joint ASTM D3139
   4. Materials: ASTM D1784 Cell Class 12454

C. PVC ASTM D3034/F679
   1. Service: Sanitary Sewer (SS), and Storm Drain (SD) piping.
   2. Pipe and fittings: ASTM D3034, SDR 35; or ASTM F679, PS 46.
   3. Materials: ASTM D1784, Class 12454-B

D. PVC ASTM D2729
   2. Pipe and fittings: ASTM D2729

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe ends. Remove burrs. Bevel plain end pipe.

B. Thoroughly clean pipe and fittings before installation.

C. Surface Preparation:
   1. Clean surfaces to remove foreign substances.
3.2 INSTALLATION

A. Run piping straight along alignment indicated on Drawings with minimum number of joints.

B. Install process piping and components according to ASME B31.3.

C. Fittings:
   1. Clean gasket seats thoroughly, and wipe gaskets clean prior to installation.
   2. Install fittings according to manufacturer's instructions.
   3. Tighten bolts progressively, drawing up bolts on opposite sides until bolts are uniformly tight; use torque wrench to tighten bolts to manufacturer's recommendations.

D. Provide required upstream and downstream clearances from devices as indicated.

E. Install piping with sufficient slopes for venting or drainage of liquids and condensate to low points.

F. Support exposed piping as specified in Section 420520 “Pipe Hangers and Supports”

G. Provide expansion joints as specified in Section 422702 “Process Piping Specialties” to compensate for pipe expansion due to temperature differences.

H. Field Cuts: According to pipe manufacturer's recommendations.

I. Fabricated Joints: According to pipe manufacturer’s recommendations.

J. Joining:
   1. Perform heat joining according to ASTM D2657.
   2. Perform electrofusion joining according to ASTM F 1290.

3.3 CLEANING

A. Keep pipe interior clean as installation progresses.

B. Clean pipe interior of soil, grit, shavings, and other debris after pipe installation.

END OF SECTION 422700.03
SECTION 422701 – PROCESS VALVES AND OPERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General requirements for all valves.
   2. Table A – Valve Schedule

1.2 SUBMITTALS

A. Product data, including actuator, with model number and size indicated; valve cavitation limits.
B. Shop Drawings:
   1. Assembly drawings indicating parts list, materials, sizes, position indicators, limit switches, control system, actuator mounting, wiring diagrams and control system schematics.
C. Valve-Labeling Schedule: Indicate valve locations and nametag text.
D. Manufacturer's Certificate: Products meet or exceed specified requirements.
E. Manufacturers' Instructions: Installation instructions and special requirements.
F. Source Quality-Control Submittals: Indicate results of shop or factory tests and inspections.
G. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections, including factory-applied coatings.
H. Qualifications Statements:
   1. Qualifications for manufacturer.

1.3 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of valves and actuators.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts:
   1. Two sets of manufacturer's recommended spare parts.
B. Tools: Special wrenches and other devices as required for Owner for maintenance. Furnish compatible and appropriately labeled toolbox.
1.5 QUALITY ASSURANCE
   A. Maintain clearances as indicated on Drawings and Shop Drawings.

1.6 DELIVERY, STORAGE, AND HANDLING
   A. Accept materials on-Site in original factory packaging, labeled with manufacturer's identification.
   B. Protect from weather and construction traffic, dirt, water, chemicals, and damage by storing in original packaging.

1.7 EXISTING CONDITIONS
   A. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

1.8 WARRANTY
   A. Furnish five year manufacturer's warranty for valves and actuators.

PART 2 - GENERAL

2.1 VALVE SCHEDULE
   A. Table A – Valve Schedule:
      1. Provide all valves shown on TABLE A – VALVE SCHEDULE, and per Drawings.
      2. TABLE A – VALVE SCHEDULE does not include valves for: domestic water, C1, C2, pressure gage cocks, hose bibs, valves provided with equipment (HW screen, UV reactors, Odor Control, MBR system, Magnesium Hydroxide tote, Rotometer for NaHOC1, etc) and all the valves for the future design.

2.2 VALVES GENERAL
   A. Valve Schedule:
      1. Provide all valves shown on Table A – Valve Schedule, and per Drawings. Table A does not include valves for future design.
      2. SCHEDULE does NOT include valves for: Domestic water, C1, C2, pressure gage cocks, hose bibs, valves provided with equipment (HW screen, UV reactors, Odor Control, MBR system, etc) and all the valves for future design.
   B. Provide valves, operator, actuator, handwheel, chain wheel, extension stem, floor stand, worm and gear operator, operating nut, chain, wrench, and other accessories as required.
   C. Valve Connections: Compatible with connecting piping system.
D. Operation: Open by turning counterclockwise; close by turning clockwise. Cast opening/closing directional arrow on valve or actuator with OPEN and CLOSE cast on valve in appropriate location.

E. Valve Marking and Labeling:
   2. Labeling: As specified in Section 422701 “Process Valves and Operators.”

F. Valve Construction:
   1. Bodies: Rated for maximum temperature and pressure to which valve will be subjected; as specified in particular valve Section.
   2. Bonnets: Clamped, screwed, or flanged to body and of same material and pressure rating as body; provide glands, packing nuts, or yokes as specified in valve Sections.
   3. Stems and Stem Guides:
      a. Of materials and with seals as specified in valve Sections.
      c. Space stem guides 10 feet o.c.
      d. Submerged Stem Guides: Type 304 stainless steel.
   4. Nuts and Bolts: Suitable for sewage environment and compatible with the material in contact with.
   5. Repaired valves are not acceptable.

2.3 OPERATORS

A. Lever Handle:
   1. Provide lever handle for all exposed quarter-turn valves 6-inch and smaller, unless otherwise indicated.

B. Handwheel:
   1. Provide handwheel for all exposed valves 6-inch and smaller, except for quarter turn valves, and unless otherwise indicated.

C. Gear-Assisted Manual Actuators:
   1. Provide gear-assisted manual actuator with handwheel for all exposed valves 8-inch and larger, unless otherwise indicated.
   2. Conforming to AWWA C504 for manual valves.
   3. Provide gear actuators with position indicators.
   4. Provide totally enclosed gears.
   7. Packing: Accessible for adjustment without requiring removal of actuator from valve.
8. Valve Actuators in NEC Class I, Group D, Division 1 or 2 Hazardous Locations: UL approved.

D. 2-inch Operating Nut with Wrench or Lever:

1. Provide valves with 2” AWWA square operating nut where indicated.

2. Tee Operating Wrench:
   a. Furnish a total of three, (3), AWWA, square nut “Tee” operating wrenches of such length that “Tee” is between 2 and 4 feet above grade. 
   b. Valve stem extensions with plate welded to operating nut shall be required where operating nut is more than four feet below the surface. The valve stem extension top shall be installed within 18 inches to 24 inches below finish grade. Valve stem extensions shall have a 2-inch square operating nut and self-centering rock-plate support. Lock down set screws shall not be used on valve operating nut extensions.

3. Operating Lever:
   a. Furnish a total of three, (3), AWWA, square nut operating lever appropriate for 2-inch square operating nut.

E. Operating Wrench for Curb Stops:

1. Furnish a total of one, (1), operating wrench for curb stops.

F. Chain Actuator

1. For valves 6-inch and larger, provide chain on actuators for valve operators 7 feet above operating floor level.

2. Chain Actuator: Sprocket-rim chain wheels, chain guides, and hot-dip galvanized operating chain extending to 5-1/2 feet above operating floor level. Provide for chain storage where chains may interfere with pedestrian traffic.

2.4 BURIED VALVES

A. Provide valves with 2” AWWA square operating nut for all buried valves, unless otherwise indicated.

B. HS-20 Rated Valve Box for Buried Valves

1. Manufacturer:
   a. Olympic Foundry Series 940B.
   b. Approved equal.

2. Valve boxes shall be cast iron with lid marked “SEWER” or “WATER” according to their service.
2.5 INSULATION
   A. All valves shall be insulated if within the insulation limits indicated on Drawings.

2.6 MATERIALS
   A. Materials in contact with potable water listed as compliant with:
      1. NSF Standard 61.
      2. NSF Standard 14.

2.7 COATINGS
   A. Valve Lining and Coating: According to AWWA C550 and manufacturer’s recommendation for intended service, unless otherwise indicated.
   B. Exposed Valves: According to Section 099600 “High Performance Coatings”
   C. Do not coat flange faces of valves unless otherwise specified.

2.8 ACCESSORIES
   A. Handwheel: Provide permanently attached handwheel for emergency manual operation.
      1. No rotation during powered operation.
      2. Permanently affix directional arrow and cast OPEN or CLOSE on handwheel to indicate appropriate direction to turn handwheel.

2.9 SOURCE QUALITY CONTROL
   A. Testing:
      1. Test valves according to manufacturer's standard testing protocol, including hydrostatic, seal, and performance testing.
      2. Certification of Valves Larger than 12 in: Certified copies of hydrostatic factory tests, indicating compliance with applicable standards.
   B. Owner Inspection: Make completed valves available for inspection at manufacturer's factory prior to packaging for shipment. Notify Owner at least seven days before inspection is allowed.
   C. Owner Witnessing: Allow witnessing of factory inspections and tests at manufacturer's test facility. Notify Owner at least seven days before inspections and tests are scheduled.
   D. Certificate of Compliance: When fabricator is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at fabricator's facility conforms to Contract Documents.
      1. Specified shop tests are not required for Work performed by approved fabricator.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Verify that piping system is ready for valve installation.

3.2 INSTALLATION
A. Install valves, actuators, extensions, valve boxes, and accessories according to manufacturer's instructions.
B. Firmly support valves to avoid undue stresses on piping.
C. Coat studs, bolts, and nuts with anti-seizing lubricant.
D. Clean field welds to remove slag and splatter to provide a smooth surface.
E. Install valves with stems upright or horizontal, not inverted.
F. Install brass male adapters each side of valves in copper-piped system. Solder adapters to pipe.
G. Install valves with clearance for installation of insulation and allowing access.
H. Provide access where valves and fittings are not accessible.
I. Comply with Section 420520 “Piping Hangers and Supports” for pipe hangers and supports.
J. Comply with Division 40 - Process Integration, for piping materials applying to various system types.
K. Install insulation as indicated on Drawings or on piping schedule.
L. Do not attempt to repair defective valves; replace with new valves.

3.3 FIELD QUALITY CONTROL
A. Valve Field Testing:
   1. Test for proper alignment.
   2. Where specified by individual specification Section, field test equipment to demonstrate operation without undue noise, vibration, or overheating.
   3. Engineer will witness field testing.

END OF SECTION 422701
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<th>Operation</th>
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### FLOW EQUALIZATION

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### PORT HADLOCK RECLAMATION PLANT AND INFLUENT PIPELINE

422701 - PROCESS VALVES AND OPERATORS

**TABLE A - VALVE SCHEDULE**

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### TABLE A - VALVE SCHEDULE

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Resilient-seated gate valves.
   2. General duty gate valves smaller than 3 inches.

1.2 GENERAL

A. See Section 422701 “Process Valves and Operators” for general requirements.

PART 2 - PRODUCTS

2.1 RESILIENT-SEATED GATE VALVES

A. Manufacturer List:
   1. American Flow Control; Series 2500
   2. M&H; Style 7000 and C515 Large
   3. Approved equal.

B. Description:
   1. AWWA C509.
   2. Minimum Working Pressure: 200 psig
   4. Provide gear actuators conforming to AWWA C509 for manual valves.

C. Operation:
   1. Non-rising stem.

D. Materials:
   1. Wedge: Resilient ASTM A536, ductile iron.
   2. Body and Disc: ASTM A536, ductile iron.
   4. Connecting Hardware: Type stainless steel.
2.2 GENERAL-DUTY GATE VALVES - 3 INCHES OR SMALLER

A. Manufacturer List:
   1. M&H Valve, AWWA C509
   2. U.S. Pipe; A-USPO
   3. Approved equal.

B. 2-1/2 inches to 3 inches:
   1. MSS SP 70, Class 125.
   2. Stem: Non-rising.
   4. Trim: Bronze.
   5. Bonnet: Bolted bonnet.
   6. Handwheel, outside screw and yoke.
   7. Wedge Disc: Solid, with bronze seat rings.

2.3 SOURCE QUALITY CONTROL

A. Testing: Test gate valves according to AWWA C509.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install according to manufacturer's instructions.

B. Support valves in plastic piping to prevent undue stresses on piping.

END OF SECTION 422701.01
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rubber-seated ball valves.
2. Plastic ball valves.

1.2 GENERAL

A. See “422701 - Process Valves and Operators” for general requirements.

PART 2 - PRODUCTS

2.1 RUBBER-SEATED BALL VALVES

A. Manufacturer List:

1. Apollo
2. Nibco
3. Approved equal.

B. Description:

1. Service: All ball valves shall be rubber-seated ball valves, unless otherwise indicated.
2. MSS SP 110.
3. Working Pressure: 150 psig
4. Two-piece bronze body.
5. Stainless-steel ball.
6. Regular port, PTFE seats.
8. End Connections: Threaded with union.

2.2 PLASTIC BALL VALVES

A. Manufacturer List:

1. Asahi America
2. Nibco Inc.
4. Approved equal.

B. Description:
   1. Service: All ball valves in the CDS system shall be plastic.
   2. Minimum Working Pressure: 150 psig
   3. Full-size ports.

C. Materials:
   1. ASTM D1784, CPVC
   2. Seats: PTFE.

2.3 SOURCE QUALITY CONTROL

A. Testing: Test ball valves according to AWWA C507.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Support valves in plastic piping to prevent undue stresses on piping.

END OF SECTION 422701.02
SECTION 422701.03 - PLUG VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Eccentric plug valves.

1.2 GENERAL

A. See Section 422701 “Process Valves and Operators” for general requirements.

PART 2 - PRODUCTS

2.1 ECCENTRIC PLUG VALVES

A. Manufacturer List:

1. Milliken Series 625
2. Victaulic Series 365/366
3. DeZurik PEF, 100% Port
4. Approved equal.

B. Description:

1. Type: Non-lubricated, eccentric.
2. Minimum Working Pressure: 175 psig
3. Ports: 100% port.
5. Stem Seals: Neoprene; V-ring type.

C. Materials:

1. Body: ASTM A536, ductile iron, lined as recommended by valve manufacturer.
2. Plug: ASTM A536, ductile iron lined as recommended by valve manufacturer.
3. Seats: Stainless steel
4. Stem: Type 316 stainless steel
5. Stem Bearings: Stainless steel
6. Seals: PTFE
7. Connecting Hardware: Type 304 stainless steel.

D. Finishes: Fusion epoxy coated inside and outside, per AWWA C550
2.2 SOURCE QUALITY CONTROL

A. Performance Testing:
   1. Operate each valve and actuator from fully CLOSED to fully OPEN to fully CLOSED under no-flow conditions.

B. Leakage Testing:
   1. Test at indicated working pressure to ensure valves are drip-tight. Test with pressure in both directions for five minutes each way.

C. Hydrostatic Testing:
   1. Perform test at twice rated pressure. Test for at least one minute to ensure no leakage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install valves according to AWWA C517 and as recommended by manufacturer.

B. Install plug valves in horizontal piping with stem horizontal; install plug valves in vertical piping with plug at top when closed.

C. Install such that plugs are on top when OPEN and on pressure side when CLOSED.

END OF SECTION 422701.03
SECTION 422701.04 - BUTTERFLY VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Rubber-seated butterfly valves.

1.2 GENERAL

A. See Section 422701 “Process Valves and Operators” for general requirements.

PART 2 - PRODUCTS

2.1 RUBBER-SEATED BUTTERFLY VALVES

A. Manufacturer List:
   1. DeZurik
   2. Mueller Co.
   3. Kennedy Valves
   4. Approved equal.

B. Description:

   1. AWWA C504, Class 250 as indicated on valve schedule
   2. Style: Flanged, unless otherwise indicated.
   4. Seats: Mounted on body or disc for valves 24 inches and smaller; field replaceable for valves larger than 30 inches.
   5. Packing: Replaceable without dismantling valve.
   7. Provide gear actuators conforming to AWWA C504 for manual valves.

C. Materials:

   1. Body: ASTM A536, ductile iron
   2. Stem: Stainless steel
   3. Disc: ASTM A536, ductile iron
   4. Seats: Resilient, replaceable, Buna-N
   5. Seating Surfaces: stainless steel
2.2  SOURCE QUALITY CONTROL

A.  Testing: Test butterfly valves according to AWWA C504.

PART 3 - EXECUTION

3.1  INSTALLATION

A.  Support valves in plastic piping to prevent undue stresses on piping.

END OF SECTION 422701.04
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Swing check valves
   2. Silent check valves
   3. Elastomeric check valves
   4. Foot check valves

1.2 GENERAL

A. See “422701 - Process Valves and Operators” for general requirements.

PART 2 - PRODUCTS

2.1 SWING CHECK VALVES

A. Manufacturer List:
   1. Mueller
   2. Approved equal.

B. Description:
   1. AWWA C508.
   2. Type: Swing, resilient-seated, with outside lever and adjustable weight or spring.
   4. Flow Area: Full open, equal to connecting nominal pipe diameter.
   5. Provide check valves 6 inches and larger with adjustable air cushion chambers.

C. Materials:
   1. Body and Cover: Cast iron, ASTM A126 Cl.B.
   2. Disc: Cast iron, ASTM A126 Cl.B.
   3. Seat: Field-replaceable, bronze, ASTM B584
   4. Chamber and Plunger: bronze, ASTM B584
   5. Hinge Pin and Key: stainless steel, ASTM A582, Type 304
   6. Packing and O-Ring: Buna-N
   7. Rubber Components: Buna-N
8. Connecting Hardware: Type 304 stainless steel.

2.2 SILENT CHECK VALVES

A. Manufacturer List:
   1. Valmatic
   2. Approved equal.

B. Description:
   2. Conformance: NSF/ANSI 61 Certified.
   4. Type: Silent operation check valve with resilient seat for zero leakage.
   5. Flow area: full flow area

2.3 ELASTOMERIC CHECK VALVES

A. Manufacturer List:
   1. Tideflex
   2. Approved equal.

B. Description:
   1. Body: Elastomeric body with 316 stainless steel appropriate for sewage service.
   2. Sizing: Size for flow.

2.4 FOOT CHECK VALVES

A. 1-inch and smaller

   1. Manufacturer List:
      a. NIBCO Chemtrol
      b. Approved equal.

   2. Description:
      a. Type: Ball check with removable strainer
      b. NSF listed
      c. Class 150 psi
      d. Body: PVC.
      e. Seats and o-ring: Viton or FKM
      f. Threaded ends
B. 6-inch

1. Manufacturer List:
   a. Valmatic, series 1900
   b. Approved equal.

2. Description:
   a. Type: globe style silent check valve with removable strainer
   b. Flow area: full flow area
   d. Conformance: NSF/ANSI 61 Certified.
   e. Body: Cast Iron
   f. Internals: Bronze, field replaceable
   g. Strainer: 304 stainless steel
   h. Seals: replaceable Buna N
   i. ANSI Class 125 Flanges

2.5 SOURCE QUALITY CONTROL

A. Testing:
   1. Hydrostatically test check valves at twice rated pressure, in conformance with requirements of AWWA C508.
   2. Permitted Leakage at Indicated Working Pressure: None.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install check valves according to AWWA C508 and as recommended by manufacturer.
SECTION 422701.10 - SPECIALTY VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Mud Valves
2. Pressure Regulating Valves
3. Pressure Relief Valve for Hydropneumatic Tank
4. Telescoping Valves
5. Corporation Stops
6. Curb Stops
7. Solenoid Valves
8. Globe Valves
9. Needle Valves

1.2 GENERAL

A. See Section 422701 “Process Valves and Operators” for general requirements.

PART 2 - PRODUCTS

2.1 MUD VALVES

A. Manufacturer List:

1. Clow Valve Company
2. Kennedy Valve
3. M&H Valve Company
4. Trumbull
5. Approved equal.

B. Mud Valve:

1. Type: Non-rising, threaded stem.
2. Furnish coupling nut, extension stem, stem guides, and operating stand as indicated on Drawings.
3. Seating head: 20 feet
4. Positive seal under seating and unseating head conditions.
5. Operator: Per Drawings.
9. Plug Seat: Buna-N tapered to accurately mate with the seat ring for a positive seal.
10. Connecting Hardware: Type 316 stainless steel.

C. Stem Guide:
1. Stem Guide: Type 316 Stainless steel or fiberglass reinforced plastic with UHMW polyethylene, minimum 3/4-inch thickness.
2. Bushings: Machined to a size 1/16” over stem diameter.
4. Connecting Hardware: Type 316 stainless steel.
5. Stem guides shall be adjustable in two directions and shall be so constructed that when properly spaced they will hold the stem in alignment and still allow enough play to permit easy operation, and sufficient strength to prevent twisting or sagging under load.

D. Operators:
1. All manual mud valves shall have 2” AWWA operating nut and stem as shown in the drawings.

E. Valve box and Position Indicator (as indicated on Drawings):
1. Provide valve position indicator Model No. 57T by Trumbull or approved equal. The position indicator shall be located inside of a valve box to indicate percent opening of the valve. The valve shall be open left.
2. Valve box shall be provided for manually operated mud valves as indicated on drawings. The valve box shall be cast iron type Model No. 367-9416 by Trumbull or approved equal. The valve box shall be covered with a lid.

2.2 PRESSURE-REGULATING VALVES

A. Manufacturer List:
1. Cla Val
2. Watts
3. Mueller
4. Cash-Acme
5. Approved equal.

B. Description:
1. Type: Pilot-operated globe valve with built-in strainer.
2. Body: Metal, suitable for operating condition. Zinc alloys not allowed.
4. Flow Area: Equal to connecting nominal pipe diameter; furnish V-ports for low-flow pressure control.
5. Operation: Normally open; hydraulic; diaphragm actuated; pilot operated.
6. Downstream Pressure Set Point: Field adjustable, zero to 110 percent.
8. Furnish piston position indicator.

C. Materials:
   1. Body: ASTM A536, ductile iron
   2. Diaphragm: EPDM rubber
   3. Control Trim:
      a. Fittings: Bronze
      b. Tubes: Nylon
   4. Valve Components: Bronze
   5. Seals: Buna-N

D. Additional Warranty Requirement:
   1. 5-year warranty against cavitation damage.

2.3 PRESSURE-SAFETY VALVE FOR HYDROPNEUMATIC TANK (see section 434200)

A. Manufacturer List:
   1. Kunkle
   2. Or equal.

B. Description:
   1. Non-adjustable, factory set at 175 psi
   2. Bronze body, Stainless Steel wetted parts
   3. Capacity/size: 150 gpm, at least ¾-inch

2.4 TELESCOPING VALVES

A. Manufacturer List:
   1. Waterman
   2. Golden Harvest
   3. Approved equal.

B. Telescoping Valves:
   1. Type: Non rising threaded stem
   2. Minimum travel range: 2 feet
   3. Handwheel: Conform to AWWA C500; cast opening direction arrow with word OPEN.
4. Maximum height from bottom of operating pedestal, including concrete pad, to top of valve: 42-inch.

C. Materials:

1. Telescopic Tube and Bail: Type 316 stainless steel, minimum Schedule 10S.
2. Guide Collar: Type 316 stainless steel; cast-iron companion flange with neoprene gasket.
3. Stem: Type 316 stainless steel.
4. Stem Cover: Butyrate plastic
5. Handwheel: Ductile iron
6. Pedestal: Type 316 stainless steel, Schedule 40 tube, minimum 6-inch diameter.
7. Mounting Bracket: Cast iron, with stainless-steel anchor bolts.
8. Connecting Hardware: Type 316 stainless steel.

D. Stem Guide:

1. Stem Guide: Type 316 Stainless steel or fiberglass reinforced plastic with UHMW polyethylene, minimum 3/4-inch thickness.
2. Bushings: Machined to a size 1/16-inch over stem diameter.
4. Connecting Hardware: Type 316 stainless steel.
5. Stem guides shall be adjustable in two directions and shall be so constructed that when properly spaced they will hold the stem in alignment and still allow enough play to permit easy operation, and sufficient strength to prevent twisting or sagging under load.

2.5 CORPORATION STOPS

A. Manufacturer List:

1. Ford Ballcorp
2. Approved equal.

B. General:

1. Saddle mounted with Romac 101S or equal; direct tap not allowed.
2. Configuration: Match threads to adjacent fittings.
3. Body: Per AWWA C800.

2.6 CURB STOPS

A. Manufacturer List:

1. Ford Ball Valve Curb Stops
2. Approved equal.
2.7 SOLENOID VALVES

A. Manufacturer List:

1. ASCO; 8210.
2. Skinner.
3. Approved equal.

B. General:

1. Two-way internal pilot operated diaphragm type, brass body, resilient seat suitable for air or water, solenoid coil molded epoxy, UL and CSA listed for general purpose.
2. Size and normal position as indicated.
3. 120 Volt, NEMA Rating: Suitable for area classification.
4. Minimum operating pressure differential no greater than 5 psig.
5. Maximum operating pressure differential not less than 125 psig.

2.8 GLOBE VALVES

A. Manufacturer List:

1. Crane, Model 1.
2. NIBCO
3. Approved equal.

B. General:

1. Globe Valves, 2-1/2 Inches and Smaller:
2. MSS SP-80; Class 125, 200-psi CWP
3. ASTM B 62 cast-bronze body and screwed bonnet, renewable bronze seat disc, silicon bronze-alloy stem, teflon-impregnated packing with bronze nut, threaded end connections
4. Aluminum or malleable-iron handwheel.

2.9 NEEDLE VALVES

A. Manufacturer List:

1. ASAHI
2. Hayward
3. Approved equal.
B. General:

1. Class 150 psi
2. ASTM D1784 PVC body
3. Polypropylene internal components
4. Viton seal
5. Threaded end connections.

2.10 SOURCE QUALITY CONTROL

A. Testing:

1. Leakage Testing:
   a. Test each assembled valve hydrostatically at 1-1/2 times rated working pressure for minimum five minutes.
   b. Test each valve for leakage at rated working pressure against closed valve.
   c. Permitted Leakage: None.

2. Functional Testing:
   a. Test each valve to verify specified performance.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install mud valves with valve seats level.

B. Install protective strainers upstream of solenoid valves, pressure-reducing valves, and pressure-sustaining valves.

END OF SECTION 422701.10
SECTION 422702 - PROCESS PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipe Penetration Mechanical Sleeve Seals
   2. Flexible Joints
   3. Expansion Joints
   4. Expansion Loops
   5. Sleeve-type Couplings
   6. Strainers
   7. Yard Hydrant Assemblies

1.2 SUBMITTALS

A. Product Data:
   1. Manufacturer's catalog information for each product specified.
   2. Expansion Joints: Maximum temperature, pressure rating, and expansion compensation.

B. Manufacturer's Instructions.

1.3 WARRANTY

A. Furnish five year manufacturer's warranty.

PART 2 - PRODUCTS

2.1 PIPE PENETRATIONS

A. Mechanical Sleeve Seals:
   1. Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.
2.2 FLEXIBLE JOINTS

A. Elastomer Bellows Type Flexible Joints:

1. Manufacturer List:
   a. PROCO
   b. Victaulic
   c. Approved equal.

2. Material:
   a. Type: Reinforced molded wide arch.
   b. Pressure Rating: 200 psig WOG and 250 degrees F.
   d. Minimum deflection: 1.06” for bellows 12” and under, 1.65 for bellows >14”
   e. Joint: Flanged, with split galvanized steel retaining rings.
   f. Washers: over retaining rings to help provide leak-proof joint under test pressure.
   g. Thrust Protection: Control rods to protect the bellows from overextension.
   h. Bellows Arch Lining: Buna-N, nitrile or butyl.

2.3 EXPANSION JOINTS

A. Formed bellows type, medium temperature (up to 800 degrees F):

1. Manufacturer List:
   a. Flexonics, Inc.
   b. Hyspan Precision Products, Inc.
   c. American BOA Inc.
   d. Approved equal.

2. Construction:
   a. 300 series stainless steel multi-ply bellows rated for the specified design temperature and pressure.
   b. Test pressures: Specified in Section 15050. Each expansion joint shall be factory tested at the test pressure.
   c. Ductwork expansion joints: May be rated at less than 50 psig but must be rated equal to the design pressure and, in no case, less than 2 psig.
   d. Engine and gas turbine exhaust expansion joints: As specified in Paragraph 15090-2.01A1b.
   e. Design: Determined by the amount and kind of movement specified (axial, lateral, angular).

B. Steel expansion compensator type:

1. Manufacturer list:
2.

**Construction**

a. 2-ply stainless steel bellows and carbon steel shroud and end fittings.

b. Rated for 175 psi maximum working pressure and 750 degrees F.

C. **Bronze Expansion Compensator Type:**

1. **Manufacturer list:**

a. Flexonics Model HB Expansion Compensator.

b. Hyspan Series 8500.

c. Keflex 7Q.

d. American BOA Inc.

e. Approved equal.

2. **Construction**

a. Multi-ply phosphor bronze or stainless steel bellows and copper tube end fittings.

b. Rated for 150 psi maximum working pressure and 400 degrees F.

### 2.4 EXPANSION LOOPS

A. Delegated Design: Provide expansion loops as indicated on Drawings and where required.

### 2.5 SLEEVE-TYPE COUPLINGS

A. AWWA C219; ductile-iron middle ring; ductile-iron followers; wedge section gaskets; steel bolts, AWWA C111 (A21.11).

B. Gaskets: Nitrile rubber (Buna N) or EPDM; ASTM D2000; compatible with service conditions.

C. Buried Couplings: Factory epoxy coated.

### 2.6 STRAINERS

A. **Description:**

1. Y-pattern type; ASTM F1199 or ASTM F1200.

2. Body: Cast bronze; flanged ends.


4. Screen:
2.7 YARD HYDRANT ASSEMBLIES

A. Backflow Protected Non-freeze Yard Hydrants - YH

1. Manufacturers list:
   a. Woodford
   b. Smith
   d. Approved equal.

2. General:
   a. Type: Non-freeze, exposed-outlet yard hydrant.
   b. Operation: Wheel handle
   c. Casing and Operating Rod: At least length required for burial of valve below frost line.
   d. Casing: Bronze with casing guard.
   e. Interior Parts: Bronze, including bronze seat and replaceable seal washer.
   f. Inlet: NPS 1
   g. Outlet: NPS 1 hose thread.
   h. Drain: Designed with hole to drain into ground when shut off.
   i. Vacuum Breaker:
      1) Non-removable drainable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
   j. Provide with compatible water hose, nozzle, quick coupling adapter and hose valve as a single assembly.

B. Water Hose

1. Manufacturers list:
   a. Dayco
   b. Approved equal.

2. General:
   a. Length: 50 feet
   b. Connections: NPS 1 with integral male and female standard connections.
   c. Body: Commercial grade 2-ply rubber hose, 20 pounds per 50-foot lengths maximum.
C. Nozzles
   1. Manufacturers list:
      a. Allenco No. 97
      b. Approved equal.

D. Quick coupling adapters:
   1. Manufacturers list:
      a. Jamesbury,
      b. Worcester
      c. Dixon
      d. Approved equal.

E. Hose Valve:
   2. Pressure Rating: Class 125.

2.8 FINISHES
   A. Prepare piping appurtenances for field finishes as specified in Section 099600 “High Performance Coatings”

2.9 SOURCE QUALITY CONTROL
   A. Certificate of Compliance: When fabricator is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at fabricator's facility conforms to Contract Documents.
      1. Specified shop tests are not required for Work performed by approved fabricator.

PART 3 - EXECUTION

3.1 PREPARATION
   A. Thoroughly clean end connections before installation.
   B. Close pipe and equipment openings with caps or plugs during installation.
   C. Surface Preparation: Clean surfaces to remove foreign substances.
3.2 INSTALLATION

A. Install Work according to ASME B31.9.

B. Coating: Finish piping appurtenances as specified in Section 099600 “High Performance Coatings”

C. Flashing:
   1. Provide flexible flashing and metal counterflashing where piping penetrates weatherproofed or waterproofed walls, floors, and roofs.
   2. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36-by-36-inch sheet size. Fasten flashing to drain clamp device.

D. Sleeves:
   1. Exterior Watertight Entries: Seal with mechanical sleeve seals.
   2. Set sleeves in position in forms. Provide reinforcing around sleeves.
   3. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
   4. Extend sleeves through floors 1 inch above finished floor level. Caulk sleeves.
   5. Where piping penetrates floor, ceiling, or wall, close off space between pipe and adjacent Work with stuffing and/or firestopping insulation and caulk airtight. Provide close-fitting metal collar or escutcheon covers at both sides of penetration.
   6. Install stainless-steel escutcheons at finished surfaces.

E. Expansion Joints:
   1. Install flexible couplings / expansion joints at connections to equipment and where indicated on Drawings.
   2. If expansion joint is supplied with internal sleeve, indicate flow direction on outside of joint.

3.3 FIELD QUALITY CONTROL

A. After installation, inspect for proper supports and interferences.

B. Repair damaged coatings with material equal to original coating.

3.4 CLEANING

A. Keep equipment interior clean as installation progresses.

END OF SECTION 422702
SECTION 424213 – PROCESS PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes insulation for process piping.

1.2 SUBMITTALS
A. Manufacturer's descriptive literature, including insulation and jacket thickness, heat transfer coefficient, and methods of installation.
B. Samples of each insulation material type and of typical jackets and covers for fittings, valves and appurtenances.
C. Certification of jacket ratings for water vapor transmission and puncture and stiffness as specified.
D. A copy of this specification section with addenda updates, and all referenced sections with each paragraph check marked to show specification compliance or marked to show deviations.

1.3 OPERATING REQUIREMENTS
A. Temperature classes:
   1. Insulation for exposed piping and equipment is classified for the following temperature ranges: low, medium, high, and very high.
   2. Low temperature class insulation shall be suitable for an operating temperature range of minus 100 to plus 100 degrees F.
   3. Medium temperature class insulation shall be suitable for an operating temperature range of 100 to 800 degrees F.
   4. High temperature class insulation shall be suitable for an operating temperature range of 800 to 1200 degrees F.
   5. Very high temperature class insulation shall be suitable for an operating temperature range of 1,200 to 1,800 degrees F.

PART 2 - PRODUCTS

2.1 GENERAL
A. Piping insulation shall be tubular type or the flexible blanket type.
B. Insulation for valves, strainers, fittings, expansion joints, flanges and other connections shall be segmented sections, molded, or blanket type coverings of the specified type and thickness of pipe insulation, or the flexible blanket type.

C. Equipment insulation shall be flexible blanket type or rigid board type cut to fit the surface.

2.2 INSULATION

A. General:

1. Low temperature class insulation shall be of the unicellular elastomeric thermal, cellular glass, or fiberglass type.
2. Medium temperature class insulation shall be of the cellular glass or fiberglass type.
3. Piping and equipment subjected to vibration (such as engine exhaust) shall be insulated with flexible blanket type.
4. All outdoor piping, including piping below vaults, shall be insulated with insulation appropriate for service condition.

B. Unicellular elastomeric thermal type: Unicellular elastomeric thermal type insulation shall conform to the requirements of ASTM C534, Type I.

C. Cellular glass type: Cellular glass type insulation shall conform to the requirements of ASTM C552, Type II.

D. Fiberglass type: Fiberglass type insulation shall conform to the requirements of FEDSPEC HH-I-558B.

E. Flexible blanket type:

1. High temperature class:
   a. High temperature insulation shall be removable 1-inch or 2-inch thick blanket-type insulation designed for continuous 1,200 degree F service.
   b. The blanket shall be a custom sewn, flexible, reusable jacket, custom designed to closely fit the piping or the equipment housing.
   c. Blanket shall be custom fitted to not restrict access to any instrumentation or equipment.
   d. Insulation shall not compact or shake down in vibrating service.
   e. Blanket insulation shall consist of a noncombustible silica cloth jacket and nonasbestos white ceramic fiber insulation.
   f. Acceptable manufacturer:
      1) Thermazip Hi-Temp blanket Style 2000-60-3000 by Accessible Products Company.
      2) Hitco AIM.
      3) Advanced Thermal Products.
      4) SEI Temp-Set 1200.
      5) Approved equal.

2. Very high temperature class:
a. Very high temperature insulation shall be removable 1-inch or 2-inch thick blanket-type insulation designed for continuous 1800 degree F service.
b. The blanket shall be a custom sewn, flexible, reusable jacket, custom designed to closely fit the piping or the equipment housing.
c. Blanket shall be custom-fitted to not restrict access to any instrumentation or equipment.
d. Insulation shall not compact or shake down in vibrating service.
e. Blanket insulation shall consist of a noncombustible silica cloth jacket and high purity alumina and silica nonasbestos white ceramic fiber insulation.
f. Acceptable manufacturer:

1) Thermazip Hi-Temp blanket Style 2000-61-3000 by Accessible Products Company.
2) Hitco AIM.
3) Advanced Thermal Products.
4) Approved equal.

2.3 INSULATION JACKETS

A. Laminated jackets: Laminated jackets shall consist of aluminum and white kraft paper. Jackets shall have a perm rating for water vapor transmission of not more than 0.02 in accordance with procedure A of ASTM E96.

B. Aluminum jackets:

1. Aluminum jackets shall be constructed of smooth finish aluminum sheet conforming to ASTM B209, alloy 5005, temper H16, with integral vapor barrier. Jackets shall be 0.016 inch thick.
2. Sheet metal screws shall be aluminum or stainless steel.
3. Jackets shall be secured with 0.020 by 3/4-inch type 304 stainless steel expansion bands.

2.4 INSULATION COVERS

A. Polyvinylchloride (PVC) covers: Polyvinylchloride covers shall be one piece, premolded polyvinylchloride conforming to FEDSPEC L-P-535E, Composition A, Type II, Grade E4.

B. Aluminum covers: Aluminum covers shall be constructed of smooth finish aluminum sheet conforming to ASTM B209, alloy 5005, temper H16, with integral vapor barrier. Covers shall be 0.016 inch thick.

C. Soft covers: Soft covers shall be of the reusable type with TFE-coated fiberglass covers and liner.

2.5 SHIELDS

A. Unless otherwise indicated, thermal pipe hanger shields shall be provided at pipe supports.
2.6 FLASHING

A. Flashing shall include aluminum caps, sealant and reinforcing. Aluminum caps shall be 20 gage thick and shall be cut to completely cover the insulation. Sealants shall be as recommended by the insulation manufacturer.

B. Reinforcement in flashing heated up to 370 degrees F shall be nylon fabric. Reinforcement in flashing for hotter surfaces shall be wire mesh or as recommended by the insulation manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Apply insulation over clean, dry surfaces. Double layer insulation, where specified or required to achieve the specified surface temperature, shall be provided with staggered section joints.

B. Pipe supports and shields: Unless otherwise indicated, the Contractor shall supply thermal pipe hanger shields and install them during pipe support installation. Where thermal pipe hanger shields are used, apply the following to all butt joints:

1. On hot pipe systems, apply 3-inch wide vapor barrier tape or band over the butt joints.
2. On cold water, chilled water, or refrigerant piping, apply a wet coat of vapor barrier lap cement on all butt joints and seal the joints with a minimum 3-inch wide vapor barrier tape or band.

C. Protection: Protect insulation and jackets from crushing, denting, and similar damage during construction. Vapor barriers shall not be penetrated or otherwise damaged. Remove any insulation, jacket, and vapor barriers damaged during construction and install new material.

D. Piping insulation:

1. General:

   a. Pipe:

      1) Insulate piping continuously along its entire length including all in-line devices such as valves, fittings, flanges, couplings, strainers and other piping appurtenances. Insulation shall be butted firmly together and jacket laps and joint strips provided with lap adhesive. Provide jackets with their seams located on the underside of pipe.

      2) Do not use PVC covers with medium-, high-, or very high-temperature class insulation. Removable flexible blanket-type insulation need not be jacketed.

   b. Fittings, connections, flanges and valves: Provide fitting, connection, flange and valve insulation with covers. Secure insulation in place with 20-gage wire and a coat of insulating cement. Covers shall overlap the adjoining pipe insulation and...
jackets. Provide covers with their seams located on the underside of fittings and valves.

2. Low temperature class:
   a. Pipe: Seal off ends of insulation with a vapor barrier coating.
   b. Fittings, connections, flanges and valves:
      1) Except where soft covers are specified, provide insulation for pipe sizes 2 inches and less with rigid PVC covers. Seal covers at edges with vapor barrier adhesive. Secure the ends of covers with vinyl tape. The tape shall overlap the jacket and the cover at least 1 inch. Do not penetrate vapor barrier.
      2) Except where soft covers are specified, provide insulation for pipes 2 1/2 inches and larger with rigid aluminum covers. Mechanically secure covers using corrosion-resistant tacks pushed into the overlapping throat joint.

3. Medium, high, and very high temperature class:
   a. Pipe: Except for flexible blanket type insulation, seal ends of insulation with end joint strips and use waterproof adhesive to hold them in place.
   b. Fittings, connections, flanges and valves: Except where soft covers are specified, provide rigid insulation with rigid aluminum covers. Mechanically secure covers using corrosion-resistant tacks pushed into the overlapping throat joint.

4. Outdoor piping:
   a. Pipe: Provide rigid insulation with aluminum jackets. Design flexible blanket-type insulation for outdoor, weather-exposed service. Where piping emerges from soil without concrete or asphalt overtop, extend the insulation a minimum of 12 inches below the finished ground level. Where piping emerges from concrete or asphalt, extend the insulation to within 1 inch of the finished surface. Do not push insulation into contact with the finished concrete or asphalt surface.
   b. Insulation over heat tracing: Provide heat tracing in specified locations on the drawings, in particular on the back flow preventer valves for potable and fire water services that are located in insulated fiberglass vaults. Install insulation over the top of heat tracing according to the specifications of the heat trace tape and insulation manufacturers.
   c. Fittings, connections, flanges and valves: Provide rigid insulation with rigid aluminum covers. Design flexible blanket type insulation for outdoor, weather-exposed service.

E. Mechanical equipment insulation:

1. General:
   a. Unless otherwise specified, fit insulation to the contours of equipment and secure it with 1/2-inch by 0.015-inch galvanized steel bands. Weld pins or stick clips with washers may be used for flat surfaces and spaced a maximum 18 inches apart. Stagger joints and fill voids with insulating cement. Unless otherwise specified, provide insulation with laminated jackets.
b. Unless specifically specified to be uninsulated, insulate all equipment connected to insulated piping.

2. Outdoor equipment: Provided insulation with a coat of weatherproof mastic and a layer of open-weave glass cloth embedded into a wet tack coat. Overlap seams at least 2 inches. Provide a finish coat of weatherproof mastic. The total coating thickness shall be a minimum of 1/8 inch.

3. Low temperature class:
   a. Where joints, breaks, and punctures occur in the insulation, seal them in facing with fire-retardant vapor barrier adhesive reinforced with 4-inch tape.
   b. Provide insulation with a layer of open-weave glass cloth embedded into a wet coat of fire-retardant adhesive. Overlap seams at least 2 inches. Provide a finish coat of fire-retardant adhesive.

4. Medium temperature class: Cover joints and cement them in place with 4-inch-wide strips of the same material as the laminated jackets.

5. High and very high temperature class: Cover high and very high temperature equipment with custom-fitted removable blanket-type insulation. Secure blanket-type insulation with stainless steel wire lacing and hooks. Overlap ends of blanket segments to prevent gaps and voids when the piping and equipment are heated. Secure blankets snugly under nuts and bolt heads to assure complete coverage during operation and to prevent vibration-induced gaps or voids. Secure blankets in strict accordance with the manufacturer's instructions.

F. Flashing:

1. Provide flashing at jacket penetrations and terminations. Provide clearance for flashing between insulation system and piping supports.

2. Trowel a heavy tack coat of sealant over the insulation, extending it over the jacket edge 1 inch and over the pipe or protrusion 2 inches. Stretch reinforcement over the tack coat after clipping to fit over pipe and jacket. Strap clipped reinforcing with a continuous band of reinforcing to prevent curling. Then trowel sealant over the reinforcement to a minimum thickness of 1/8 inch.

3. Form aluminum caps to fit over the adjacent jacketing and to completely cover coated insulation. Hold cap in place with a jacket strap.

3.2 INSULATION THICKNESS

A. The insulation dimensional tolerances shall comply with the specified standards. Equipment insulation shall match thickness of attached piping.

END OF SECTION 424213
SECTION 424214 – ELECTRIC HEAT TRACE

PART 1 - GENERAL

1.1 SUMMARY

A. This section specified the requirements of all electric heat trace and appurtenances used in this project.

1.2 RELATED SECTION

A. Section 422700 “Process Piping General”

1.3 STANDARDS AND CODES

A. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing label.

B. Equipment listed/labeled by an NRTL shall be as dictated by the latest printing of the Electrical Testing Laboratories Accreditation Report available from the State of Washington Department of Labor and Industries, Electrical Inspection Division. Any NRTL listing/labeling shall be as accepted by the local authority having jurisdiction.

C. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer’s place of assembly. All costs and expenses incurred for such inspections shall be included in the original contract price.

1.4 SUBMITTALS

A. The Contractor shall submit catalog data showing material information including the following:

1. Pipe heat loss and cable capacity calculations for the submitted cable type.

PART 2 - PRODUCTS

2.1 HEAT TRACE CABLE AND COMPONENTS

A. Provide heat trace system appropriate for the piping material and area classification.

B. The self-regulating heat trace cable shall consist of two (2) 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length. The heat trace cable shall be constructed to allow the tape to be
crossed over itself without overheating. The cable shall be capable of being cut to length in the field. The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a modified polyolefin or fluoropolymer outer jacket.

C. A ground-fault protection device set at 30 mA, with a nominal 100-ms response time, shall be used to protect each circuit.

D. The heating cable shall be Raychem BTV-CT or BTV-CR self-regulating heater, with continuous exposure (maintain) capability up to 150°F (65°C) and intermittent exposure capability up to 185°F (85°C), or approved equal.

E. Ambient and line sensing thermostats shall be installed for each circuit. Thermostats shall have an adjustable setpoint and contain a fluid filled, stainless steel sensor operating a SPST switch rated to 22 amperes at 120 volt AC, minimum. Enclosure shall be NEMA 4X, case aluminum with stainless steel hardware. Thermostat shall be Raychem AMC-1A, Barksdale, or approved equal.

F. Heat trace terminators shall be provided at the un-powered end of each circuit. Terminator shall include a pilot light indicating the heat trace is energized, Raychem E-100-L-A or approved equal. Power connection, end terminators, splice and tee kits components shall be applied in the field.

2.2 HEAT TRACE CAPACITY SELECTION

A. The heat trace cable capacity shall be sized according to the maximum expected heat loss for a given pipe material, pipe diameter and insulation thickness. The ambient temperature shall be assumed to be 10 degrees F and the minimum required pipe temperature shall be assumed to be 50 degrees F. Calculations of pipe heat loss used for cable selection shall be submitted for approval.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Heat trace tape shall be applied linearly on the pipe after piping has been successfully pressure tested. Heat trace shall be secured to piping with cable ties or fiberglass tape in accordance with the manufacturer’s instructions. After completing the insulation, “electric traced” labels shall be applied to the outside of the thermal insulation.

3.2 TESTS

A. After installation and before and after installation of the thermal insulation, heat trace shall be tested using a 2500 volt DC megger. Minimum acceptable insulation resistance shall be 20 megohms to ground. Completed test data shall be submitted to the ENGINEER.
HEAT TRACE TEST FORM

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<th>CABLE IDENTIFICATION</th>
<th>LOCATION</th>
<th>RESISTANCE TO GROUND</th>
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END OF SECTION 424214
SECTION 432113 - CENTRIFUGAL LIQUID PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Vertical multi-stage pumps for plant effluent.

1.2 SUBMITTALS

A. Product Data: Submit information concerning materials of construction and fabrication.

B. Shop Drawings:
   1. Submit detailed dimensions for materials and equipment, including wiring and control diagrams, performance charts and curves, equipment weights, installation and anchoring requirements, fasteners, and other details.
   2. Include manufacturer's specified displacement tolerances for vibration at operational speed specified for pumps.

C. Product Data: Submit information concerning materials of construction and fabrication.

D. Manufacturer's Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures, anchoring, and layout.

E. Source Quality-Control Submittals: Schedule of factory tests, equipment lead time, and delivery to job site. Indicate results of factory tests and inspections.

F. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

G. Manufacturer Reports: Indicate that equipment has been installed according to manufacturer's instructions.

H. Manufacturer’s Warranty

1.3 QUALITY ASSURANCE

A. The pumping equipment specified herein shall be the design and fabrication of a single manufacturer which shall have sole source responsibility for said equipment. The manufacturer shall have pumping equipment of this design and of comparable capacity in successful operation in the field for a minimum of 10 years.

B. Reference Standards: Design, manufacturing and assembly of elements of the equipment herein specified shall be in accordance with the standards of the below listed organizations. Where reference is made to a standard of one of the following or other organizations, the version of the standard in effect at the time of the bid opening shall apply.
1. American National Standards Institute (ANSI)
2. Anti-Friction Bearing Manufacturer’s Association (AFBMA)
3. Hydraulic Institute Standards
4. National Electrical Code (NEC)
5. Underwriters Laboratories, Inc. (UL)

1.4 SPARE PARTS

A. Sets consisting of the following spare parts shall be provided for each pump:

1. 2 each – all gaskets
2. 2 each – all bearings
3. 1 each – mechanical seal
4. 1 each – impeller
5. 1 each – backing plate

PART 2 - PRODUCTS

2.1 VERTICAL MULTI-STAGE PUMPS

A. Manufacturer List:

1. Goulds
2. Grundfos
3. Approved Equal

B. Description: Vertical multi-stage centrifugal pump, with close-coupled, single speed electric motor.

1. C3 Pump
2. Equipment Number
   a. PMP 240001
   b. PMP 240002

C. Performance and Design Criteria:

1. Design Flow Rate: 75 gpm.
3. Minimum Flow Rate: 50 gpm
4. Minimum Flow Total Dynamic Head: 305 feet
5. Maximum Flow Rate: 110 gpm
6. Maximum Flow Total Dynamic Head: 210 feet
7. NPSH Required: 10 feet max
10. Shut off Head: greater than 300 ft
D. Pump Casing:
   1. Material: ASTM A48-30 B, cast iron
   2. Type: Single volute.
   3. Connections: Air vent and drain.

E. Impeller:
   1. Material: AISI stainless steel
   2. Secured to pump shaft by stainless steel tapered split cone and locking nut or splined shaft arrangement.
   3. Statically and dynamically balanced after assembly.

F. Pump Shaft:
   1. Material: AISI stainless steel
   2. Key couplings to shaft.
   3. Furnish shaft wearing sleeve.

G. Coupling:
   1. Connect pump shaft to drive motor with universal flexible coupling to compensate for minor misalignment.
   2. Shaft Guard: Enclose shaft and universal joint with enclosed-type metal shaft guard complying with OSHA Standards.

H. Wearing Rings:
   1. Replaceable.
   2. Stainless-steel fasteners.

I. Bearings:
   1. Intermediate and lower shaft bearings shall be bronze or tungsten carbide and ceramic.
   2. Minimum L-10 Life: 100,000 hours at continuous maximum load and speed, according to ABMA 9.

J. Seals: Mechanical seal with tungsten carbide deal faces mounted in stainless steel seal components.

K. Lubrication: Oil

L. Base:
   1. Heavy cast-iron base with drip rim and drain connection.

M. Operation:
   1. Electrical Characteristics: As specified in Section 260500 “Common Work Results for Electrical” and following:
a. 10 hp  
b. Voltage 460 V, three phase, 60 Hz.

2. Motors: As specified in Section 460513 “Common Motor Requirements for Water and Wastewater Equipment.”
3. Controls: As specified in Section 409513 “Panels” - Process Control Panels and Hardware Disconnect Switch: Factory mounted in control panel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pumps where indicated on Drawings and in accordance with manufacturer's instructions.
B. Provide and connect piping, power and control conduit, and wiring to make system operational and ready for startup.
C. Flush piping with clean water.

3.2 FIELD QUALITY CONTROL

A. Pre-operational Check: Before operating system or components, perform the following:
   1. Check pump and motor alignment.
   2. Check for proper motor rotation.
   3. Check pump and drive units for proper lubrication.
B. Startup and Performance Testing:
   1. Operate pump on clear water at design point for continuous period of two hours, under supervision of manufacturer's representative and in presence of Engineer.
C. Verify pump performance by performing time-drawdown test or time-fill test.
D. Check pump and motor for high bearing temperature and excessive vibration in accordance with the manufacturer's recommendations. Check for motor overload by taking ampere readings.
E. Equipment Acceptance:
   1. Adjust, repair, modify, or replace system components that fail to perform as specified, and rerun tests. Make final adjustments to equipment under direction of manufacturer's representative.

END OF SECTION 432113
SECTION 432113.16 - SUBMERSIBLE NON-CLOG PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Submersible non-clog pumps.

1.2 SUBMITTALS

A. Shop Drawings:

1. Detailed dimensions for materials and equipment, including wiring and control diagrams, performance charts and curves, equipment weights, installation and anchoring requirements, fasteners, and other details.
2. Include manufacturer’s specified displacement tolerances for vibration at operational speed specified for pumps.

B. Product Data: Information concerning materials of construction, fabrication, and protective coatings.

C. Manufacturer's Installation Instructions: Submit detailed instructions on installation requirements including storage and handling procedures, anchoring, and layout.

D. Source Quality-Control Submittals: Schedule of factory tests, equipment lead time, and delivery to job site. Indicate results of factory tests and inspections.

E. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

F. Manufacturer's Field Reports: Certify equipment has been installed according to manufacturer’s instructions.

G. Manufacturer’s Warranty

1.3 QUALITY ASSURANCE

A. The pumping equipment specified herein shall be the design and fabrication of a single manufacturer which shall have sole source responsibility for said equipment. The manufacturer shall have pumping equipment of this design and of comparable capacity in successful operation in the field for a minimum of 10 years.

B. Reference Standards: Design, manufacturing and assembly of elements of the equipment herein specified shall be in accordance with the standards of the below listed organizations. Where reference is made to a standard of one of the following or other organizations, the version of the standard in effect at the time of the bid opening shall apply.
1. American National Standards Institute (ANSI)
2. Anti-Friction Bearing Manufacturer’s Association (AFBMA)
3. Hydraulic Institute Standards
4. National Electrical Code (NEC)
5. Underwriters Laboratories, Inc. (UL)

1.4 EXTRA MATERIALS

A. Furnish one complete set of manufacturer's recommended spare parts for each pump, including:
   1. One set lower and upper seals.
   2. One set lower and upper bearings.
   3. One impeller.
   4. Impeller wear ring.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE NON-CLOG PUMPS

A. Manufacturers
   1. ITT Flygt Corp.
   2. Fairbanks Morse Pump Corp.
   3. ABS Pump
   4. Approved Equal

B. General:
   1. Submersible non-clog pumps, each equipped with submersible electric motor. Furnish power and signal hypalon jacketed type SPC cable. Furnish mating cast iron discharge connection elbow.
   2. Furnish each pump with stainless steel lifting chain of strength to permit raising and lowering pump.

C. The following is the list of submersible pumps to be furnished in this Contract:

<table>
<thead>
<tr>
<th>Pump Service</th>
<th>Equipment</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent Pump</td>
<td>PMP 310001</td>
<td>Submersible (Single Speed)</td>
</tr>
<tr>
<td>Influent Pump</td>
<td>PMP 310002</td>
<td>Submersible (Single Speed)</td>
</tr>
<tr>
<td>Feed Forward Pump</td>
<td>PMP 040102</td>
<td>Submersible (VFD)</td>
</tr>
<tr>
<td>Feed Forward Pump</td>
<td>PMP 040103</td>
<td>Submersible (VFD)</td>
</tr>
<tr>
<td>Feed Forward Pump</td>
<td>PMP 040202</td>
<td>Submersible (VFD)</td>
</tr>
<tr>
<td>Feed Forward Pump</td>
<td>PMP 040202</td>
<td>Submersible (VFD)</td>
</tr>
<tr>
<td>WAS Pump</td>
<td>PMP 190101</td>
<td>Dry-pit Submersible (VFD)</td>
</tr>
</tbody>
</table>
D. Pump Design:

1. Influent Pump and Feed Forward Pump
   
   a. Discharge connection elbow permanently installed in wet well with discharge piping.
   b. Connected automatically to discharge connection elbows when lowered into place and easily removed for inspection or service.
   c. Integral sliding guide bracket part of pump unit; entire weight of pump unit guided by no less than two guide bars and pressed tightly against discharge connection elbow with metal-to-metal contact.
   d. Discharge interface sealed by means of diaphragm.
   e. Do not permit any portion of pump to bear directly on floor of sump.
   f. Capable of continuous submergence underwater without loss of watertight integrity to depth of 20 ft.
   g. Provide two impellers for each Influent pump: 1) installed impeller trimmed for initial operating condition 2) spare impeller trimmed for future operating condition.

2. WAS Pump
   
   a. Pump shall be capable of operating in a continuous non submerged condition in horizontal (NZ) position in a dry pit installation and permanently connected to inlet and outlet pipes. Pump shall be of submersible construction and will continue to operate satisfactorily should the dry pit be subjected to flooding.
E. Performance and Design Criteria:

<table>
<thead>
<tr>
<th>Pump</th>
<th>Type of Sludge Pumped</th>
<th>Capacity (GPM)</th>
<th>Discharge Head (TDH)</th>
<th>Maximum Speed (RPM)</th>
<th>Maximum Motor Size</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent Pump (Initial)</td>
<td>Raw Sewage</td>
<td>Design: 937</td>
<td>54</td>
<td>1760</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Influent Pump (Future)</td>
<td>Raw Sewage</td>
<td>Design: 1875</td>
<td>58</td>
<td>1760</td>
<td>25</td>
<td>In future, the pump shall install new impeller trimmed to meet future operating point.</td>
</tr>
<tr>
<td>Feed Forward Pump</td>
<td>Mixed Liquor</td>
<td>Design: 874</td>
<td>12</td>
<td>1745</td>
<td>5</td>
<td>Explosion Proof</td>
</tr>
<tr>
<td>WAS Pump</td>
<td>Sludge (3% to 5% solids)</td>
<td>Design: 550</td>
<td>30.4</td>
<td>1745</td>
<td>7.5</td>
<td>Explosion proof. Min. connection size: 4”</td>
</tr>
</tbody>
</table>

F. Pump Construction:

1. Gray cast iron, ASTM A48/A48M (Class 30), with smooth surfaces devoid of blow holes and other irregularities.
2. Exposed nuts and bolts ASTM A276 Type 304 stainless steel construction.
3. Spray exterior with PVC epoxy primer and chloric rubber paint finish.
4. Seal mating surfaces watertight, machined and fitted with nitrile rubber O-rings.
5. Seal fittings by metal-to-metal contact between machined surfaces.

G. Cable Entry Seal:

1. Design cable entry water seal of single cylindrical elastomer grommet, flanked by stainless steel washers, with close tolerance fit against cable outside diameter and entry inside diameter and compressed by entry body containing strain relief function, separate from function of sealing cable.
2. Bear assembly against shoulder in pump top.
3. Separate cable entry junction chamber and motor by stator lead sealing gland or terminal board that isolates motor interior from foreign material gaining access through pump top.

H. Mechanical Seal System:

1. Shaft: ASTM A276 Type 420 stainless steel.
2. Shaft Seal: Tandem mechanical type.
3. Upper Tandem Set of Seals: Operate in oil chamber located just below stator housing; one stationary tungsten-carbide ring and one positively driven rotating carbon ring.
4. Lower Tandem Set of Seals: Stationary tungsten carbide ring and positively driven rotating tungsten carbide ring.
5. Furnish pump with oil chamber for shaft sealing system; drain and inspection plug, with positive anti-leak seal, accessible from outside.
6. Rotate shaft on two permanently lubricated bearings; upper bearing single row roller bearing and lower bearing two row angular contact ball bearing.
7. Mount double electrode in seal chamber to actuate remote alarm when water is detected in seal chamber.

I. Impeller and Volute:

1. Impeller gray cast iron, ASTM A48/A48M (Class 30), dynamically balanced, double shrouded non-clogging design having long threut without acute turns.
2. Furnish impeller capable of handling solids, fibrous materials, sludge and other matter found in normal sewage applications.
3. Furnish impeller of two vane design, capable of passing minimum 3 inch solid sphere.
4. Furnish fit between impeller and shaft sliding fit with one key.
5. Furnish volute of single piece, non-concentric design with smooth fluid passages capable of passing solids passing through impeller.
6. Install wear ring system for sealing between volute and impeller.
7. Furnish wear ring system of stationary ring made of nitrile rubber molded with steel ring insert drive fitted to volute inlet and rotating stainless steel ASTM A276 304 ring drive fitted to impeller skirt.

J. Pump Motor:

1. Squirrel-cage, induction, shell type design, housed in air-filled, watertight chambers, non-overloading throughout entire pump performance range based on 1.0 service factor.
2. Motors with VFD’s shall be inverter duty rated.
3. Furnish stator windings and stator leads insulated with moisture resistant Class F insulation capable of resisting temperature of 155 degrees C.
4. Furnish stators dipped and baked three times in Class F varnish and heat-shrink fitted into stator housings.
5. Furnish motors designed for continuous duty, capable of sustaining minimum of ten starts per hour.
6. Furnish pump with cooling system consisting of water jacket that encircles stator housing.
7. Furnish cooling media channels. Furnish parts non-clogging by virtue of their dimension with separate, clear, external motor cooling and lower seal flushing.
8. Furnish pump motor capable of operating indefinitely without overheating when unsubmerged and operating in air.
9. Furnish junction chamber, containing terminal board, sealed from motor by elastomer compression seal (O-ring).
10. Furnish connection between cable conductors and stator leads made with threaded compressed type binding post permanently affixed to terminal board.
11. Furnish thermal sensors to monitor stator temperatures; stator equipped with three thermal switches embedded in end coils of stator winding (one switch in each stator phase).

K. Pump Relay Panel:

1. Furnish pump relay panel consisting of Hoffman NEMA 250 4X fiberglass clamp-cover enclosure housing supervision relay (or relays) for pump temperature and leakage
sensors, 15 amp, 1 phase circuit breaker, 24 VAC transformer with necessary fusing, Allen-Bradley Bulletin 800H reset push button for temperature circuit, 600 VAC terminal blocks for pump power and signal wiring, and ground lug.

2. Furnish laminated phenolic nameplate on front of each pump relay panel; black with white engraved letters reading PUMP RELAY PANEL.

L. Access Frames, Covers and Guides:

1. Furnish aluminum access frame and cover, complete with hinged and flush locking mechanisms, upper guide holders and level sensor cable holders.
2. Secure frames placed, mounted above pumps and provided with sliding nut rails to attach accessories required.
3. Integral lower guide bar holders with discharge connections.
5. Covers: Skid proof design.

2.2 ELECTRICAL CHARACTERISTICS AND COMPONENTS

A. Electrical Characteristics: According to Section 260500 and following:

1. 460 volts, three phase, 60 Hz.

B. Motors: According to Section 460513.

C. Disconnect Switch: Factory mounted in control panel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify layout and orientation of pumps, accessories, and piping connections.

3.2 INSTALLATION

A. Install pumps and accessories where indicated and according to manufacturer's instructions.

B. Provide and connect piping, accessories, power and control conduit and wiring to make system operational, ready for startup.

C. Flush piping with clean water.

3.3 FIELD QUALITY CONTROL

A. Pre-operational Check: Before operating system or components, check:

1. Pump and motor alignment.
2. Proper motor rotation.
3. Pump and drive units for proper lubrication.

B. Startup and Performance Testing:
   1. Operate pump on clear water at design point for continuous period of two hours, under supervision of manufacturer's representative and in presence of Engineer.

C. Verify pump performance by performing time/draw down test or time/fill test.

D. Check pump and motor for high bearing temperature and excessive vibration. Check for motor overload by taking ampere readings.

E. Equipment Acceptance:
   1. Adjust, repair, modify or replace system components that fail to perform as specified and rerun tests. Make final adjustments to equipment under direction of manufacturer's representative.
   2. Document adjustments, repairs and replacements in manufacturer’s field services certification.

3.4 MANUFACTURER'S FIELD SERVICES

A. Furnish services of manufacturer's representative experienced in installation of products furnished under this specification for not less than 4 days on-Site for installation inspection and field testing, and instructing Owner's personnel in maintenance of equipment.

B. Certify that equipment has been properly installed and is ready for startup and testing.

3.5 DEMONSTRATION

A. Demonstrate equipment startup, shutdown, routine maintenance, alarm condition responses, and emergency repair procedures to Owner’s personnel.

END OF SECTION 432113.16
SECTION 434200 – HYDROPNEUMATIC TANK

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies a hydropneumatic tank with replaceable heavy-duty butyl bladder for use in the plant water system.

B. Type: Hydropneumatic tank shall be horizontal, carbon steel type. Inside and outside shall be epoxy coated.

C. Equipment List: Equipment numbers are as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Equipment Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydropneumatic Tank</td>
<td>HT 240003</td>
</tr>
</tbody>
</table>

1.2 QUALITY ASSURANCE

A. Performance and Design Requirements:

1. General: The hydropneumatic tank will contain nonpotable water with a chlorine residual up to 20 mg/l. Temperatures for this water will range from 35°F to 70°F and have a pH that varies between 6 and 9.

2. Operating Requirements: The hydropneumatic tank shall be designed for a pressure booster system with cyclic pump operation. The tank shall be an ASME rated pressure vessel designed for a working pressure of 200 psig and arranged to be vertically mounted as shown on drawings. Operating requirements shall be as follows:

   a. System flow, gpm: 1-150
   b. System pressure

      1) Minimum psig: 90
      2) Maximum psig: 125

   c. Tank size

      1) Maximum Diameter, inches: 60
      2) Maximum Length, inches: 92
      3) Approximate total volume, gallons: 792
      4) Maximum liquid volume, gallons: 267
      5) Minimum liquid volume, gallons: 80

B. Designed for earthquake loads according to the UBC and seismic criteria listed in Section 220548 “Vibration and Seismic Controls.” For purposes of this requirement the weight of the tank shall be the weight when completely filled with water.

1.3 ENVIRONMENTAL CONDITIONS

A. The equipment to be provided under this specification shall be suitable for continuous service and installation indoors at an elevation near sea level. Temperatures indoors are expected to range from 50°F to 90°F. Relative humidity indoors is expected to range between 10 and 100 percent.

1.4 SUBMITTALS

A. The following submittals shall be provided in accordance with Section 013300 “Submittal Procedures”:

1. Manufacturer’s information which will show location of bosses and supports.
2. Template of supports to equipment pad anchorage requirements.
3. Drawings showing complete dimensions and confirming the location of piping connections, accessories, and weights.
4. Manufacturer’s specification data and descriptive literature including materials list.
5. All submittals required by Section VIII, Division 1 or 2 of the ASME Boiler and Pressure Vessel Code.
6. A copy of the contract document control diagrams and process and instrumentation diagrams that apply to the equipment in this section, marked to show specific changes necessary for the supplied equipment. If no changes are required, the drawings shall be marked “No Changes Required.”
7. A copy of this specification section and all referenced sections with each paragraph check marked to show specification compliance or marked to show deviations.
8. A copy of all related contract schematic, structural, and mechanical drawings with all piping, foundations, supports, and layout sizes and dimensions requiring Contractor confirmation marked.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Wessels Co.
B. Approved equal.

2.2 EQUIPMENT

A. General:

1. Hydropneumatic tanks shall be of butt welded steel construction and epoxy-coated inside and outside conforming to the requirements of Section 099600 “High Performance Coatings”.
2. Equipment delivered under this specification shall meet the requirements of Section VIII, Division 1 or Division 2 of the ASME Boiler and Pressure Vessel Code. Tank shall bear an ASME inspector’s stamp, complete with design working pressure and date and place of manufacture. Tanks and anchorage shall be designed to meet seismic loading requirements as specified in the 1997 edition of UBC for a seismic zone 3 designation. Tanks shall have a supports suitable for anchor bolting.

3. The tank shall have NPT epoxy lined system connections and a 0.302”-32 charging valve connection (standard tire valve) to facilitate the on-site charging of the tank to meet system requirements.

B. Tank Appurtenances: The tank shall be provided with the following connections and appurtenances. (Location of tank nozzles and weldolets are shown on Drawings).

1. Butt welded steel construction with field replaceable heavy duty butyl rubber bladder.
2. 3-inch flange end-mounted system connection, as shown on the drawings.
3. Equip with lifting lugs.
4. Equip with stainless steel wetted parts.
5. Safety relief valve: per Section 422701.10 “Special Valves”, 2.3

2.3 PRODUCT DATA

A. The following information shall be provided in accordance with Section 013300 “Submittal Procedures”:

1. Data required by Article AG-302.2, Division 2, in Section VIII of the ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The hydropneumatic tanks and accessories shall be installed, filled, and pressurized in strict accordance with the tank manufacturer’s written instructions and the 1997 edition of the Uniform Building Code seismic loading requirements.

B. Precharge: Perform in the presence of the Engineer.

<table>
<thead>
<tr>
<th>Equipment No.</th>
<th>Precharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT 240003</td>
<td>Factory pre charged at 30 psig and field adjustable</td>
</tr>
</tbody>
</table>
3.2 TESTING

A. After installation, the equipment specified in this section shall be completely tested to ensure compliance with operating requirements. Field testing shall be in accordance with the testing procedures in Sections 019150 “System Startup, Testing and Training” and 409002 “Testing and Commissioning”.

END OF SECTION 434200
SECTION 443119 – PACKAGED ODOR CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies the requirements for a packaged odor control system for treating foul air withdrawn from treatment plant headworks. The odor control system shall include an activated carbon adsorber vessel, carbon media, mist eliminator, exhaust fan, sound enclosure, and associated ducting, and instrumentation for a complete operating odor control system.

1.2 EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Fan Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAN 010401</td>
<td>Odor Control Fan</td>
</tr>
<tr>
<td>T010403</td>
<td>Carbon Adsorber Vessel</td>
</tr>
<tr>
<td>ME010404</td>
<td>Mist Eliminator</td>
</tr>
<tr>
<td>SE010405</td>
<td>Odor Control Fan Sound Enclosure</td>
</tr>
</tbody>
</table>

1.3 SYSTEM DESCRIPTION

A. Malodorous air shall be pulled by an exhaust fan through the grease filter/mist eliminator, then enter the carbon adsorber and flow through a densely packed bed of activated carbon. The air shall continue through the carbon adsorber and be exhausted through the outlet. The activated carbon shall remove hydrogen sulfide and other odor causing constituents.

1.4 WARRANTY

A. All equipment supplied under this Section of the Specifications shall be warranted for a period of one (1) year from date of substantial completion, providing all equipment is operated in strict accordance with the manufacturers Operations and Maintenance Manual.

B. The equipment shall be warranted to be free from defects in workmanship, design, and materials. If any part of the equipment should fail during the warranty period, it shall be repaired or replaced and the unit(s) restored to service at no expense to the Owner.
1.5 PERFORMANCE REQUIREMENTS

A. Odor Control System: The odor control system will be utilized to remove volatile malodorous compounds of municipal sewage off-gases. These gases could contain but are not limited to ammonia, hydrogen sulfide and mercaptans. The odor control system components shall meet the following design requirements:

1. Carbon Adsorber:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Requirement Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum operating temperature, °F</td>
<td>95</td>
</tr>
<tr>
<td>Inlet Hydrogen Sulfide Concentration, ppm</td>
<td>10</td>
</tr>
<tr>
<td>Air Flow Rate, cfm</td>
<td>500</td>
</tr>
<tr>
<td>Minimum Inside diameter, ft</td>
<td>3.5</td>
</tr>
<tr>
<td>Maximum face velocity, fpm</td>
<td>52</td>
</tr>
<tr>
<td>Number of carbon beds</td>
<td>1</td>
</tr>
<tr>
<td>Maximum carbon depth, feet</td>
<td>3</td>
</tr>
<tr>
<td>Maximum face velocity in bed, fpm</td>
<td>3.5</td>
</tr>
<tr>
<td>Static Pressure Drop in WC</td>
<td>5.0”</td>
</tr>
<tr>
<td>Minimum Weight carbon bed, pounds</td>
<td>735</td>
</tr>
<tr>
<td>Minimum H₂S removal at ≤1 ppm inlet</td>
<td>95%</td>
</tr>
<tr>
<td>Minimum H₂S removal at ≥10 ppm</td>
<td>99%</td>
</tr>
</tbody>
</table>

2. Mist Eliminator:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Requirement Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Flow Rate, cfm</td>
<td>500</td>
</tr>
<tr>
<td>Static Pressure Drop in WC</td>
<td>1.5”</td>
</tr>
<tr>
<td>Droplet removed, &gt;10 microns</td>
<td>99.9%</td>
</tr>
<tr>
<td>Droplet removed, &gt;5 microns</td>
<td>80%</td>
</tr>
</tbody>
</table>

3. Fan: The fan shall be designed and selected for continuous operation.
   a. The fan shall be suitable for operation in Class 1, Division II, Group D environment and located outdoors.
   b. Air stream temperatures are expected to vary between 50 and 95 degrees F.
   c. The fan shall be capable of operating at the following conditions:
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Flow Rate, cfm</td>
<td>500</td>
</tr>
<tr>
<td>Static Pressure upstream of Mist Eliminator</td>
<td>1.0</td>
</tr>
<tr>
<td>Mist Eliminator Pressure Drop, in. WC</td>
<td>1.5</td>
</tr>
<tr>
<td>Carbon Adsorber Pressure Drop, in. WC</td>
<td>5</td>
</tr>
<tr>
<td>Total S.P., in WC</td>
<td>7.5</td>
</tr>
<tr>
<td>Minimum Motor HP</td>
<td>2</td>
</tr>
<tr>
<td>Minimum Wheel Diameter, inches</td>
<td>18</td>
</tr>
<tr>
<td>Voltage/phase</td>
<td>460/3</td>
</tr>
<tr>
<td>Max Fan RPM</td>
<td>1,950</td>
</tr>
<tr>
<td>Max Motor RPM</td>
<td>1,800</td>
</tr>
</tbody>
</table>

4. **Noise Performance Requirements**

   a. Maximum noise emission of the entire odor control system shall meet the following requirements with all equipment running at capacity including the sound enclosure.

   1) Not to exceed 65 dba at 10 ft.

1.6 **QUALITY ASSURANCE**

   A. **Referenced Standards:**

   1. ASTM D883: Standard Terminology Relating to Plastics
   2. ASTM D2471: Standard Test Method for Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins
   6. ASME RTP-1: Reinforced Thermoset Plastic Corrosion Resistant Equipment
   7. NBS Voluntary Product: Standard PS 15-69, Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment
   9. ASTM D4097: Standard specification for contact-molded glass fiber reinforced thermoset resin corrosion resistant tanks.
B. All systems shall be supplied by a single manufacturer fully experienced, reputable and qualified in the manufacture of the equipment to be furnished.

C. In order to ensure unity of responsibility, equipment skid, fan, ducting, odor control vessel, mist eliminator, carbon and other miscellaneous system appurtenances shall be furnished by a single manufacturer.

D. The supplier shall also provide a list of five installations where such identical equipment is in service, with names and contact phone numbers.

E. Equipment provided under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with contract drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the Engineer.

F. Equipment provided under this section shall be furnished and installed complete with all mechanical and electrical equipment required for proper operation, all components indicated on the contract drawings and specification, and any additional materials or construction required by the manufacturer’s design.

G. Equipment shall be designed for long life under working conditions and design requirements specified herein for intermittent or continuous operation. All wearing parts and items requiring adjustment shall be readily accessible. All parts, which are exposed to corrosive conditions, shall be made from corrosive-resistant materials.

H. The manufacturer shall be regularly engaged in the design and manufacture of canister-type activated carbon odor control systems. Detailed design of the FRP tank shall follow the procedures and methods, utilize the equations and formulas, and incorporate safety factors and allowable design stresses and strains set forth in ASME/ANSI RTP-1.

I. Certification: Fan shall bear the AMCA rating seal for both Air and Sound performance. Fan shall be from a manufacturer’s model line that bears the AMCA seal prior to the submittal review.

J. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.7 SUBMITTALS

A. Product drawings and cut sheets, descriptive literature, bulletins and catalogs on all equipment including but not limited to the following.

2. Detailed drawings to include all external piping connections and associated sizes, and materials of construction.
3. Control system schematic diagrams indicating necessary field connections.
4. The manufacturer’s standard installation, operation and maintenance manual.
5. Data and descriptive material showing materials of fabrication, sizes of components, mounting hardware, and installation requirements for sound enclosure.
B. Fan performance curves for the specified operating condition and for the ultimate capacity conditions. Ultimate capacity is the maximum flow at which the fan is recommended to operate by the manufacturer.

C. Fan motor and sound level data

D. Dimensioned drawing of fan including motor V-belt drive and base.

E. Sound power level ratings in eight octave bands in accordance with AMCA Standards 300 and 301.

F. Bearing ratings with supporting calculations for the fan and motor at design conditions.

G. Shop drawings: Dimensioned drawing including direct drive motor and base.

1.8 PRODUCT HANDLING

A. All equipment items shall be properly protected so that no damage or deterioration will occur from the time of shipment until installation is completed and the units and equipment are ready for operation.

B. Finished surface of all exposed equipment openings shall be protected.

C. Proper care shall be taken to protect mechanical parts from the entrance of water during shipment, storage, and handling.

D. Each box or package shall be properly marked to show its contents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS LIST

A. Siemens

B. Spunstrand

C. Approved Equal

2.2 CARBON ADSORBER VESSEL

A. The vessel shall be made of FRP and shall be designed for not less than 20 inches water column pressure and 12 inches water column vacuum. The design, applicable construction, and inspections shall be in accordance with ASME RTP-1 Level II visual inspection criteria.

B. Fabrication shall be in accordance with NBS PS 15-69, ASTM D 3299 and ASTM D 4097.

C. A minimum structural safety factor of 5 shall be used in the design of the Vessel.
D. The resin used shall be Hetron 992FR or approved equal selected to meet the exposures and temperatures of the air to be exhausted.

E. Exterior laminates shall contain sufficient resin to insure a relatively smooth surface free from exposed glass fibers or sharp projections. Adsorber vessels located outdoors shall contain an exterior colored surface coat with white gel coat containing ultraviolet light inhibitors.

F. The bed shall have top access manway for filling and replacing the adsorber media.

G. Differential Pressure Gauge: The carbon vessel shall consist of a Dwyer series 2000 differential pressure gauge to continuously monitor the pressure drop across the carbon bed. The differential pressure gauge shall be isolated with isolation valves and shall be mounted on the vessel.

H. Carbon Sample Probes: The carbon vessel shall have a minimum of three 1” diameter sample probes per bed which shall extend into the bed a minimum of 12 inches. The sample probes shall be blocked off with a ball valve constructed of PVC.

I. A stainless steel grounding rod shall be provided to adequately ground each carbon bed. Rods shall be grounded via a 10-guage wire.

J. Exhaust Stack: An exhaust stack shall be provided as shown on the drawings to prevent rain water from entering into the system and shall have a maximum velocity of 2,000 fpm.

K. The adsorber inlet and outlets shall be flanged as shown on the drawings.

L. Vessel shall be equipped with a minimum of 3/4” NPT drain connection.

M. Activated carbon shall be specifically manufactured for continuous exposure to moisture-laden foul air containing concentrations of hydrogen sulfide up to 10 parts per million. Foul air will have temperatures ranging from 50 to 95 degrees F and relative humidity up to 100 percent.

N. Activated Carbon: Activated carbon shall be virgin, pelletized, derived from bituminous coal, vapor phase type, suitable for control of sewer odors. The carbon shall not contain chemical impregnants. The carbon shall have the following performance specifications:
<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodine No., milligrams per gram (per ASTM D4607)</td>
<td>1,000</td>
</tr>
<tr>
<td>Hardness number, minimum (per ASTM D3802)</td>
<td>95</td>
</tr>
<tr>
<td>Ash, % by Weight (per ASTM D2866)</td>
<td>10</td>
</tr>
<tr>
<td>Maximum moisture content, percent by weight (per ASTM D2867)</td>
<td>5</td>
</tr>
<tr>
<td>Apparent density, grams per cubic centimeter, minimum (per ASTM D2854)</td>
<td>0.45 to 0.55</td>
</tr>
<tr>
<td>Maximum head loss through bed at 50 feet per minute linear velocity, in inches water gauge per foot bed depth</td>
<td>0.6 loose pack 1.5 dense pack</td>
</tr>
<tr>
<td>Nominal Size, diameter, mm</td>
<td>4</td>
</tr>
<tr>
<td>Sieve Fraction through 6 mesh, wt %</td>
<td>5</td>
</tr>
<tr>
<td>H$_2$S Capacity, minimum$^2$</td>
<td>&gt;0.01 grams H$_2$S removal per cubic centimeter carbon</td>
</tr>
</tbody>
</table>

$^1$Pressure drop shall be determined by passing dry air at 70 degrees F and one atmosphere pressure through a 2-inch diameter x 12-inch deep bed of carbon placed in a dense packed arrangement per ASTM D2854.

$^2$Determination of H$_2$S breakthrough capacity shall be in accordance to ASTM D6646-01. Results are expressed in grams H$_2$S removed per cubic centimeter of carbon.

### 2.3 MIST ELIMINATOR

A. The mist eliminator shall be designed for continuous outdoor operation, conveying corrosive air, gases and miscellaneous service generated by treatment of municipal wastewater.

B. The mist eliminator shall consist of single housing with two layers of filter pads one for grease and one for mist, housed inside a fiberglass reinforced plastic (FRP) enclosure.

C. The FRP housing shall be designed for not less than 10 inches water column pressure and 10 inches water column vacuum. The design, applicable construction, and inspections shall be in accordance with NBS PS 15-69 and SMACNA.

D. A minimum structural safety factor of 4 shall be used in the design of housing.

E. Maximum deflection of rectangular components under dead load and operating conditions shall not exceed 1 percent of the width of the longest side.

F. Exterior laminates shall contain sufficient resin to insure a relatively smooth surface free from exposed glass fibers or sharp projections. Adsorber vessels located outdoors shall contain an exterior colored surface coat with white gel coat containing ultraviolet light inhibitors. Color should match the connecting ductwork and the carbon vessel.

G. Equipment Features:
1. The Mist eliminator shall consist of a 6” slide in type woven polypropylene removable mesh pad housed inside the fiberglass housing.
2. The grease filter pad shall be 304 stainless steel pad nominal 2” thick for grease removal of 80% at 5 micron.
3. A Dwyer 2003 magnehelic gauge shall be provided on the outside of the housing with Polyethylene tubing attached to 1/8” FPT coupling on the inlet and outlet transitions. The range of the magnehelic gauge shall be 0-3” W.C.

H. The pads shall be removable for cleaning.

I. Foul airflow shall be horizontal.

J. The FRP housing shall have flanged and drilled to be ready for installation into the system supply ductwork.

K. A minimum 1” NPT schedule 80 PVC drain coupling shall be provided in the bottom of the fiberglass housing.

2.4 FAN

A. Materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>Fiberglass Reinforced Plastic</td>
</tr>
<tr>
<td>Wheel</td>
<td>Fiberglass Reinforced Plastic</td>
</tr>
<tr>
<td>Shaft seal</td>
<td>Teflon</td>
</tr>
<tr>
<td>Hub</td>
<td>Type 316 stainless steel encapsulated in FRP</td>
</tr>
<tr>
<td>Bolts</td>
<td>Type 316 stainless steel</td>
</tr>
<tr>
<td>Base</td>
<td>Epoxy coated steel</td>
</tr>
<tr>
<td>Shaft</td>
<td>Type 316L stainless steel</td>
</tr>
</tbody>
</table>

B. FRP Fabrication:

1. Housing:
   a. Ultraviolet light stabilized.
   b. Structural layer resin shall, if necessary, contain antimony trioxide, antimony pentoxide, or equivalent fire retardant to achieve ASTM Class II fire retardance of 30 or less.
   c. Built up with laminate construction using vinyl ester resin such as Dow Derakane 510A-40, or equivalent, a C-glass or equivalent veil for corrosion resistance and chopped strand fiberglass for structural core strength.
   d. Outer layers: A 100 percent resin gel coat.
   e. The next layer shall be a C-glass or equivalent corrosion resistant veil followed by another resin rich gel coat layer and another C-glass or equivalent veil.
   f. Structural core layer: Comprised of resin and chopped strand fiberglass. Total glass content shall be 30 to 40 percent.
Wheel and housing shall have a carbon-rich resin coating on air stream contact surfaces and shall be grounded through the base to prevent static buildup. Provide housing with an access door.

2. Wheel:
   a. Built up using laminate construction.
   b. Resin: Vinyl ester such as Dow Derakane 510A-40 or equivalent.
   c. Wheel material shall, if necessary, contain antimony trioxide, antimony pentoxide, or equivalent fire retardant to achieve ASTM Class II fire retardance of 30 or less.
   d. First layer of wheel laminate: A 100 percent resin gel.
   e. The next layer shall be a C-glass corrosion resistant veil followed by another resin rich gel coat and another C-glass veil.
   f. Structural core consisting of chopped strand fiberglass and resin shall be laid next, followed by a C-glass veil, a resin rich gel coat, another C-glass veil, and a final 100 percent resin gel coat. Total glass content shall be 30 to 40 percent.
   g. Wheel shall be graphite impregnated and grounded to prevent static buildup.

3. Type: Construction type and material thicknesses shall be in accordance with ASTM D4167.

C. Fan shall be v-belt driven arrangement#10.

D. Shaft: Shafts shall be Type 316L stainless steel, precision turned, ground and polished. The shaft’s critical speed shall be at least 125% of the fan’s maximum operating speed.

E. Balance and Vibration: Wheels shall be dynamically balanced before assembly. The vibration of the assembled fan and drive shall be checked prior to shipment to assure that it does not exceed 1.5 mils RMS displacement at full speed and design load. The Manufacturer stating that the fan has been tested and found to meet these criteria shall provide a certificate of compliance.

F. Motor bearings shall be self-aligning, grease lubricated and prelubed, antifriction bearings of the pillow block type, complete with grease fittings.

1. Motor: Motor shall be a severe duty, Totally Enclosed Fan Cooled (TEFC) motor meeting the requirements of NEC 501 for a Class I, Division 2, Group D area. Motor shall be inverter duty rated at 10:1 turndown for continuous operation with a variable frequency drive.
   2. Electrical characteristics shall be 460 volts, 3-phase, 60 Hertz.
   3. Baldor, Reliance, Siemens, or Emerson shall manufacture the motor.
   4. Motor shall have a temperature sensing device embedded in the motor winding which is sensitive to both over temperature and rate of temperature rise.
   5. 1.15 Service Factor

G. Construction

1. Configurations shall be as indicated on Drawings.
2. Rotor: Statically and dynamically balanced after fabrication.
3. One-inch FRP drain connection at the lowest point of the scroll housing.
4. Provide flanged outlets suitable for a flanged flexible connection. All flanges shall be factory drilled. Inlet and outlet shall be a minimum of 6-inches, ANSI 150 lb flange connection and suitable to connect to carbon adsorber vessel and the mist eliminator.

5. Inspection port, cleanout door, and a 1-inch FNPT drain coupling.

6. All fasteners shall be Type 316 stainless steel.

7. Base shall be fabricated of epoxy coated steel, adequately braced, and equipped with lifting eyes.

H. Painting: All fan exposed surfaces are to be thoroughly prepared prior to factory painting. After cleaning, all surfaces are to be bead blasted 316 SS. On-site painting will not be allowed.

I. Fan shall include graphite impregnation for grounding.

2.5 SOUND ENCLOSURE

A. Construction:

1. All panels shall be minimum 3 inches thick with a solid metal exterior shell and a perforated metal interior facing.
2. The outer shell shall be constructed of 16 gage aluminum and the interior facing constructed of 22 gage aluminum.
3. Each panel assembly shall be completely filled with acoustic insulating material, which is non-combustible, inert, mildew-resistant, and vermin-proof. Insulation shall be of a type that will not settle within the panel assembly.
4. All external panel connectors, external trim, base channels/panel interfaces, base channel floor interfaces, and penetrations for equipment shall be sealed with a permanently resilient sealant. Sealant to be supplied by the enclosure manufacturer. Sufficient sealant shall be used to extrude surplus sealant and give a visual indication of complete coverage in all joints. The sealant shall have an adhesive strength to prevent air leakage through the assembly when a pressure differential exists, but still allow system disassembly without damage to the panel components.
5. Enclosure shall have silenced intake and exhaust.
6. Sound enclosure should provide natural draft cooling sufficient to keep fan motor from overheating.

B. Enclosure Accessories:

1. Access Doors: Provide a removable access door where indicated.
2. The door shall be equipped with acoustical compression style seals installed around the entire perimeter of the door frame in such a manner that the door operation will provide direct compression with no sliding action between the door and seals.
3. Ventilation System: Provide a ventilation system for the enclosure to draw adequate amount of air through the enclosure for removal of heat generated by the fan and motor. The ventilation system shall maintain the acoustical integrity of the enclosure and shall consist of the following components:
   a. An air intake opening silenced with a lined plenum or elbow-type duct silencer built into and utilizing one of the enclosure panels. The intake opening shall be covered with a suitable intake grate or grill.
b. An air discharge opening acoustically treated to the same degree as the inlet silencer opening.
c. An interior ventilation fan capable of drawing adequate amount of cooling air through the enclosure and the acoustically treated intake and discharge silencers.
d. Thermostatic Fan Control.

2.6 EQUIPMENT SKID

A. The entire system shall be factory assembled on a carbon steel equipment skid to minimize field installation requirements. The skid shall be sand blasted and coated with a two-part epoxy enamel, with a compatible primer coat.

2.7 INTERCONNECTING DUCT WORK

A. The odor control system manufacturer shall provide the necessary ductwork between the fan and the carbon adsorber vessel. Flexible connectors shall be provided to dampen axial, lateral and vibration duct movement as shown in the contract drawings.

2.8 CONTROLS

A. Odor control unit controls include a main disconnect, fan control switch with pilot lamp to indicate the fan running, and speed control for the fan.

2.9 SYSTEM WIRING

A. The Contractor shall provide power and necessary controls to the fan as indicated on the drawings and listed in this specification. Contractor shall install in accordance with the Manufacturer’s recommendations. All wiring shall be in accordance with National Electrical Code (NEC), and all other related local electrical and fire codes requirements.

PART 3 - EXECUTION

3.1 INSTALLATION AND INSPECTION

A. Equipment installation shall be in strict accordance with the manufacturer's requirements. Units shall be vibration isolated using "seismically restrained 1” deflection spring vibration isolators in hot dip galvanized housings. Units shall be installed in locations shown on drawings and as detailed. Units shall be supported and braced as required to meet Uniform Building Code seismic zone 3 requirements and to be level and aligned.

B. The carbon shall be installed in strict accordance with manufacturer's recommendations. Carbon shall be evenly spread and compacted. Special care shall be taken to insure there are no voids or opportunities for short circuiting. Carbon shall be placed in lifts not exceeding one foot in depth.
C. Manufacturer’s Representatives who have complete knowledge and experience in the proper installation and assist with all field functional tests of the equipment.

3.2 FUNCTIONAL TESTING

A. Alignment: Test complete assemblies for correct and proper alignment and connection, and quiet operation.

B. Test and Balance Fan: Characteristics to be tested and adjusted include the following:

1. Total airflow rates delivered by fan.
2. Measure static air pressure conditions on fan and total pressure across the fan.
3. Adjust fan speed and motor drive within drive limitations for required air volume. Set a speed to provide air volume farthest distance from the fan without excess static pressure. Check draw amps of fan on initial start-up. If running amps exceed nameplate, shut off motor immediately, and make necessary drive changes.
4. Airflow rates exhausted shall be within plus or minus five percent of the design values specified.

3.3 OPERATOR TRAINING

A. A trained and authorized representative from the Manufacturer shall be present to perform the required inspection, start-up, and operator training services for the system. Time allotted for the above mentioned services will be one 8 hour day. The Contractor or Engineer shall schedule this service with the Manufacturer and provide at least 2 weeks’ notice in advance of the intended date. It will be the responsibility of the Contractor or Engineer to schedule the training with the operators responsible for maintaining the equipment.

B. Operator training to include:

1. Operations and inspection training.
2. Safety instruction.
3. Details preventative maintenance instruction.
4. Trouble shooting and other pertinent services

END OF SECTION 443119
PART 1 - GENERAL

1.1 SUMMARY

A. This specification is for a fully engineered, substantially airtight, surface mounted aluminum cover structure comprised of panels, and beams. This specification shall be regarded as a minimum standard for design and fabrication.

B. Scope of Work:

1. Furnish all labor, materials, and equipment to provide a complete, installed system of fixed and removable, custom fit, flat aluminum covers. The Tank Cover system includes cover panels, structural supports, and attaching hardware.

2. Supplier shall see all structural drawings for locations and sizing of cover system required.

1.2 ENGINEERING

A. A submittal shall be provided to the engineer prior to the beginning of fabrication. The submittal shall include:

1. Complete structural calculations showing the governing stresses in all members and connections, and detailed shop drawings. Preliminary drawings shall be stamped by cover manufacturer’s PE. Final Drawings and calculations shall bear the stamp of local state PE if required.

2. Manufacturer’s standard guarantee.

3. A letter of certification signed and sealed by a registered Professional Civil Engineer confirming that the aluminum cover is in full compliance with the plans and specifications including any testing provisions included therein.

1.3 QUALIFICATIONS

A. Manufacturer:

1. Shall be a company specialized in providing engineered aluminum covers for wastewater treatment tanks/troughs for at least ten (10) years. When requested by the Engineer, submit written evidence to show experience qualifications and adequacy of plant capability and facilities for performance of contract requirements.

B. Erector:

1. Regularly engaged for at least ten (10) years in the erection of aluminum covers for wastewater treatment tanks.
C. Welders:
   1. Qualified within the past two (2) years in accordance with AWS.

1.4 PERFORMANCE

A. Span:
   1. The clear span length of the cover shall be as noted in the scope of work.

B. Width:
   1. The inside width of the cover shall be as noted in the scope of work.

C. Walking surface elevation:
   1. Installed cover system walking surface elevation to be approximately two inches above top elevation of tank/basin walls.

D. Distributed Design Live Load and Deflection:
   1. All structural components shall be designed to support the dead weight of the structure, plus a live load of 50 pounds per square foot of surface. The maximum deflection of any component under this load shall not exceed L/240 of the span of that component. In no event shall the dead load deflection exceed the rise of any component in order to avoid surface ponding.

E. Concentrated Live Load:
   1. The structural components shall be designed to support a 400-pound load on a 6" X 6" area located anywhere on the surface of the structure without permanently deforming the tested area.

F. Design Stresses:
   1. All allowable design stresses in structural aluminum shall be in accordance with the "Specifications for Aluminum Structures" for building-type structures by the Aluminum Association.

G. Skid Resistance:
   1. The cover shall possess an integral non-skid surface and no exposed area of cover system wider than one inch shall be without ribs/non-skid surface. The aluminum-decking surface of the structure shall be Hallsten's Deck Slat, which is ribbed to provide an aggressively non-skid surface. The edges of adjacent deck slats shall double interlock so that the slats shall act together. The decking surface shall be manufactured form 6061-T6 alloy. The Manufacturer of the non-skid surface shall demonstrate in writing satisfactory performance for a minimum period of 10 years in the wastewater industry for the intended purpose. This surface shall not be achieved by the use of paint, adhesive tapes, sand blasting or any other means other than an extruded process.
H. Chemical Resistance:
   1. Panels shall be fabricated entirely of 6061-T6 corrosion resistant aluminum extrusions. Every panel to beam connection shall be chemical resistant and will not weaken or corrode and will interlock. A mechanical and replaceable Santoprene seal shall isolate the cover perimeter from the concrete wall. No foam tape or caulk shall be allowed.

I. Configuration:
   1. The aluminum cover shall be composed of panels and beams. All panels shall interlock with the adjoining beam/beams without the use of threaded fasteners. Uplift of each panel will be resisted with the use of an integral latch system. The weight of an individual panel shall not exceed 150 pounds, except as noted on the contract drawings. Each removable panel shall be easy to remove without disruption of adjacent panels and the lifting force required shall not exceed the dead weight of the panel.

PART 2 - PRODUCTS

2.1 Manufacturer List
   A. Basis-of-Design Product: The contract drawings and specifications are based on surface mounted aluminum covers as manufactured by Hallsten Corporation, P.O. Box 41036, Sacramento, California 95841, (800) 473-7440.
   B. Substitutions Permitted. The Contractor may request that the Engineer authorize the use of substitute equipment as described in Section 007200 EJCD Standard General Conditions of the Contract paragraph 7.05 and in Specification section 012500 Substitution Procedures.

2.2 MATERIALS
   A. Aluminum:
      1. All aluminum used in the fabrication of the cover shall be alloy 6061-T6. All plate shall be alloy 6061-T6. Material shall be new and of top quality.
   B. Welding Electrodes:
      1. Welding shall be with electrodes of an alloy, which shall produce welds with strength and corrosion resistant characteristics compatible to the base metal.
   C. Fasteners:
      1. All fasteners between aluminum components shall be stainless steel or structural plastic. Aluminum shall be isolated from dissimilar materials by means of a stainless steel spacer or an elastomeric isolator. Beams and panels shall be fastened to concrete using stainless steel drill in place anchor bolts.
D. Steel Accessories:
   1. No carbon steel components shall be used.

E. Seals:
   1. A mechanical and replaceable Santoprene seal shall isolate the cover perimeter from dissimilar materials such as concrete and steel. No foam tape or caulk shall be allowed for isolation of cover system.

F. Access Hatch Panels:
   1. Access to any location under the cover shall be gained through integral gear hinged access hatches. The Access Hatch Panels shall have the identical properties as the rest of the aluminum cover including loads, deflection and slip resistance specifications. The access-hinged panels shall be the full panel width. The length of the access panel shall be clearly indicated on drawings. Hinged panel components including hinges, decking and lifting handles shall be extruded 6061-T6. While in the closed position the hatches will be completely flush therefore posing no tripping hazard. In the open position the panel shall lie flat on the cover and will not need a hold open device.

G. Penetration Hatches:
   1. Cover penetration hatches shall be provided at the size and location shown on the drawings. Hinged panel components including hinges, decking and lifting handles shall be 6061-T6 or 304 stainless steel. While in the closed position the hatches will be completely flush therefore posing no tripping hazard. In the open position the panel shall lie flat on the cover and will not need a hold open device.

H. Handles:
   1. Handles shall be an integral flush mounted aluminum and incorporated into the non-skid deck slat.

I. Vents:
   1. Rectangular vents shall be provided at the size and location shown on the drawings. Vent hoods shall be 6061-T6 aluminum or 304 stainless steel with seams or reinforcing to provide rigid construction. Vents shall have dampers. Vents shall have rain hoods with 180 degree downturned opening to exclude rain and debris from falling into the vent. Downturned opening shall be 12 inches above cover deck. Downturned opening shall have ¼-inch mesh screen to exclude debris or small animals from entering the vent.

2.3 FABRICATION AND WORKMANSHIP

A. Workmanship:
   1. The quality of workmanship shall be equal to the best general practice in modern structural fabrication shops. Workmanship, fabrication, and shop connections shall be in
accordance with the latest edition of ANSI/AWS D1.2 "Structural Welding Code - Aluminum”.

B. Experience:

1. The manufacturer must furnish adequate evidence of a minimum of ten (10) years of ongoing experience in the manufacture of similar structures.

C. Preparation for Welding:

1. All components to be welded shall be free of dirt, grease, and other contaminants and shall fit up properly for sound welding. Surfaces to be welded may not be cut with oxygen. Sawing, shearing, or machining may be used.

D. Welding Procedures:

1. All welding shall be with an inert gas shield arc process. Machine settings shall be developed with test welds of the same material, alloy and geometry as the work pieces and samples will be tested destructively.

2.4 TESTING

A. Loads:

1. After installation the cover structure will be tested for conformance with the deflection limits. A load of 400 pounds will be placed as directed by the Engineer and the maximum deflection created by the load will be measured.

B. Prequalified Shop Testing:

1. Manufacturer shall perform a prequalified shop air tightness test and certification for the cover components proposed. This test shall be performed in accordance with the “Procedural Standards for Testing, Adjusting and Balancing of Environment System” as published by the National Environmental Balancing Bureau (NEBB) on cover components of not less than 80 square feet. Said test shall be conducted and witnessed by a NEBB certified technician. The method of testing, test apparatus and proposed contents of the test report shall be submitted to the Engineer for approval. Subsequent to the receipt of Engineer’s approval, the Manufacturer shall set up testing protocol and schedule the test. The Manufacturer will provide the Engineer with at least 72 hours notice prior to the scheduled test. A report of the test shall be prepared by the certified technician and shall be sealed with the NEBB seal. The report shall include a description and illustration of the test components, a description and illustration of the test apparatus and a report of the results. The cover shall maintain an air intrusion leakage rate not to exceed 0.2 cfm per square foot at an applied negative pressure of 0.2 inches of water column for a 5-minute duration.
PART 3 - EXECUTION

3.1 DELIVERY AND INSTALLATION

A. Delivery:
   1. Delivery of the components of the structure shall be made to a location nearest the site that is accessible to over the road trucks, unless otherwise specified.

B. Storage:
   1. The manufacturer shall be responsible for jobsite storage of the delivered components. The components shall be stored off the ground on level surface in such a manner as to prevent damage.

C. Installation:
   1. The manufacturer shall furnish such personnel, tools, equipment, and materials as required to install the cover using the recommended procedure.

D. Contractor Installation:
   1. The cover manufacturer can provide installation instructions, on site supervision, and inspection if desired.

E. OEM Manual:
   1. The manufacturer shall provide an OEM Manual that includes drawings, maintenance instructions, and removal and replacement instructions for the installed cover.

END OF SECTION 444225.02
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. The work consists of furnishing all material, labor and equipment required for installation of the influent sewage sampler, recycle drain sampler and effluent sampler as shown on the Drawings and specified.

1.3 SUBMITTALS

A. Procedures: Submit in accordance with Division 1, Section 013300 “Submittal Procedures.”

B. Submit complete data in accordance with the requirements of Division 1, Section 017823 “Operation and Maintenance Data.”

C. Submit complete Shop and Working Drawings for equipment supplied in accordance with Division 1 Section 013300 “Submittal Procedures.”

1.4 OPERATION AND MAINTENANCE MANUAL

A. Submit complete operation and maintenance manuals for equipment supplied in conformance with the requirements of Division 1 Section 017823 “Operation and Maintenance Data.”

1.5 MANUFACTURER’S SERVICES

A. Provide the services of a factory trained manufacturer’s representative as follows:

1. For a period of at least 1 day to supervise final installation and testing of the equipment.

2. For a period of at least 1 day to instruct representative of the Owner in proper operation and maintenance of equipment supplied.

1.6 TOOLS AND SPARE PARTS

A. Provide any special tools required for normal operation and maintenance of the equipment supplied. Provide the manufacturer’s assortment of spare parts including as a minimum:

1. Three extra 2.5-gallon sample bottles.
2. 50 feet medical grade silicon pump tubing.

PART 2 - PRODUCTS

2.1 WASTEWATER SAMPLERS

A. General:

1. Provide three complete automatic wastewater samplers located as shown on the Drawings as follows:

<table>
<thead>
<tr>
<th>Equipment No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMP 310019</td>
<td>Refrigerated Influent sampler</td>
</tr>
<tr>
<td>SMP 180014</td>
<td>Refrigerated Effluent sampler</td>
</tr>
<tr>
<td>SMP 310020</td>
<td>Portable Drain sampler</td>
</tr>
</tbody>
</table>

2. Sampler shall be suitable for collecting composite wastewater samples of raw wastewater. Samples shall be withdrawn through flexible tubing by a peristaltic pump. The sampling mechanism shall be mounted in a UV and corrosion resistant fiberglass housing. The samplers shall be designed to operate on an operator selectable time or flow proportional basis. The sampler shall be corrosion resistant and suitable for exterior use.

3. Suction Lines and Strainers: The sampler will utilize a suction line and strainer for taking samples. The suction line shall be 3/8 inch × 25 ft long vinyl with standard weighted polypropylene strainer.

4. Sample Collection Containers: The sampler shall be supplied with sample collection 1-bottle configuration, including one polyethylene 2.5 gallon round bottle, locating base, two caps and two discharge tubes.

5. The sampler shall have a built-in fail safe shut-off to prevent overfilling the sample bottle.

6. Refrigerated Sampler

   a. ISCO Model 5800 or equal.
   b. Refrigerator: The refrigerator shall include sensing devices for ambient air temperature, evaporator plate temperature, and interior air temperature. The refrigerator shall include built-in heaters to prevent the sample from freezing if the ambient air temperature drops below freezing. Sample bottle shall be mounted below in a refrigerated cabinet capable of maintaining the composite sample at 4 degrees C.
   c. Power Source: The sampler will be line AC powered 110 volt 60Hz.

7. Portable Sampler

   a. ISCO Model 3700 or equal.
   b. Power Source: The sampler shall require 12 volt DC power for operation.
   c. Provide two power sources:

      1) Nickel-Cadmium rechargeable 4 amp-hours battery and charger.
      2) AC Power Converter 120 volt to 12 VDC.
B. Design requirements: Samplers shall be designed on the following basis:

1. Sample transport velocity, minimum fps 2.0
2. Sample suction lift, maximum, feet 28
3. Sample hose
   a. Inside diameter, inches 3/8
   b. Length, feet 25
4. Sample bottle, capacity, gallons 2.5
5. Sample volume (adjustable)
   a. Minimum, ml 10
   b. Maximum, ml 9,990
6. Purge pressure, minimum, psi 25
7. Operational temperature range, degrees C -29 to 50
8. Sample temperature range, degrees C 1 to 9

C. Construction

1. Provide a complete system including a peristaltic pump, controller and all other equipment, valving, piping, hose and appurtenances required for operation. The sample shall be collected in a clear measuring chamber with sample volume continuously adjustable as noted above. The inlet hose shall be positioned near to the base of the measuring chamber to reduce air mixing and splashing. Inlet hose shall be reinforced plastic tubing of the diameter and length indicated above. All portions of the sampler in contact with the fluid shall be corrosion resistant and nonmetallic. Sample bottles shall be polyethylene and provided with screw-on caps and carrying handles. A pre-sample and post-sample purge shall be provided to prevent clogging of the sample hose and to reduce cross contamination. In the event that the first attempt to withdraw a sample is prevented due to clogging, a second purge/sample cycle shall be automatically initiated. The sampler shall come with an automatic sampler shutoff switch and warning light when sample jar is full.
2. The sampling mechanism and controls shall be enclosed in a UV and corrosion persistent fiberglass housing. NEMA 4 enclosure shall be gasketed with a key locking door.

D. Controls

1. Refrigerated sampler
   a. The sampler’s memory shall maintain the program settings, stored programs, and the results of the last two sampling sequences when the sampler is turned off or an external power interruption occurs. A user-initiated diagnostics routine shall indicate the operational status of the sampler. The controller will display any error conditions detected by the diagnostic routines. The current refrigeration temperature shall appear on the sampler’s display, and temperature readings shall be stored in a report. The controller shall be able to automatically switch input power to a connected battery in the event of a loss of AC power.
   b. The sampler shall have four standard digital alarm outputs capable of direct wiring to a Programmable Logic Controller (PLC) or data logger (5 volt, 100 mA).
c. The sampler shall collect sequential or composite samples at user-definable intervals and volumes. A delay to first sample collection shall be programmable by the real-time clock.

1) Time Pacing-The sampler will use an internal real-time clock to provide time and date information. Uniform time-paced samples shall be collected at regular time intervals from 1 minute to 99 hours 59 minutes. Sample volumes may be equal or variable in proportion to flow.

2) Flow Pacing, DC Pulse-The sampler shall accept a 5 to 15 VDC flow proportional pulse or isolated dry contact closure, at least 25 ms in duration, from an external flow meter for flow pacing. Samples shall be equal in volume and shall be taken at variable times proportional to flow. The number of flow pulses shall be selectable, from 1 to 9,999 pulses, as the flow interval for each sample collection.

3) Flow Pacing, Analog Input-The sampler shall have a standard 4-20mA flow proportional input compatible with most flow meters without additional interfacing. Samples shall be equal in volume and shall be taken at variable times proportional to flow.

4) Flow-Weighted Volumes, DC Pulse-The sampler shall accept a 5 to 15 VDC flow proportional pulse or isolated dry contact closure, at least 25 ms in duration, from an external flow meter. Samples shall be taken at equal time intervals, and variable sample volumes shall be proportional to cumulative flow.

5) Flow-Weighted Volumes, Analog Input-The sampler shall have a standard 4-20 mA flow proportional input compatible with most flow meters without additional interfacing. Samples shall be taken at equal time intervals, and variable sample volumes shall be proportional to cumulative flow.

2. Portable sampler

a. All electrical components shall be housed in a single controller. There shall be no external electrical or control components. The controller shall use a 2 line 40 character display to show sampler status and program information. A 24 position keypad shall be used for all program entries, manual control of the sampler, and data transfer functions. The sampler shall provide battery-backed memory with a typical life of five years. This memory shall maintain the sampler's program settings, any stored programs, and the results of the last sampling sequence when the sampler is turned off or in the event of an external power interruption. A user-initiated diagnostics routine shall determine the operational status of the sampler. The controller shall continually run internal diagnostics checks to ensure proper operation of electrical components. Any error conditions detected by the diagnostic routines shall be displayed to the user. A software program lock shall be provided to prevent unauthorized tampering or accidental changing of the sampler control settings.

b. The user can program the sampler to collect samples at user-definable intervals. A delay to first sample collection shall be programmable in minutes from 0 to 9,999 or by the real-time clock. The sampler shall have the ability to be programmed for up to 24 real-time sampling stop/resume times. The stop/resume routines and delay to the first sample are independent of the sample pacing interval. The sampler shall be capable of storing up to 4 sampling routines.
1) The sampler shall use an internal real-time clock to provide both time and date information. It shall also offer two types of time pacing: uniform and non-uniform. Uniform time paced samples shall be collected at regular time intervals from 1 minute to 99 hours and 59 minutes. Non-uniform time intervals from 1 to 999 minutes between samples are available. Sample events based on real-time settings shall also be available. Non-uniform time shall be common to both sequential and composite sampling routines.

2) The sampler shall accept a 12V DC flow proportional pulse or isolated dry contact closure for flow pacing. The pulse or contact closure must be at least 25 ms in length. The user shall select the number of pulses as the flow interval for each sample collection.

3) There shall be furnished a 4-20 mA input interface unit to convert a flow-proportional signal from a non-Isco flow meter into a sampler initiation signal compatible with an Isco wastewater sampler.

3. The following controls shall be mounted within the locking sampler enclosure:
   a. Power on/off switch and indicator light.
   b. Time/flow switch.
   c. Manual purge button.
   d. Manual cycle button.
   e. Time control interval selector switch.

4. All electrical equipment shall be UL approved and shall be installed in accordance with these Specifications and prevailing electrical codes.

E. Performance: Sample volume shall be selectable within 2% of nominal size and shall not be affected by changes in vertical lift. Clock interval control shall be achieved with a minimum accuracy of 0.03 percent.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the manufacturer's recommendations and the requirements of these Specifications.

3.2 TESTING

A. When all equipment has been properly installed it shall be given full functional tests prior to acceptance. When treatment plant processes are on line, sampler shall be test operated during a full 24-hour cycle using time control. An additional 24-hour test cycle shall be performed using flow proportional control.

END OF SECTION 444248
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Grout.
2. Mechanical demolition.
3. Equipment installation requirements common to equipment sections.
4. Painting and finishing.
5. Concrete bases.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.
The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Procedures: Submit in accordance with Division 1, Section 013300 “Submittal Procedures.”

B. Submit complete data in accordance with the requirements of Division 1, Section 017823 “Operation and Maintenance Data.”

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
PART 2 - PRODUCTS

2.1 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 MECHANICAL DEMOLITION

A. Refer to Division 1 Sections "Cutting and Patching" and "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
D. Install equipment to allow right of way for piping installed at required slope.

3.3 PAINTING

A. Painting of mechanical systems, equipment, and components is specified in Section 099600 “High Performance Coatings.”

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.4 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated in Division 3 specifications and as indicated on Plans, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor as indicated on Plans.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section 033000 "Cast-in-Place Concrete."

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.6 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.
3.7  GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 460500
SECTION 460513 - COMMON MOTOR REQUIREMENTS FOR WATER AND WASTEWATER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Single- and three-phase motors for application on equipment provided under other Sections and for motors furnished loose to Project.

B. Related Requirements:
   1. Section 260526 “Grounding.”
   2. Section 260500 “Common Work Results for Electrical”

1.2 REFERENCE STANDARDS

A. American Bearing Manufacturers Association:
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. National Electrical Manufacturers Association:
   1. NEMA MG 1 - Motors and Generators.

C. International Electrical Testing Association:

1.3 SUBMITTALS

A. Section 013300 “Submittal Procedures” Requirements for submittals.

B. Product Data: Submit catalog data for each motor furnished loose. Indicate nameplate data, standard compliance, electrical ratings and characteristics, physical dimensions, weights, mechanical performance data, and support points.

C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

D. Test and Evaluation Reports: Indicate procedures and results for specified factory and field testing and inspection.

E. Qualifications Statements:
1. Submit qualifications for manufacturer and testing agency.

1.4 QUALIFICATIONS

A. Manufacturer: Member of International Electrical Testing Association and specializing in testing products specified in this Section with minimum three years documented experience.

B. Testing Agency: Company specializing in testing products specified in this Section with minimum three years documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Section 016000 “Product Requirements” for transporting, handling, storing, and protecting products.

B. Lift only with lugs provided. Handle carefully to avoid damage to components, enclosure, and finish.

C. Protect products from weather and moisture by covering with plastic or canvas and by maintaining heating within enclosure.

D. For extended outdoor storage, remove motors from equipment and store separately.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS FOR MOTORS FURNISHED WITH EQUIPMENT

A. Motors 3/4 hp and Larger: Three-phase motor as specified below.

B. Motors Smaller than 3/4 hp: Single-phase motor as specified below, except motors less than 250 watts or 1/4 hp may be equipment manufacturer’s standard.

C. Three-Phase Motors: NEMA MG 1, Design B, energy-efficient squirrel-cage induction motor with windings to accomplish starting methods and number of speeds, as indicated on Drawings.

1. Voltage:
   a. 460 volts, three phase, 60 Hz.

2. Service Factor: 1.15

3. Enclosure: Meet conditions of installation unless specific enclosure is indicated on Drawings.

4. Design for continuous operation in 40-degree C environment, with temperature rise according to NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
5. Insulation System: NEMA Class F.
6. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
7. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy-encapsulated solid state-control relay with wiring to terminal box.
8. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum, V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

D. Single-Phase Motors:
   1. Permanent split-capacitor type where available; otherwise use split-phase start/capacitor run or capacitor start/capacitor run motor.
   2. Voltage: 115 volts, single phase, 60 Hz.

E. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated.

2.2 THREE-PHASE MOTORS FURNISHED LOOSE

A. Manufacturer List:
   1. General Electric Company
   2. Marathon Electric Motors
   3. Siemens Industry
   4. WEG

B. Description: NEMA MG 1, Design B, energy-efficient squirrel-cage induction motor, with windings to accomplish starting methods and number of speeds indicated.

C. Voltage: 460 volts, three phase, 60 Hz.

D. Service Factor: 1.15.

E. Enclosure: Meet conditions of installation unless specific enclosure is specified or indicated.

F. Design for continuous operation in 40-degree C environment, with temperature rise according to NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

G. Insulation System: NEMA Class F.

H. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
I. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy-encapsulated solid state-control relay with wiring to terminal box.

J. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum, V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

K. Sound Power Levels: Conform to NEMA MG 1.

L. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated.

2.3 SOURCE QUALITY CONTROL

A. Section 014000 “Quality Requirements”: Requirements for testing, inspection, and analysis.

B. Testing: Test motors according to NEMA MG 1, including winding resistance, no-load speed and current, locked rotor current, insulation high-potential test, and mechanical alignment tests.

PART 3 - EXECUTION

3.1 PREPARATION

A. Section 017300 and 017700 “Execution” and “Closeout Requirements”: Requirements for installation preparation.

3.2 INSTALLATION

A. Maintain access to existing motors and other installations remaining active and requiring access. Modify installation or provide access panel.

B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.

C. Install engraved plastic nameplates according to Section 260500 “Common Work Results for Electrical.”

D. Ground and bond motors according to Section 260526 “Grounding.”

3.3 FIELD QUALITY CONTROL

A. Section 014000 “Quality Requirements”: Requirements for inspecting and testing.
B. Inspect and test according to NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.15.

END OF SECTION 460513
SECTION 462133 – ROTARY DRUM SCREENS

PART 1 - GENERAL

1.1 SUMMARY

A. Contractor shall furnish and install a rotating perforated plate or drum screen, here on called as a “rotary drum screen” for removing floating, particulate and fibrous material from influent raw wastewater. This section specifies the requirements of the fine screen. The fine screen will be located in the headworks as shown on the Drawings.

B. The contract drawings and the specifications listed in this section are based on perforated plate screen model RPPS 1200 manufactured by Huber-Technology. The Contractor shall be responsible for any modifications required for proper installation of the screens by other screen manufacturers.

C. It is the intent of these specifications that all equipment called for under this section shall be supplied by a single manufacturer.

D. Related Requirements:

1. Section 055000 “Metal Fabrications”: Fasteners, brackets, and other miscellaneous metal fabrications as required by this Section.
2. Section 099113 and 099123 “Exterior Painting” and “Interior Painting”: Product and execution requirements for painting specified by this Section.
3. Section 422700 “Process Piping - General”: Execution requirements for piping specified by this Section.
4. Section 262726 “Wiring Devices”: Wiring connections to equipment.
5. Section 460513 “Common Motor Requirements for Water and Wastewater”: Electric motors and their accessories normally supplied as part of equipment assemblies.

1.2 DEFINITIONS

A. Rotary Drum Screen: Wastewater treatment equipment that is used to separate and sieve suspended solids and fibrous materials from wastewater. Also referred to as a "rotating drum screen"

1.3 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM) Publications:

B. American Bearing Manufacturers Association:
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

C. National Electrical Manufacturers Association:
   1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. NEMA MG 1 - Motors and Generators.

D. American Institute of Steel Construction (AISC) Publications

E. American Welding Society (AWS) Publications

F. American Structures Painting Council (ASPC) Publications

G. American Iron and Steel Institute (AISI)

1.4 SUBMITTALS

A. Refer to Section 013300 “Submittal Procedures” for submittal Procedures.

B. Product descriptive literature, brochures, catalogs, cut-sheets and other detailed descriptive material of the equipment.

C. Motor characteristics and performance information.

D. Manufacturer's Certificate: Certify that the rotary drum screen will meet or exceed the requirements listed in this specification.

E. Manufacturer's Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.

F. Source Quality-Control Submittals: Indicate results of factory inspections.

G. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

H. Manufacturer Reports: Indicate that equipment has been installed according to manufacturer's instructions.

I. Parts list including a list of recommended spare parts.

J. Shop Drawings shall include Manufacturer's installation drawings and wiring and schematic diagrams.

K. Operations and maintenance data: See Section 017839 “Project Record Documents.”

L. Detailed installation instructions, with clear step-by-step points on the correct mechanical and electrical installation procedures.

ROTARY DRUM SCREENS
M. Equipment weights and lifting points.
N. Recommendations for short and long term storage.
O. A copy of the manufacturer’s warranty
P. A copy of documents proving certification of the Manufacturer’s Quality Management System according to ISO 9001 and Environmental Protection Management System according to ISO 14001.
Q. Failure to include all drawings applicable to the equipment specified in this section will result in rejection of the entire submittal with no further review.

1.5 CLOSEOUT SUBMITTALS
A. Refer to Section 017700 “Closeout Procedures.”
B. Project Record Documents: Record actual locations of rotary drum screens.

1.6 MAINTENANCE MATERIAL SUBMITTALS
A. Refer to Section 017300 “Execution” and 017700 “Closeout Procedures” for Execution and Closeout Requirements.
B. Spare Parts: The following Spare Parts shall be included and supplied together with the equipment:
   1. 1 Complete bottom bearing assembly
   2. 1 set of basket cleaning brushes
   3. 1 Solenoid valve rebuild kit
   4. 5 Boxes with 295’ endless bags each
   5. 3 Plastic rollers

1.7 QUALITY ASSURANCE
A. To ensure quality, conformance, and reliability with regard to the manufacturing and production of the equipment, the manufacturer shall meet all requirements listed hereafter:
B. Manufacturer shall have a minimum of twenty (20) years experience producing equipment substantially similar to that required and shall be able to submit documentation of at least fifteen (15) independent installations using the same size or larger equipment as detailed below. Each installation must have been in satisfactory operation for at least five (5) years.
C. The Contract Documents represent the minimum acceptable standards for the screening equipment for this project. All equipment shall conform fully in every respect to the requirements of the respective parts and sections of the drawings and specifications. All manufacturers shall modify, redesign, and furnish with special features or accessories, use materials or provide equipment with
finishes as may be necessary to conform to the quality mandated by the technical and performance requirements of this specification.

D. The entire unit shall be manufactured from AISI 316 stainless steel shapes unless otherwise specified. All components made of stainless steel shall be passivated by full submergence in a pickling bath for perfect surface finishing. No stainless steel components may be fabricated or assembled in a factory where carbon steel products are also fabricated, in order to prevent contamination by foreign debris which can cause corrosion of stainless steel.

E. Electric motors, gear reducers, and other self-contained or enclosed components shall have an acrylic enamel finish.

F. All stainless steel parts of the unit shall be fully submerged into a pickling bath for at least 8 hours to remove welding spots and to protect the stainless steel against corrosion. Glass bead blast or chemically treated stainless steel shall not be allowed.

G. Fabrication shall be done in compliance with all applicable ASTM standards or equivalent international standards.

H. All welding in the factory shall use shielded arc, inert gas, MIG or TIG method. Filler wire shall be added to all welds to provide for a cross section equal to or greater than the parent metal. Butt welds shall fully penetrate to the interior surface and gas shielding to interior and exterior of the joint shall be provided.

I. Bolts, nuts and washers shall be selected from AISI 304L or 316L stainless steel such that they are anti-seizing.

J. Manufacturer shall have established an ISO 9001 certified quality management system. Equipment suppliers not utilizing ISO 9001 facilities shall not be considered or approved for this project. Equipment supplier shall provide evidence of certification before being named as an acceptable manufacturer.

K. Manufacturer shall have established an ISO 14001 certified environmental protection management system designed to monitor and help minimize the harmful effects on the environment caused by its manufacturing processes. Equipment suppliers not utilizing ISO 14001 facilities shall not be considered or approved for this project. Equipment supplier shall provide evidence of certification before being named as an acceptable manufacturer.

L. All welding is performed in accordance with American Welding Society (AWS) D1.1 Structural Welding Code, or equivalent.

M. Manufacturer shall provide screen, motors, gear reducers, controls, control panels, and lifting attachments as a complete integrated package to ensure proper coordination, compatibility, and operation of the system. The manufacturer shall test-run the fully assembled machine in his factory before shipment.

N. Manufacturer shall provide services by a factory-trained Service Engineer, specifically trained on the type of equipment specified. The Service Engineer requirements include, but are not limited to the following:
1. The Service Engineer shall inspect and verify location of anchor bolts, placement, leveling, alignment and field erection of equipment, as well as control panel operation and electrical connections. The service Engineer shall inspect and verify tight seal between the drum basket and the concrete channel so that the wastewater doesn’t bypass from the bottom of the basket. The Service Engineer shall provide a written inspection report and certify that the screen is correctly installed.

2. The Service Engineer shall provide classroom and/or field training on the operation and maintenance of the equipment to operator personnel. These instructions may include the use of slides, videos, literature, and/or oral presentations.

3. Manufacturer shall state field service rates for a Service Engineer to Owner and Contractor. In the event that the field service time required by this section should not be sufficient to properly place the equipment into operation, and the requirement for additional time is beyond the manufacturer’s responsibility, additional time shall be purchased by Contractor to correct deficiencies in installation, equipment, or material without additional cost to Owner.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 016000 “Product Requirements” for transporting, handling, storing, and protecting products.

B. Deliver materials in manufacturer's packaging, including application instructions.

C. Inspection: Accept rotary drum screens on-Site in original packaging. Inspect for damage.

D. Store rotary drum screens according to manufacturer's instructions.

E. Protect rotary drum screens from water and wet weather.

1.9 EXISTING CONDITIONS

A. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

1.10 WARRANTY

A. Section 017300 and 017700 for “Execution” and “Closeout Procedures.”

B. The manufacturer shall furnish warranty for all equipment covered in this section against manufacturing defects in materials and workmanship during normal use and service for a period of one (1) year from date of startup.
PART 2 - PRODUCTS

2.1 MANUFACTURER LIST

A. Huber Technology, Inc

B. Enviro-Care

2.2 PERFORMANCE AND DESIGN CRITERIA

A. Screen Design Criteria

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<th>Value</th>
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<td>Nominal screen basket diameter, ft</td>
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<td>Average flow per screen, MGD</td>
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<td>Max. Waste water flow per screen, MGD</td>
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</table>

Fine screens Location Rating

Class 1 Division 1 Group D: Enclosed area below covers and
Within a 10’ envelope.
2.3 ROTARY DRUM SCREENS

A. The screen shall be designed to handle the maximum flow with the maximum upstream and downstream liquid levels as specified above.

B. The nominal bar spacing specified above shall be the size of the circular openings.

C. The average flow through velocity through the screen shall not exceed 3.3 ft/sec (1.0 m/sec) under any flow condition. The screen design shall minimize solids deposits in the channel.

D. The screen shall be capable of processing spherical objects with a diameter of 3-1/8". Such objects shall be conveyed through the auger and shall be discharged with the screenings.

E. The screen shall consist of a rotating cylindrical screen with an integral screw conveyor and screenings press. The fine screen shall use a single drive for screening, conveying, dewatering and compressing the screening material. The screen shall have an inclination of 35 degrees.

F. Operation of the rotating screen shall be automatically initiated at a preset high upstream liquid level. Screens that operate continuously or via timer only will not be acceptable. The rotating basket shall remove solids from the flow and deposit them into the concentric screw conveyor hopper using a spray bar and basket cleaning brush providing positive cleaning of the screen basket surface.

G. All open spaces of the screen shall be cleaned via a spray bar and cleaning brush system.

H. The screening equipment shall produce dewatered screenings that will reliably pass the EPA Paint Filter Test as described in method 9095 of EPA Publication SW-486.

I. Cleaned screenings shall be substantially free of fecal (brown colored) material in the screenings.

J. Materials

1. Unless otherwise specified in these specifications, the entire equipment shall be manufactured from AISI 316 stainless steel shapes (rods, angles, and channels), pipes, and sheets. All mechanical parts shall be designed to handle the forces that may be exerted on the unit during fabrication, shipping, erection, and proper operation according to the O&M manual.

2. The entire equipment shall be manufactured in a stainless steel only factory to prevent contamination of the stainless steel with foreign contaminants.

3. The equipment, after its fabrication, shall undergo a passivation (pickling) process to ensure maximum resistance to corrosion. All stainless steel components and structures shall be submersed in a chemical bath of nitric acid and hydrofluoric acid to remove any residues that may be present on the material as a result of forming, manufacture, or handling. After removal from the pickling bath, the equipment must be washed with a high-pressure wash of cold water to remove any remaining surface debris and promote the formation of an oxidized passive layer which is critical to the long life of the stainless steel. Submergence insures complete coverage. Spray on chemical treatments and glass bead blasting are specifically not acceptable due to their inability to provide complete and uniform corrosion protection.

ROrzARY DRUM SCREENS

462133 - 7
2.4 PRODUCT DESIGN SPECIFICATIONS

A. Screen

1. The screen shall be designed and built to withstand static and hydraulic forces exerted by the liquid to the screen. All structural and functional parts shall be sized for the loads encountered during the screening, conveying and pressing operations. All submerged components and all components of the rotary screen in contact with the screened solids shall be of stainless steel construction.

2. The screen basket shall be of a cylindrical shape with perforations around the entire basket circumference. Spacing of the perforations shall be as specified in 2.1.A. Bars or wedge wire will not be acceptable screen media.

3. The basket diameter shall have a width as noted in 2.1.A and be provided with a sufficient clear opening area to ensure the maximum flow rate of 3.3 fps is not exceeded at the maximum flow as specified in 2.1.A.

4. The upper end of the basket shall incorporate a support ring which shall be machined and supported by three (3) guide rollers made of polyamide. The guide rollers shall be attached to an upper support plate. This plate shall match a flange that is attached to the augur tube to ensure proper alignment of the basket. A brush shall be clamped to the upper support plate sealing the gap between the rotating screen basket and the fixed upper support plate.

5. The lower support ring of the basket shall be connected to the shaft of the auger and be driven by a common drive with the auger. The basket shall be connected with a solid support arm at the lower end of the basket which is bolted to the auger shaft.

6. A seal plate shall be provided between the circular screen and the channel. The seal plate shall be one-piece fabricated of stainless steel plate. The sealing plate shall be of sufficient height to prevent bypassing of flow around the screen at the maximum screen hydraulic capacity.

7. A polyurethane seal shall be provided to ensure proper sealing of the rotating screen basket against the fixed sealing plate. This polyurethane seal ensures that there will be no bypass of unwanted solids through the screen. Sealing Polyurethane shall be affixed to the internal drum, such that positive flow differential compresses the seal. Seals that are affixed such that positive flow differential forces are in a direction that would possibly facilitate the creation of seal bypass shall not be acceptable.

8. The screen shall be provided with a support stand allowing for easy removal of the screen basket from the channel for maintenance purposes. The support stand shall be fabricated from stainless steel Double-C-Channels having the minimum dimensions of 7 inches by 2.75 inches with a thickness of 0.125 inches.

B. Cleaning brushes

1. The screen basket shall rotate in one direction and pass through the topmost position where it is cleaned with a stainless steel high pressure spray bar and a stainless steel backed nylon brush with bristles that penetrate the depth of the perforations in the screen to ensure positive screenings removal. Brush bristles shall be high-strength nylon for superior life.

2. The brush shall be designed to ensure cleaning of the spaces to the full depth of the perforations of the screen basket. The cleaning brush shall be mounted upon a stainless steel holding device which keeps the brush in constant contact with the basket and shall be adjustable to allow for brush wear.
3. Another stainless steel backed nylon brush shall be attached to the rotating basket and positioned to make contact with the screening trough to sweep material caught on the edges of the trough.

C. Screenings Conveyor and Screenings Wash-Press

1. The auger tube shall have a diameter of 10.75 inches. The auger tube shall incorporate two (2) anti-rotation bars which shall be welded to the inside of the transport tube along the longitudinal axis. The screw shall not be in contact with the anti-rotation bars during normal operation, the screw shall be supported by a Teflon® lined bronze slide bearing at the bottom and the gear box at the top.

2. A support flange with a minimum thickness of 0.6 inches shall be welded to the screenings transport tube. The screen basket rollers and the screenings collection hopper shall be attached to this plate.

3. A gear box support flange with a minimum thickness of 0.467 inches shall be welded to the upper end of the screenings transport tube for attachment of the drive assembly.

4. A shafted auger screw that is made of ST52 structural steel or AISI 316 stainless steel shall be provided to transport and dewater the screened material. A shaft-less screw shall not be acceptable. Screw flights shall be of decreasing pitch approaching the compaction zone to provide a mechanical compressing action on the screenings material. The shaft shall have a diameter of 3.5 inches and shall have flights with a minimum thickness of 0.2 inches in the transport zone and 0.4 inches in the compaction zone. A replaceable flight section with an angle of about 120 degrees that is bolted to the shaft shall be provided at the bottom of the shaft where the wear is highest.

5. A compaction zone shall be an integral part of the screenings screw conveyor and transport tube design. The compaction zone shall be designed to form a screenings plug of material and to return water released from the screened material back to the wastewater channel/pump sump through circular holes that are machined into the screenings transport tube.

6. The auger shaft shall be fitted with an upper and a lower solid stub. Stubs and screw shaft shall be accurately machined and shrink-fitted.

7. The lower end of the screenings conveyor shall be supported by a sealed, self-lubricated, Teflon® lined bronze slide bearing. This bearing shall not take any thrust load from the screw conveyor. Lower ball or roller bearings, or bearings requiring lubrication, shall not be acceptable.

8. The lower bearing shaft and arm shall be designed to minimize material wrapping around the shaft. A seal plate shall be furnished to mate between the stationary lower bearing support and the rotating arm to prevent material intrusion into the bearing seals.

9. A compaction zone shall be provided as an integral part of the screw conveyor and tube. The compaction zone shall be designed to form a plug of screenings material and to return water released from the screened material back to the channel through 0.24 inch (5 mm) diameter perforations that are machined into the screenings transport tube in a square configuration.

10. The compaction zone shall be provided with split glass fiber reinforced housing, furnished with gaskets and bolts, and easily removable for access. Designs requiring removal of the drive assembly, discharge head, or screw conveyor to gain access to the compaction zone will not be acceptable. The housing shall be provided with a drain connection at its lowest point and a clamped flexible PVC hose for drain water whose other end is connected to a
connection through the screen basket’s upper support flange to return the drain water into the screen basket. The plastic housing shall also be provided with a 1 inch flush connection.

D. Drive

1. The basket mechanism and transport screw shall be driven by a shaft mounted geared motor. The geared motor shall have a minimum service factor of 1.0. The motor shall be provided with thermostats to provide thermal overload protection in addition to current overload protection.
2. The gear reducer shall be bolted to a machined flange welded to the upper end of the transport tube.
3. The gear reducer shall be driven by a 3 phase, 60 Hertz, 230/460 volt, Class 1, Division 2, Group D continuous-duty, totally-enclosed, fan-cooled motor which leads to a conduit box for outdoor operation. The motor rating shall be a minimum of 1.5 HP.

E. Spray Wash Systems

1. The screen shall be designed for a water supply of 36 gpm and shall be provided with wash water distribution manifold with a single 1.25 inch NPT for connection to the treatment plants final effluent water supply.
2. An automatic spray wash system shall be provided for cleaning of the screen basket and shall be constructed of minimum 1 inch diameter piping and minimum 1 inch diameter flexible reinforced PVC hose. The spray wash systems shall be operated only while the screen basket is rotating. The spray wash system shall include a single 1 inch solenoid valve for flow control. Min. pressure to the spray wash shall be 75 psi (5 bar).
3. The screen shall incorporate a screenings washing system (IRGA) consisting of two washing points, one being in the rising tube of the screen and the second being in the screenings collection hopper. The screenings wash zone in the conveyor tube shall be provided with three nozzles located equidistant around the circumference to maximize the washing performance. A lower wash system shall be located above the open top of the hopper and shall utilize a spray bar with a minimum of 6 spray nozzles. The screenings washing system shall include a single 1 inch solenoid valve for flow control.
4. The screen compaction zone shall be provided with a wash nozzle designed to flush the entire interior surface of compaction zone housing to ensure no debris buildup can occur. The compaction zone flushing system shall include a single 1 inch solenoid valve for flow control.
5. The solenoid valves shall be operated by the programmable logical controller. Individual manual operation of each solenoid shall also be possible from the control panel.
6. The solenoid valves shall be minimum 1 inch diameter, brass body, 2-way, and designed for 110 VAC with an explosion-proof rating. Solenoid valves shall be normally closed and rated for up to 100 psig.
7. A brass body Y-strainer shall be provided for the incoming plant water supply.

F. Bagger

1. The discharge chute shall be furnished with a bagging device to contain and encase dewatered screenings. The bagging device shall use endless bags.
2. The bagging device shall be fabricated of minimum 12 gage (2.5 mm) stainless steel.
3. The screenings bagger shall be designed to be fitted with 295ft endless replaceable plastic bags.

G. Anchor Bolts

1. Equipment manufacturer shall furnish all anchor bolts of ample size and strength required to securely anchor each item of equipment. Anchor bolts, hex nuts, and washers shall be 316 stainless steel.
2. Anchor bolts shall be set by the contractor. Equipment shall be placed on the foundations, leveled, shimmed, bolted down, and grouted with a non-shrinking grout.

H. Control System

1. The control system shall be programmed such that when the duty screen reaches the maximum upstream level (118.75) then the standby screen shall be activated.
2. All controls necessary for the fully automatic operation of the screen shall be provided, including a NEMA 4X main control panel, and a NEMA 7 local control station.
3. The electrical control system shall provide for automatic control of the screen via a high liquid level using a Milltronics Pointek ultrasonic level sensor in combination with an adjustable timer.
4. Main control panel shall be suitable for outdoor, wall-mounting. Enclosure shall be NEMA 4X Stainless Steel with continuous hinge and lockable door latch, and shall include the following:

   a. Door-interlocked and fused disconnect
   b. 600 VAC terminal block
   c. VFD and Circuit Breaker Branch Circuit Protection for screen motor
   d. Control power transformer with 120 VAC transient voltage surge compressor (TVSC) and fused primary and secondary
   e. Programmable logic controller (PLC), Allen Bradley Micrologix 1400
   f. Operator Interface (OIU), Allen Bradley PanelView C400
   g. Pilot lights for

      1) Control power on (white)
      2) Screen running (green)
      3) Screen high level (amber)
      4) Screen fault (red)

   h. E-stop push button (red)
   i. Screen reset push button (black)
   j. Door mounted elapsed time meters for the following:

      1) Screen drive

   k. Digital inputs for the following:

      1) Machine start water level
      2) Maximum water level
3) One spare input

l. Remote dry contact outputs for the following:

   1) Screen running
   2) Screen fault
   3) Screen E-stop
   4) Screen high level
   5) One spare output

m. Flashing alarm light and alarm horn with silencer-reset button

n. Plastic Nameplates

I. A local operator station shall be provided, and shall be suitable for wall-mounting. Enclosure shall be NEMA 7 cast Aluminum, and shall include the following:

   1. Hand-Off-Auto selector switches for the following

      a. Screen drive

   2. Screen forward-off-reverse

      a. Screen drive

   3. E-stop pushbutton (red)

J. Out Door Weather Protection

   1. The screenings transport tube shall be furnished with thermal insulation of closed cell foam, riveted stainless steel protective covers and a heat tracing system for outdoor weather protection which shall enclose the screenings transport tube, compaction and dewatering zone and all spray wash piping, ball valves and solenoid valves.

   2. The outdoor weather protection system shall include (Class I, Division 2, Group D) self-regulating heat tracing, adjustable thermostat, insulation and a stainless steel protective jacket. Provide indicator light signal when system is energized.

   3. The heat tracing system shall be suitable for operation down to a minimum temperature of -25 deg C (-13 deg F) and shall be powered from the main control panel.

   4. Where the wash water supply and electrical wiring conduit penetrates the stainless steel cover bulkhead adapters shall be provided. Easy access shall be provided to every component requiring service or maintenance.

K. Covers

   1. Provide two piece rectangular stainless steel housing and covers with split sliding access doors.

   2. The housing shall be made of 5/64” (2 mm) thick stainless steel plate and covers shall be made of 0.06” (1.5mm) thick stainless steel plate. Each sliding section shall be provided with two handles and secured with turn-locks.
3. Each cover assembly shall consist of a stationary section, and a sliding section with rollers and tracks which allow the sliding section to be easily opened in order to gain access to the screens. Covers which require tools to gain access to the screens shall not be accepted.

4. Each sliding section shall be provided with two handles. Handles shall be arranged such that the entire sliding section of the cover can be opened and closed by a single operator.

2.5 ACCESSORIES

A. Fasteners and Supports: As specified in Section 055000 “Metal Fabrications”

2.6 SOURCE QUALITY CONTROL

A. Owner Inspection:
   1. Make completed rotary drum screen assembly available for inspection at manufacturer's factory prior to packaging for shipment.
   2. Notify Owner at least seven days before inspection is allowed.

B. Certificate of Compliance: When fabricator is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at fabricator's facility conforms to Contract Documents.
   1. Specified shop tests are not required for Work performed by approved fabricator.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that designated areas, clearances, structural requirements, piping, utility connections, and electronic signals are ready to receive equipment.

3.2 INSTALLATION

A. Install rotary drum screens and appurtenances according to manufacturer's instructions.

B. Electrical: As specified in Section 460513 “Common Motor Requirements for Water and Wastewater Equipment”

C. Painting:
   1. As specified in Section 099600 High-Performance Coatings.
3.3 FIELD QUALITY CONTROL

A. Test for proper alignment.

B. Start up, inspect, and operate the unit.

C. Certification: Certify in writing that unit has been satisfactorily tested and that final adjustments have been performed.

D. Manufacturer Services: Furnish services of manufacturer's representative experienced in installation of products furnished under this Section for (2) trips including three (3) days on-Site for installation, inspection, field testing, and instructing Owner's personnel in maintenance of equipment.

3.4 DEMONSTRATION

A. Section 017300 and 017700 “Execution” and “Closeout Procedures” for demonstration and training.

B. Demonstrate equipment startup, shutdown, routine maintenance, alarm condition responses, and emergency repair procedures to Owner's personnel.

END OF SECTION 462133
SECTION 463300 – CHEMICAL FEED SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish, install, and test chemical feed storage tanks, eductors, and associated equipment as shown on Drawings and as specified herein, and fittings as required to completely interconnect equipment with piping for complete and operable systems. This section covers the following chemical feed systems:

1. Sodium hypochlorite feed system for washwater secondary disinfection.
2. Magnesium Hydroxide Storage tank.

1.2 SUBMITTALS

A. Submit under provisions of Section 013300 “Submittals Procedures.”

B. Submit manufacturer’s data demonstrating conformance to specification, including performance information, materials of construction, and other applicable information.

C. Submit shop drawings and installation instructions for eductors and associated equipment, including, but not limited to, requirements, anchorage, and seismic restraint systems.

1.3 OPERATION AND MAINTENANCE DATA

A. Submit Operation and Maintenance Manuals, including names, functional titles, addresses, and phone numbers of technical personnel available for ongoing technical support; maintenance requirements; recommended spare parts, and local spare parts sources.

1.4 QUALIFICATIONS

A. Material and equipment furnished under this section shall be of manufacturer who has been regularly engaged in design and manufacture of the material and equipment for at least 5 years.

B. Demonstrate to satisfaction of owner that quality is equal to material and equipment made by manufacturer specifically named herein, if alternative manufacturer is proposed.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Material and equipment shall be prepared and protected for shipment and shipped in accordance with manufacturer’s instructions.

B. Material and equipment openings shall be covered during shipment, storage, and handling.
C. Material and equipment shall be inspected upon arrival for damage.

1.6 COORDINATION

A. Coordinate installation of pumps with installation of connecting piping, electrical, instrumentation, mounting connections, and other appurtenances associated with chemical feed system.

B. Coordinate and incorporate instrument relay, indicators, controllers and power supplies for equipment furnished under Division 40.

1.7 WARRANTY

A. The supplier(s) of material and equipment shall warrant them to be free from defects in material and workmanship for one year from date of final acceptance.

PART 2 - PRODUCTS

2.1 GENERAL

A. Equipment shall be new, first quality products, and free from defects specifically manufactured to feed the chemicals identified in the specifications.

B. Equipment shall be marked to identify material, manufacturer, and other appropriate data.

C. Equipment shall be furnished with operators, knobs, indicators, or other appropriate appurtenances as specified herein, and as shown on Drawings.

2.2 SERVICE CONDITIONS


B. Liquid Inflow Temperature: 35 to 90 degrees F.

C. Relative Humidity of Ambient Air: Up to 100 percent.

D. Sodium hypochlorite

   1. Description: Sodium hypochlorite
   2. Concentration: 12.5 percent
   3. Solids: None
   4. Density: 10.2 pounds per gallon

E. Magnesium Hydroxide

   1. Description: Magnesium Hydroxide Slurry
   2. Percentage By Weight: 98.8%
3. Active Content: 61%
4. Density, lbs./gal. 12.8

2.3 EQUIPMENT

A. Material and equipment shall meet the following performance requirements when operating at service conditions listed in this section:

1. Equipment shall not deform, crack, corrode, become brittle, or otherwise become unserviceable.
2. Equipment shall consistently function as intended by manufacturer.
3. Electric and electronic components shall not corrode, short circuit, change function, or otherwise become unserviceable.
4. Equipment and equipment connections shall not leak.
5. Equipment shall be chemically resistant for intended use.

B. Eductor shall be Schedule 80 PVC or other approved material suitable for sodium hypochlorite application.

1. Eductor for Plant Water Service (1 eductor):
   a. Suction Fluid Flow: Sodium hypochlorite, 0.5 gallons/hour maximum
   b. Suction Lift: 10 feet
   c. Discharge Head: 6 psi
   d. Available Motive Water: 1.7 gallons/minute @ 16 psi

C. Variable area flow meter rotameter shall be panel mount style, with integral flow adjustment valve, and shall be constructed of PVC or other approved material suitable for sodium hypochlorite application. Float guides shall be PVC or Hastelloy C, and floats shall be PVC, Hastelloy C, or other approved material suitable for sodium hypochlorite application.

D. Sodium hypochlorite storage (Owner supplied):

1. Sodium hypochlorite in a 55 gallon replaceable drum.

E. Magnesium Hydroxide Storage tank (tote) for alkalinity adjustment:

1. Outer Container: Rectangular grid box made from tubular steel material, with bottom plate, closed with tie-bar, label plate on front side, additional label plate on the back side.
2. Outer Container Material: Grid / Bottom Plate: Steel, galvanized against corrosion; Corner Protector: 4 pieces made of HDPE
3. Inner Container: Rectangular blow molded tank of high density polyethylene (HDPE), with filling opening (6") in the middle of the top section. Valve opening in front section.
4. Inner Container Material: High Density Polyethylene – natural
5. Filling Opening: Filling opening 6" with external thread, closed with red screw cap, 2” plug.
6. Extra opening added by manufacturer as 2” bung on top of the tote on the valve side
7. Filling Opening Material: Screw cap 6": HDPE, red; O-ring gasket: TP; G2-plug: HDPE; O-ring 2”-plug: HDPE
8. Discharge Opening: Integrated Ball valve, 2” male cam lock outlet, 1 pc dust cap.
9. Discharge Opening Material: Housing Ball valve: HDPE; Disk inside valve Polypropylene; Disk gasket: generic Teflon; Screw cap: HDPE
10. Pallet: Steel frame pallet (1000 x 1200 mm), 4-way entry.
11. Pallet Material: Galvanized steel tube
12. Colorant: Heavy-metal free
13. Delivery: Ready for filling, clean

F. Provide drum scale with integral secondary containment for C3 system sodium hypochlorite

1. The drum scale shall be of the digital readout/electronic load cell type. Scale platform shall be sized to accept up to a 24 inch diameter drum. Platform shall have integral secondary containment with capacity of 66 gallons. Overall platform height shall be no more than 6 inch to permit easy loading and unloading of drums. Platform and containment system shall be non-metallic to eliminate the possibility of corrosion.
2. Scale shall be of the multiple load cell design. Weight shall be transferred via pivoted platform to three (3) NTEP approved load cells of the shear beam strain gauge type. Flexible cable shall connect scale platform to indicator to allow easy remote installation of the readout.
3. A remote mounted 32 character LCD indicator shall be housed in a NEMA 4X, UL approved enclosure; LCD indicator shall be back lit with 0.5 inch characters for ease of readability in low light conditions. Tare weight and level alarm set point values shall be entered via a keypad. Indicator shall output net weight via a 4-20mA signal for remote monitoring. Indicator shall have adjustable set points for alarm or liquid level control.

G. Provide a heavy duty polyethylene spill containment pallet (76.5-inch length x 53-inch width x 6-inch depth) for the CIP sodium hypochlorite

1. Holds up to 2000 lbs
2. Minimum 55 gallons sump capacity
3. Meets EPA 40 CFR 264.175
4. Forkliftable
5. Removable grate for easy cleaning
6. Drain with plug

H. Provide removable spill pallet ramp to connect to the spill containment pallet for drum transfer.

1. 100% polyethylene
2. 10% ramp slope
3. Ribbed, non-skid surface for safe walking

I. Provide chemical transfer pump for magnesium hydroxide refilling.

1. Manufacturers: AMT, A Gorman-Rupp Company, Magnum Power Products LLC, or approved equal
2. Type: Self-Priming diaphragm Pump designed to pump mud, slurry, sewage, and thick liquids that have the ability to flow
3. Motor: 1.5 HP single phase, 115/230 Volt motor with manual reset overload includes 20 foot 115 VAC power cord and weatherproof on/off switch
4. Suction and Discharge: 2" NPT Port Sizes
5. Total Head: Built-in molded polyurethane flapper/check valve assures self-priming to 25 ft
6. Capacity: Up to 35 gpm
7. Accessories: Each unit includes a 2” or 3” NPT steel suction strainer, two NPT nipples, and a wheel kit with 10” semi-pneumatic transport wheels for portability.

J. Provide Drum Truck for transfer Sodium hypochlorite storage drum
   1. Adjustable to handle fiber, plastic & steel drums 23” to 42” high with rims up to 85 gal overpack.
   2. 4-ply, 4.80/4.00 x 8” tires.
   3. 1,000-lb capacity
   4. Waterworks tool company, Drum Hustler II or equal

K. Provide Pallet Jack for transfer Magnesium Hydroxide storage tote
   1. Spring loaded self-righting safety loop handle
   2. Operate with 3-function hand control (raise, neutral, lower)
   3. Floor protective polyurethane steer and load wheels
   4. 5500-lb capacity
   5. Global Industrial, Pallet Jack 5500 lb or equal

2.4 SPARE PARTS
A. Contractor shall provide the following spare parts:
   1. 1 Eductor for plant water service
   2. 1 Rotameter and Flow Control Valve Assembly for plant water service.

PART 3 - EXECUTION

3.1 CHEMICAL FEED SYSTEM
A. Equipment Inspection: The Contractor shall examine all equipment at the site and determine that it is the specified equipment, or approved replacement, that it is new and in good condition, and that it is capable of the required performance.
B. Site Inspection: The Contractor shall examine the installation site, mounting pads, etc., as applicable to determine their suitability and/or conformance to Specifications for the equipment installation.
C. Equipment Installation: The Contractor shall install the equipment in the location specified on the Contract Drawings or in accordance with the manufacturers’ recommendations.
D. Valves and Piping. The Contractor shall provide and install any valves and piping as required for an operable system in accordance with the Plans and Section 422700 “Process Piping - General.”
E. Electrical. The Contractor shall connect all necessary electrical power and signal wiring, including furnishing of all necessary material in addition to that included in the specified equipment. Wiring material and installation shall be in accordance with the Electrical Specifications.

3.2 STARTUP

A. The Contractor shall arrange for qualified representatives of the manufacturers to inspect the installation and perform startup of the equipment and to demonstrate required performance to the satisfaction of the Owner.

3.3 INSTRUCTION

A. The Contractor shall arrange for not less than 4 hours of adequate instruction of operators selected by the Owner at a time acceptable to the Owner and the manufacturers. Instruction shall be for operation and routine maintenance and repair.

3.4 FIELD TESTS

A. Functional Test: Prior to plant startup, equipment described herein will be inspected by owner for proper level, proper alignment, and proper connection.

B. Performance Test: Performance testing shall be performed as described in Sections 019150 and 409002

C. Calibrate and test eductors, flow meters, and associated equipment throughout their design range for chemical feed solution. Calibrations shall be witnessed by Owner and Engineer.

END OF SECTION 463300
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The Work of this section includes all labor and materials necessary to provide the Membrane Bioreactor System. The Owner will assign to the Contractor its contract with OVIVO for membrane bioreactor system goods and services as described in Division 0 of the Specifications.

B. Ovivo, the Membrane Bioreactor System supplier will supply the necessary equipment as per the Scope of Supply attached at the end of this specification section. Contractor shall install the equipment as per the manufacturer’s installation requirements.

C. The Membrane Bioreactor System includes membrane units, pumps, blowers, air diffusers, mixers, valves, instrumentation, controls and related appurtenances.

D. Project Reference Documents:

1. Port Hadlock Water Reclamation Facility Membrane Bioreactor (MBR) equipment procurement contract documents are available for review at the Port Hadlock City Hall and the office of Engineer. Copies may be purchased for the cost of reproduction. These reports are not part of the Contract Documents and Contractor may not rely upon or make any claim against Owner, Engineer or any of Engineer’s consultants with respect to the reports.

1.3 DEFINITIONS AND ABBREVIATIONS

A. MBR System: All membrane bioreactor equipment, material, services, systems, and appurtenances required to achieve a complete, fully integrated, and operational system meeting all the design conditions and testing requirements as specified herein and shown on the drawings.

B. Membrane Unit: An assembly of membranes intended to be removed from an immersed system as a group. Also referred to as module or cassette. A unit shall have the capability to be isolated from the rest of the system for testing, or repair.

C. Train: a grouping of membrane filtration units that share common ancillary equipment and that can be isolated from the rest of the system for cleaning or maintenance.
D. Membrane Tank or Membrane Basin: A structure that contains multiple membrane units that share common mechanical and electrical systems such as permeate pumps and piping, chemical feed lines and air supply lines.

E. Transmembrane Pressure (TMP): The difference in pressure between the average feed/concentrate pressure and the permeate pressure; the driving force, or hydraulic head loss, associated with any given flux. The TMP of the membrane system is an overall indication of the feed pressure requirement; it is used, with the flux, to assess membrane fouling and the need for chemical cleaning. In a crossflow membrane system, TMP is measured as the average of the inlet and outlet pressures, minus the permeate backpressure.

F. Filtrate or Permeate – The water that has passed through the membrane. The term “filtrate” is often referred to as “permeate.”

1.4 RELATED SECTIONS
A. Work under this section shall be in compliance with all of the following divisions. Specific sections are listed for coordination of the equipment listed in this section.

B. Division 01
C. Division 26
D. Division 40 (409007 and 409012)
E. Division 42
F. Division 46

1.5 UNIT RESPONSIBILITY
A. OVIVO shall be responsible for ensuring that all parts of the MBR System are properly integrated to deliver the required performance for the design conditions.

1.6 COORDINATION
A. OVIVO will furnish the products for the MBR System listed in OVIVO’S Scope of Supply at the end of this specification section. All other products and incidental items needed to provide a complete operational MBR System, as described herein, shall be provided by the Contractor.

B. The equipment will be installed and interconnections made by the Contractor.

C. OVIVO shall provide installation instructions to the Contractor, and review the installation of the entire MBR System prior to equipment Startup.

D. The Contractor will assume responsibility for the satisfactory installation of the MBR System components.
E. Substantial Completion: When Performance Testing is completed as described herein, Engineer will issue Notice of Substantial Completion to Contractor and OVIVO for the MBR System. This only applies to the MBR System. Notice of Substantial Completion for the remainder of the Work outside of the responsibility of the MBR system by the Contractor will be issued separately.

1.7 REFERENCES
A. ASME Boiler and Pressure Vessel Code
C. ASTM A 36 – Standard Specification for Structural Steel
D. ANSI B16.5 – Pipe Flanges and Flanged Fittings
E. AWS D10.9 – Standard for Qualification of Welding Procedures and Welders for Piping and Tubing
F. AWS A5.9 – Specification for Bare Stainless Steel Welding Electrodes and Rods
G. AWS D1.1- Structural Welding Code – Steel
H. Hydraulic Institute (HI)
I. National Electric Code (NEC)
J. Standards of National Electrical Manufacturers Association (NEMA)
K. Standards of American Water Works Association (AWWA)
L. Underwriter’s Laboratory (UL)

1.8 SUBMITTALS
A. Supply shop drawings for all equipment as required by Division 01 “Submittal Procedures.” Shop drawings shall also include the following:
   1. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories
   2. Assembly and installation drawings including anchor bolt plan, parts nomenclature, material list, and outline dimensions.
   3. Design loadings to be transmitted to foundation or supports.
   4. Design calculations showing dead, live, and dynamic loadings for normal and seismic conditions.
   5. Certified copies of test logs and performance curves for all pumps and blowers.
B. Submit manufacturer’s product data for all equipment as required by Division 01 “Submittal Procedures.” At a minimum, product data shall include the following:
1. Manufacturer’s catalog descriptive literature and cut sheets with identifying arrows pointing to the specific equipment, devices, and materials to be supplied for the individual specification sections;
2. Specific equipment information including manufacturer, materials of construction, performance data, inspections, test reports, and any certifications.
3. Certification from OVIVO stating that all equipment complies with this Specification.

C. All specification submittals shall be submitted as required in Division 01 Section 013300 “Submittal Procedures.”

D. Provide Operations and Maintenance (O&M) Manuals for all equipment supplied as required in Division 01 Section 017823 “Operation and Maintenance Data.” At a minimum, each O&M manual shall include the following information:

1. Manufacturer’s contact information (name, number, address, etc.);
2. Process and instrumentation diagrams and design criteria;
3. Control strategies and diagrams;
4. Shop drawings;
5. As-built wiring diagrams of overall system;
6. Program documentation printout with tag numbers and descriptive comments, including backup program on compact disc;
7. Installation procedures;
8. Start-up, commissioning, and shutdown procedures;
9. System operating procedures, including normal operations and operations during all alarm conditions;
10. Troubleshooting procedures;
11. Testing and calibration procedures;
12. Preventative maintenance schedules and procedures;
13. Component repair and replacement procedures;
14. Catalog data and complete parts list;
15. Recommended spare parts list; and
16. Recommended maintenance tools and equipment.

E. Issue written reports summarizing all testing conducted, data collected, and results.

1. Reports shall include, but is not limited to:
   a. Description of performance testing activities.
   b. Testing procedures
   c. Operating conditions and parameters
   d. Results
   e. Comparison to performance requirements
   f. Recommended operating conditions and parameters
   g. Recommended frequency and duration of cleaning cycles
   h. Recommended sampling protocol
   i. Recommended laboratory analyses
   j. Schedule

2. The reports shall recommend any changes to the published operation and maintenance procedures.
F. Any changes to the sizing of any system shall require submittal to the Engineer for approval revised design calculations that were developed by OVIVO during the design work as part of the shop drawing submittal.

1.9 WARRANTY

A. General

1. Warrant the MBR System equipment and performance as specified herein. The warranties obtained from OVIVO will consist of three parts: a general equipment warranty for all equipment provided by OVIVO, a system performance warranty, and a membrane warranty.

2. The documents shall be submitted to the Engineer during the submittal review process, in a form acceptable to the Owner and the Engineer.

3. Warranty and Guarantee documents shall be assigned to the Owner.

B. General Equipment Warranty

1. For a period of one calendar year from the date of Substantial Completion of the construction contract, not to exceed 24 months after equipment shipment, OVIVO warrants that all work, material, equipment, and products provided by OVIVO will be free from defects in material and workmanship. The General Equipment Warranty does not cover membranes. The warranty for membranes is described under paragraph 1.10 D of this Section.

2. For MBR System equipment supplied as part of the original MBR equipment installation, the “date of installation” is when the date the membrane system has successfully completed the Performance Testing and the Notice of Substantial Completion of the MBR System has been issued.

C. MBR System Performance Warranty

1. For a period of one calendar year from the date of Substantial Completion of the construction contract, OVIVO agrees to warrant that the MBR System, when operated within the conditions specified in the Contract Documents, will meet or exceed the performance requirements specified herein.

2. If, during the MBR System performance warranty period, the MBR System is unable to meet any of the specified performance requirements, OVIVO shall make changes to the system, or supply additional membranes or other equipment necessary to bring the system performance into compliance with the specified performance requirements. Any such changes or additions to the system shall be approved by the Engineer and Owner and shall not result in increased operation and maintenance costs.

3. The Owner shall make available to OVIVO electronic records of historical performance for OVIVO review.

4. If the system performance deficiency, in the reasonable opinion of the Owner, requires immediate correction to avoid injury to Owner personnel or to avoid a permit violation of any kind:

   a. The Owner may make or have made such repairs, adjustments, replacements, or other corrective work.
b. Payment for this work by OVIVO or its surety shall be guaranteed by the Performance Bond.

c. The Owner will make a reasonable attempt beforehand to contact OVIVO to allow OVIVO an opportunity to make immediate correction, if in the opinion of the Owner doing so will not result in injury or permit violation.

5. If the system performance deficiency, in the reasonable opinion of the Owner, does not require immediate attention:

a. The Owner will make a reasonable attempt to notify OVIVO of the conditions as a first step in establishing corrective procedures.

b. Unless the deficiency requires immediate correction as stated in Paragraph 1.10 C.4 above, the Owner shall not do or cause to be done any work, purchase any services or material or incur any expense for the account of OVIVO until after Owner has provided OVIVO full details (including estimate of material cost and amount and rate of labor required) of the work, services, material or expenses, and OVIVO has approved the same in writing.

c. OVIVO will not accept Products returned by the Owner unless OVIVO has previously accepted the return in writing and provided the Owner with shipping instructions.

d. OVIVO shall have no liability with respect to any Products that have been altered or repaired in any way without OVIVO’s prior written authorization.

6. If, in the Performance Testing or operation of the equipment after installation, the Owner finds latent performance deficiencies or finds that equipment fails to meet any performance requirements of the specifications, the Owner shall have the right to make reasonable use of such equipment until it can be shut down for correction of performance deficiencies without injury to the Owner; provided that the period of such operation pending the correction of performance deficiencies shall not exceed 6 months without the written consent of OVIVO.

D. Membrane Warranty

1. For a period of 7 calendar years from the date of Substantial Completion of the construction contract OVIVO warrants that the membranes, membrane modules, and membrane cassettes provided by OVIVO will conform to specifications to be free from defects in material and workmanship, and lack of membrane integrity failure and irreversible flux loss. For a period of 7 calendar years from the date of Substantial Completion of the construction contract, OVIVO agrees to warrant that the membranes, membrane modules, and membrane cassettes provided by OVIVO, when operated within conditions specified in the Contract Documents, will meet or exceed the performance requirements specified herein.

2. OVIVO agrees to fully warrant membrane replacement due to defects or inadequate performance during the 7 year membrane performance warranty period. Membrane replacement during the first year of the membrane warranty period shall be provided at no additional cost to the Owner. Membrane replacement during the following 6 years of the membrane warranty period will be provided at a prorated cost based on the guaranteed membrane purchase cost provided in the Proposal. The guaranteed membrane purchase cost will be prorated by the ratio of the effective service life of the membranes beyond the first year of operation divided by 6 years.
3. OVIVO shall be responsible for packaging, shipping, and any applicable taxes required to transport new membranes to the Port Hadlock WRF, and to transport defective membranes from the Port Hadlock WRF to a location determined by OVIVO.

4. The Owner will be responsible for the cost of removing the defective membranes and installing the replacement membranes.

E. Limitation of Membrane Module Warranty: The Owner recognizes that the occurrence of any of the following may void the membrane warranty.

1. Physical damage or faulty installation of the membrane units by others.
2. Unauthorized alteration by others of components not manufactured by OVIVO.
3. Catastrophic exposure to chemicals not normally associated with wastewater treatment as a result of accidents, vandalism, or other acts that are totally outside the bounds of routine and normal wastewater treatment plant operations.
4. Use of water treatment chemicals, chemical cleaning solutions, or cleaning procedures other than chemicals, solutions and procedures approved by OVIVO, other than those prescribed in the Procurement Documents.
5. Exposure of the membranes to wastewater treatment chemicals at concentrations, levels, or contact times unacceptable to OVIVO. OVIVO is responsible to provide the Owner a listing of the known wastewater treatment and cleaning chemicals and concentrations and time of exposure that could result in a loss of membrane integrity or cause irreversible fouling. Operation or cleaning of the membrane outside the stated limits shall void the remaining portion of the membrane warranty.
6. Improper operation or maintenance of equipment, as defined by the O&M Manual.
7. If OVIVO’s customer or original user fails to perform its obligations under the warranty or any other agreement between the parties or OVIVO’s customer and the original user fail to pay any charges otherwise due OVIVO.

1.10 FACTORY TEST REPORT

A. OVIVO shall submit prior to delivery of the membrane units the following:

1. OVIVO shall identify the membrane units to be provided under this contract. In the table below

<table>
<thead>
<tr>
<th>Part Identification</th>
<th>Type</th>
<th>Number of Units</th>
<th>Serial Numbers</th>
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<td>Membrane Units</td>
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<tr>
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<td>1200 / Train (600 lower and 600 upper cartridges)</td>
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2. OVIVO shall identify each membrane unit by a unique serial number and indicate the Membrane Lot.
3. OVIVO shall provide the membrane specification sheets that specify each membrane unit’s normalized specific flux (gpm/psi @ 20° C), nominal pore size, and the nominal inside and outside surface area of the filter module.
4. Certification of testing for each membrane unit conducted at OVIVO’s facilities. OVIVO shall certify that each membrane unit has passed the quality assurance/quality control tests for membrane element integrity. Acceptable quality assurance and quality control
tests include permeability, weld, bubble point, pressure hold or vacuum hold tests above the minimum value recommended by OVIVO and approved by the Engineer. OVIVO shall submit a copy of all test data including serial number, test pressures, test duration and clean water permeability determined from the test. OVIVO shall provide a specific description of the test procedures and apparatus.

5. Identify membrane units that have undergone pinning or repair for more than 0.1% of the original fibers at the factory.

PART 2 - PRODUCTS

2.1 GENERAL

A. Membrane units shall be prefabricated, preassembled, and tested before shipment to site. Assembly of components on site will be allowed to meet shipping requirements.

2.2 MANUFACTURERS

A. OVIVO shall furnish products for the MBR System as listed in OVIVO’S Scope of Supply at the end of this specification section.

EXECUTION

2.3 DELIVERY

A. OVIVO, Contractor, Engineer, and Owner shall inspect all equipment immediately upon delivery to site.

1. If damaged, notify Engineer and OVIVO immediately.

B. OVIVO shall pay all freight charges and shall file all claims and bear all responsibility for the equipment, material, and products from the point of origin to the site. All prices shall be F.O.B to the site.

C. Spare parts and special tools shall be properly marked to identify the associated equipment by name and part number. Parts shall be packaged in a manner for protection against damage from the elements during shipping, handling, and storage. Spare parts and special tools shall be shipped in appropriately sized, hinged-covered, wood or metal boxes. The boxes shall be marked to indicate the contents and use. The special tools shall be delivered at the same time the associated equipment is delivered.

D. The Contractor shall unload the equipment and materials at the point of delivery based on written handling and storing instructions to be furnished by OVIVO.

E. Contractor shall not install damaged equipment until repairs are made in accordance with OVIVO’s written instructions approved by the Engineer.

1. Only minor repair work shall be permitted in the field, as approved by the Engineer.
2. All other damaged items shall be sent to factory for repair or replacement.

F. The Contractor is responsible for properly storing all equipment provided by OVIVO per OVIVO’s storage instructions.

G. The Contractor shall complete the installation in accordance with OVIVO’s instructions and recommendations.

2.4 INSTALLATION

A. OVIVO shall furnish complete installation instructions and recommendations to the Owner and the Contractor.

B. The Contractor will install the equipment in accordance with OVIVO’s written instructions and recommendations.

C. Installation Services:

1. OVIVO shall provide services for installation assistance of the supplied equipment. At a minimum, the services include two site visits for a period of 4 working field days each. Installation services shall be performed by a trained factory representative, and shall include inspection and testing supervision during placement and installation of the membrane units.

2. OVIVO shall inspect that structures, pipes, and equipment are compatible. OVIVO shall give written notice to the Contractor of any adjustments required to place the system in proper operating condition.

3. Prior to startup and testing, OVIVO shall provide a written certification that the supplied equipment has been properly installed, lubricated, and maintained after delivery to the site; is accurate in alignment; is free from undue stress from connecting pipe and anchoring; protective devices and alarms have been installed; and the system has operated satisfactorily under full load conditions, satisfying the proper installation requirements of the warranty described in Paragraph 1.8.

4. OVIVO shall provide manufacturer’s certificates in accordance with Division 01 Section 013300 “Submittal Procedures” for major equipment furnished as part of the MBR SYSTEM including but not limited to:

   a. Submersible mixers
   b. Aeration Blowers
   c. Air Scour Blowers
   d. Permeate Pumps
   e. Chemical Feed Pumps
   f. Membrane PLC System
   g. Membrane units

D. System Integration:

1. OVIVO shall provide a trained factory representative to provide all programming for the MBR system equipment, VFD’s and controls. OVIVO shall coordinate the programming with the Contractor’s Instrumentation Supplier to ensure smooth transfer of information
between the plant SCADA system and the membrane PLC in accordance with the Contract Documents.

2. This service shall include two site visits for a period of four calendar days each.

3. Following successful start-up and commissioning of the control system, OVIVO shall provide written documentation of membrane unit integration with the Port Hadlock WRF control system.

2.5 START-UP AND TESTING

A. General:

1. Work shall be performed in conjunction with the provisions of Division 01 Section 019150 “System Startup, Testing, and Training.”

2. OVIVO shall provide services for Functional Testing, Clean Water Testing, and Start-Up assistance for the supplied equipment. At a minimum, the services shall include 2 site visits for a period of 4 working field days. Services shall be performed by a trained factory representative, and shall include supervising and documenting compliance of all start-up procedures outlined in OVIVO’s O&M manual as well as documenting any adjustments made during the start-up period. Representatives from OVIVO shall be scheduled by the Contractor with minimum two weeks notice.

3. OVIVO shall assist the Contractor in the testing of the MBR System. Deficiencies in portions of the Work that affect the performance of the testing and is outside of the MBR System shall be corrected by the Contractor prior to testing. All testing shall be conducted by the Contractor under the direction of the representatives from OVIVO. The Engineer and the Owner’s operation and maintenance staff shall also assist in testing under the direction of OVIVO. Any labor required for the testing that is above normal plant operating requirements shall be provided by the Contractor and paid for separately by OVIVO.

B. Functional Testing

1. Prepare equipment so it will operate properly and safely and be ready to demonstrate functional integrity during Performance Testing.

2. Procedures include but are not limited to the following:

   a. Power, control, and monitoring circuits for continuity prior to connection to power source
   b. Voltage of all circuits
   c. Phase sequence
   d. Cleanliness of connecting piping systems
   e. Alignment of connected machinery
   f. Vacuum and pressure of all closed systems
   g. Lubrication
   h. Valve orientation and position status for manual operating mode
   i. Tankage for integrity using clean water
   j. Pumping equipment using clean water
   k. Instrumentation and control signal generation, transmission, reception, and response; individual instrumentation loops
   l. Tagging and identification systems
   m. All equipment: Proper connections, alignment, calibration, and adjustment.
3. Calibrate all safety equipment
4. Manually rotate or move moving parts to assure freedom of movement
5. “Bump” start electric motors to verify proper rotation
6. Perform other tests, checks, and activities required to make the equipment ready for Performance Testing.
7. Prepare a log showing each equipment item subject to start-up procedures and listing what is to be accomplished during Start-up and Testing. Provide a place for OVIVO to record date and person accomplishing required work. Submit completed document before requesting inspection for Substantial Completion certification.

C. Clean Water Testing

1. After successful functional testing, the clean water testing of the MBR System will be conducted in conjunction with the clean water testing of the influent pump station, fine screens, anoxic basins, aeration basins, post anoxic basins, membrane basins, treatment equipment building, UV disinfection and associated facilities. Effluent from the MBR system and UV disinfection shall drain to the influent pump station and then be pumped to the headworks for recirculation through the plant for the duration of the clean water test. The clean water testing shall be conducted in accordance with the requirements of the Contractor’s construction contract. OVIVO will assist the Contractor with the operation of the MBR System during clean water testing.

   a. Both trains installed in Phase 1 will be operated with clean water and will be completed upon successful operation without interruption for 8 consecutive calendar days.
   b. Clean water testing shall be scheduled to occur for all membrane basins after submittal and acceptance of O&M Manuals, satisfactory completion of operator training, and functional testing for all equipment and systems, and prior to introduction of wastewater to the membrane basins.
   c. The clean water test shall incorporate continued operator training as OVIVO representatives bring the MBR System into service in preparation for treating wastewater.

2. The following shall be tested:

   a. Pumps
   b. Mixers
   c. Blowers – both scour air blowers and biological treatment blowers
   d. Level sensors
   e. Flow meters
   f. Pressure gauges
   g. Automatic failover of treatment trains

D. Start-up

1. After clean water testing, OVIVO will assist the Contractor with the startup of the MBR System in conjunction with the start-up of the influent pump station, headworks screens, anoxic basin, aeration basin, post anoxic basin, membrane basin, disinfection system, and all associated facilities with wastewater.

2. Seeding: The Contractor shall be responsible for the transportation and delivery for any return activated sludge required for proper startup of the biological treatment system.
3. Provide sufficient seeding to bring mixed liquor concentration to 8,000 mg/L as recommended by OVIVO.
4. Monitor MBR filtrate to ensure compliance with performance requirements. Monitor effluent to ensure compliance with permit requirements. Any filtrate that is not in compliance will be returned to the influent pump station for re-treatment.
5. The start-up activities shall incorporate continued operator training as OVIVO representatives operate the MBR System to treat wastewater.

E. Performance Testing

1. OVIVO shall assist in organizing, conducting, supervising, and documenting the performance test of the supplied equipment. The purpose of performance testing is to demonstrate that the equipment and system provided by OVIVO is in compliance with the service conditions specified herein, and that it meets the operating conditions stated by OVIVO in the Scope of Work for Design Services. At a minimum, OVIVO’s services shall include 2 site visits for a period of 4 working field days. The performance test will also determine whether the equipment is in compliance with the instrumentation and controls requirements set forth in Division 40.
2. Performance testing shall commence within 60 days after successful Start-up and completion of training at a mutually agreed upon time among OVIVO, the Owner, and the Contractor. If warranted performance is not obtained, then OVIVO is to be notified within ten (10) days. OVIVO shall have the right, and if requested by the Owner, the obligation, to visit the installation to determine the cause of such failure. It is a condition of the warranty that the customer will, at its expense, cooperate with OVIVO in making further tests and make available necessary personnel, feed and operating conditions to enable OVIVO to conduct such tests.
3. Performance testing shall simulate wastewater treatment prior to the release of actual effluent to the reuse field. Successful performance testing shall be required prior to the release of any treated wastewater effluent to the reuse field. Performance testing of individual treatment trains in series is permissible, but will double the time required to complete performance testing.
4. Because of the unknown conditions for influent flow available at the time Performance Testing would be scheduled, the details of the Performance Testing described below may be modified in conjunction with the Engineer during design of the Facility. The details described herein demonstrate the testing goals required for Performance Testing, including but not limited to, design hydraulic loading, cleaning cycles, and failover provisions.
5. Performance testing shall extend over a period of 30 consecutive days, and shall take place in accordance with the following operating requirements:
   a. OVIVO’s representative, as identified in the Proposal, shall be present on site for the agreed upon days from 8 a.m. to 5 p.m. on weekdays, and shall be directly available via cellular phone at any other time during the performance test. OVIVO’s representative shall take daily field notes and collect daily test data when on site and instruct the Contractor on how to properly collect data when not on site.
   b. The performance testing shall be conducted to simulate the Phase 2 flow conditions specified in Paragraph 2.3 and to demonstrate compliance with the performance requirements specified herein with operation of all membrane basins or one membrane basin if influent flow is inadequate.
   c. The membrane basins shall be operated with the appropriate membrane cleaning cycles to demonstrate the system’s ability to produce the required net filtrate...
d. Upon completion of the performance test, OVIVO’s representative shall submit a written report detailing the results of the test, including a copy of all field notes and test data.
e. If the performance test was interrupted for more than six consecutive hours at the request of OVIVO’s representative due to OVIVO’s faults, the test shall start again from the beginning at the sole cost of OVIVO. If the interruption was not within OVIVO’s responsibility, such as utility supplier failure and no wastewater supply, additional time may be required to recover the system performance status and restart the performance test. In this case, OVIVO will be compensated by the Owner for the cost and expenses of OVIVO’s representative on site.

6. The net specific flux that is measured during the performance test shall be converted to the net specific flux normalized to 20°C using the following equation:

\[ J_{20} = J_T \times e^{[-0.032 \times (T - 20)]} \]

Where

- \( J_{20} \) = normalized flux at 20°C (gpd / sf)
- \( J_T \) = actual flux at temperature T (gpd / sf)
- T = water temperature (°C)

7. The corresponding transmembrane pressure for each measurement of net specific flux shall be recorded.

8. Performance testing for the following conditions shall be conducted for one membrane train: Plant effluent can be recirculated through the plant via the influent pump station to increase plant flow for the following sequence of test conditions.

a. Max Month flow for 14 days
b. Peak Day flow for 24 hours
c. Execute Cleaning Cycles: Maintenance Clean and Backpulse
d. Peak Day flow for 24 hours
e. Max Month flow for 7 days
f. Execute Recovery Clean
g. Max Month flow for 7 days

9. Successful conclusion of each test shall be achieved when the system is able to operate continuously without failure, shutdown, or other interruption while meeting all filtrate production and performance requirements.

10. When a failure, shutdown, or interruption occurs, the test shall be terminated and OVIVO or Contractor shall take corrective actions depending on the cause of the failure.

11. Engineer reserves the right to direct resumption of the test from the point of failure, shutdown, or interruption, or to restart the test with no credit given for the operating time achieved before the test was terminated. If the failure, shutdown, or interruption is not within OVIVO’s responsibility, the Owner will compensate OVIVO for the additional cost and expenses of OVIVO’s representative on site caused by the failure, shutdown, or interruption.
12. The date of Substantial completion shall be established upon successful completion of all Performance Testing for one membrane train and the successful completion of Start-Up for all trains.

13. Within 14 days following completion of each performance test, OVIVO shall submit a written report summarizing the test and all data and results as specified in Paragraph 1.9.

2.6 TRAINING

A. OVIVO shall provide the following training sessions for the plant staff at the Project Site:

1. OVIVO shall schedule the training sessions to accommodate the availability of Owner personnel. The training shall be at such times as requested by the Owner. No training session for a single group shall last more than 4 hours.

2. The objective of the training shall be to convey the knowledge needed by the Owner for operation and maintenance staff to safely operate, maintain, and repair the equipment and systems provided by OVIVO.

3. OVIVO shall submit an overall training plan and a detailed lesson plan for each training activity at least 10 days in advance of the training. The training plan shall include the following as a minimum:

4. The Owner reserves the right to video tape or record the training sessions, and to use such tapes for continuing operator training.

5. Preliminary Training:

   a. Preliminary training is to take place during the MBR System installation and start-up.
   b. Preliminary training shall include basic training for the various equipment and process subsystems that are part of the MBR System. Training shall include basic training on the VFD(s) provided.
   c. Preliminary training shall occur no later than four weeks prior to start-up

6. Initial Training Period: OVIVO shall provide for one site visit for three calendar days to train Owner staff in the operation and maintenance of the supplied equipment. Training shall include all procedures outlined in the draft O&M manual. The factory representative providing installation services and the lead process or controls engineer shall participate in this training. Individual training sessions shall be provided for the membrane cassettes, filtrate system, backwash system, return activated sludge system, air scour system, and chemical feed system. Initial Training shall include as a minimum:

   a. Equipment operation
   b. Detailed component description
   c. Equipment preventative maintenance
   d. Equipment troubleshooting

7. Training Refresher Period: OVIVO shall provide one site visit for two calendar days to provide a training refresher to the Owner staff in the operation of the supplied equipment and per the project schedule. A lead process engineer or lead controls engineer, as identified in the Proposal, shall participate in this training.

8. Training Aids:
a. OVIVO’s instructor shall incorporate training aids as appropriate to assist in instruction.

1) Text and figure handouts, bound in 3-ring binders.
2) Audio-Visual aids
3) Equipment cutaways and samples
4) Tools

b. Hands-On Demonstration

1) OVIVO’s instructor shall present “hands-on” demonstrations of operations and maintenance of OVIVO supplied and component equipment.
2) The proposed “hands-on” demonstrations shall be described in OVIVO’s proposed training plan.

END OF SECTION 464240
### Pre Anoxic Basins (PA-01 & 02)

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### Post Anoxic Basins (AXP-01 & 02)

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### MBR Basins (MBR-01 & 02)

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### MBR / MBT / Standby Blower System

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SECTION 466616 – ULTRAVIOLET DISINFECTION

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies complete requirements for materials, labor, equipment and appurtenances required to provide a pressurized closed-vessel ultraviolet (UV) disinfection system with high-intensity low-pressure amalgam lamps, automatic wiping and constant output electronic ballasts. The UV system shall be complete and operational with all control equipment and accessories as specified herein and as shown on the contract drawings.

B. The system shall be installed by the Contractor and tested and commissioned by UV Manufacturer, as specified in this section.

1.2 QUALITY ASSURANCE

A. The Manufacturer shall be regularly engaged in the manufacture of closed vessel UV disinfection systems with a proven track record of at least twenty (20) municipal wastewater installations, each with a flow rate of at least 0.5 USMGD. The manufacturer shall provide experience documentation for UV disinfection systems in use with municipal wastewater reuse applications.

B. The UV Manufacturer shall submit a Bioassay Validation Report for the proposed reactor. The bioassay testing and results shall be validated by a qualified independent third party in full compliance with the NWRI Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (May 2003). The bioassay must demonstrate that the proposed UV system design and number of lamps will deliver the specified dose.

C. The UV manufacturer shall submit California Title 22 Approval for closed vessel UV units at time of submittal.

D. Bioassay testing shall evaluate reactor performance over the wide range of flow rates, UV Transmittance (UVT) (measured at 254 nm, 1 cm path length) and MS2 Reduction Equivalent Dose (RED). The bioassay testing must encompass the range of design and operating conditions described herein. Extrapolations of flow rates, UV Transmittance values, or UV doses outside the range actually tested, shall not be permitted.

E. Validation testing shall verify that the headloss generated by the proposed reactor is less than or equal to the specified limits.

F. The UV manufacturer must demonstrate that the electrical consumption based on Reduction Equivalent (bioassay) Dose, at peak flow and specified water quality (UV transmission), does not exceed the amount specified in this specification. If the maximum power consumption exceeds the specified amount, the Contractor shall pay the Owner a present worth cost based on a 25-year life and a 6% interest rate. The present worth cost shall be the difference between the average cost of operation and the cost to operate at the specified power consumption. The cost
of power shall be assumed to be $0.09/kWh. The credit shall be applied through a deductive change order.

The present worth cost can be calculated using the following formula:

\[
\text{Present worth cost} = (\text{Power Usage/ reactor @ Full Load } - 4.9\text{kW}) \times $0.09/\text{kWh} \times 8760/\text{year} \times 12.783 \text{(Present Worth Factor, 25 years, 6%)}
\]

G. Documentation of the UV manufacturer’s service capabilities including location and experience must be submitted.

1.3 SYSTEM DESCRIPTION

A. Design Criteria:

<table>
<thead>
<tr>
<th>Reactor Type</th>
<th>Closed Vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basis of Design</td>
<td>TrojanUVFit™ 18AL40</td>
</tr>
<tr>
<td>Capacity Each, mgd</td>
<td>0.4 mgd @ 65% Transmittance</td>
</tr>
<tr>
<td>Capacity Each, mgd</td>
<td>0.5 mgd @ 72% Transmittance</td>
</tr>
<tr>
<td>Range of Turn down</td>
<td>60% - 100%</td>
</tr>
<tr>
<td>Power Usage/ reactor @ Full Load</td>
<td>4.9 KW</td>
</tr>
<tr>
<td>Power Usage/ reactor @ max turn down</td>
<td>3.1 KW</td>
</tr>
<tr>
<td>No of Reactors</td>
<td>2</td>
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<tr>
<td>Design UVT (minimum):</td>
<td>65% (at 254 nm, 1 cm path length)</td>
</tr>
<tr>
<td>UV dose at 65% UVT and 0.4 mgd</td>
<td>80 mJ/cm²</td>
</tr>
<tr>
<td>UV dose at 72% UVT and 0.5 mgd</td>
<td>80 mJ/cm²</td>
</tr>
<tr>
<td>Total Suspended Solids:</td>
<td>5 mg/L, 7 Day Average of grab samples</td>
</tr>
<tr>
<td>Effluent Temperature Range:</td>
<td>33°F to 85°F (1°C to 30°C)</td>
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<tr>
<td>Max. Inlet Pressure:</td>
<td>150 psig (6.8 bar)</td>
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</table>

B. Design Dose:

1. The UV disinfection system shall be designed to deliver the Reduction Equivalent Dose (RED) specified in Section 1.3.D, Performance Requirements. To ensure the UV system can deliver the RED at the end of lamp life, with fouled sleeves, the RED shall incorporate an End of Lamp Life (EOLL) factor and Fouling Factor (FF). EOLL is the ratio of lamp output at end of the lamp life relative to new lamp output. FF is the ratio of UV light transmission through the quartz sleeve at worst-case fouling conditions relative to a new quartz sleeve.

2. The RED shall be delivered under Peak (Design) Flow and Design UVT conditions specified in 1.3.A.1.
a. The RED must be verified by third party witnessed bioassay testing per Section 1.2.C and Section 1.2.E.
b. Headloss through each UV train shall not exceed 28.7 in - H2O under peak flow conditions.

C. System Components: The UV system shall be comprised of the following components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>Control Panel</td>
<td>1 per reactor</td>
</tr>
<tr>
<td>UV Intensity Sensor</td>
<td>1 per reactor</td>
</tr>
<tr>
<td>Wiping System Automatic</td>
<td>1 per reactor</td>
</tr>
</tbody>
</table>

D. Performance Requirements:

1. The UV Manufacturer shall provide a written guarantee that the equipment will continuously meet the specified performance requirements. The UV disinfection system shall be capable of producing an effluent conforming to the following Class A reclaimed water requirements:

   a. Less than 2.2 Total Coliforms/100 ml based on a 7 day average.
   b. Maximum concentration of 23 Fecal Coliform/100 ml in a single reclaimed water sample.

2. The UV system shall be designed to deliver a minimum UV dose of 80 mJ/cm² at peak flow, in effluent with a UV Transmittance of 65% at end of lamp life (EOLL) after reductions for quartz sleeve fouling. The basis for evaluating the UV dose delivered by the UV system shall be the independent third party bioassay, without exception. Bioassay validation methodology to follow protocols described in NWRI Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (May 2003).

3. The UV dose will be adjusted using an end of lamp life factor of 0.5 to compensate for lamp output reduction over the time period corresponding to the manufacturer’s lamp warranty. The use of a higher lamp aging factor will be considered only upon review and approval of independent third party verified data that has been collected and analyzed in accordance with protocols described in NWRI Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (May 2003).

4. The UV dose shall be adjusted using a quartz sleeve fouling factor to compensate for reduction of UV dose due to wastewater fouling during operation. If no quartz sleeve wiping system is included, a fouling factor of 0.5 shall be applied. If an automatic wiping system is included, a fouling factor of 0.8 shall be applied. If a re-circulating chemical feed system is installed, the FF shall be 0.9.

5. Independent validation for use of a higher lamp aging factor must be submitted to the Engineer for review a minimum of fifteen (15) days prior to bid.

6. The UV system shall be able to continue providing disinfection while the automatic wiping system is in operation.

7. System shall be designed to operate in an environment with ambient relative humidity of 5-90% and ambient air temperature of 32-104°F (0-40°C).

1.4 SUBMITTALS

A. Procedures: Section 013300 “Submittal Procedures.”

B. Submit for review, engineering drawings showing the following:
C. Complete description in sufficient detail to permit comparison with the specifications.

D. Dimensions and installation requirements.

E. Descriptive information including catalogue cuts and manufacturer’s specifications for all major components.

F. Electrical schematics and layouts.

G. Independent bioassay validation letter and dosage calculations demonstrating compliance with the specified dose requirements.

H. Disinfection performance guarantees and warranty letters.

I. California Title 22 Approval certification for UV disinfection.

J. Operation and maintenance information specified in Section 017300 “Execution”

1.5 WARRANTY

A. Equipment: The equipment furnished under this section shall be warranted to be free of defects in materials and workmanship, including damages that may be incurred during shipping for a period of one (1) year from start-up or 18 months after shipment, whichever occurs first.

B. UV Lamps: The UV lamps shall be warranted for 12,000 hours of operation (prorated after 9,000 hours) or 36 months after shipment, whichever occurs first.

C. Ballasts: The ballasts shall be warranted for 5 years, prorated after 1 year.

D. In case of premature UV lamp failure, the UV System Supplier shall offer the following:
   1. Lamp failure before 9,000 hours - send a replacement lamp free of charge
   2. Lamp failure after 9,000 hours - issue a credit proportional to the hours not used

1.6 SPARE PARTS

A. The following spare parts and safety equipment shall be supplied:
   1. 10% of UV lamps
   2. 5% of sleeves
   3. 5% ballasts
   4. 10% wiper rings
   5. One (1) UV intensity sensor
   6. Two (2) face shields that block UV light wavelengths between 200 and 400 nm.
PART 2 - PRODUCTS

2.1 GENERAL

A. The UV system must operate in a pressurized closed vessel, use high-intensity low-pressure amalgam UV lamps, electronic ballasts with multiple power settings, and incorporate an automatic sleeve wiping system for lamp sleeves.

B. A 24-hour, 7 days a week, phone support line must be provided by the Manufacturer for the life of the system.

C. If other equipment is proposed, the Contractor will demonstrate to the Engineer and the Owner that all requirements of materials, performance, and workmanship are met by the equipment proposed. Contractors proposing alternate manufacturers will be responsible for all costs associated with system evaluation and redesign including all electrical, mechanical and civil aspects of the installation.

2.2 MANUFACTURER LIST

A. Basis-of-Design Product: The contract drawings and specifications are based TrojanUVFit™ model 18AL40, as manufactured by Trojan Technologies, London, Ontario, Canada.

B. Substitutions Permitted. The Contractor may request that the Engineer authorize the use of substitute equipment as described in Section 007200 EJCDC Standard General Conditions of the Contract paragraph 7.05 and in Specification section 012500 Substitution Procedures. In addition, the Contractor shall provide cost data comparing proposed substitution with specified product and amount of net change to Contract Sum, annual O&M costs and 20 year present worth. Estimate O&M costs at current local unit cost for consumables, power at $0.09/KWh and labor at $45/hr. The Engineer will consider the information provided by the Contractor and notify Contractor in writing of decision to accept or reject request.

C. The drawings are based on the UVFIT model 18AL40 system by Trojan Technologies. The contractor shall be responsible for the cost of any changes that may be required to accommodate alternate model and equipment by other manufacturers, including, but not limited to, structural, mechanical, instrumentation, and electrical work. CONTRACTOR shall also pay any additional engineering costs necessary for revisions of Contract Documents and extended review of equipment shop drawing resubmittal(s) required to accommodate alternate equipment.

D. The present worth cost can be calculated using the following formula:

\[
\text{Present worth cost} = (\text{Power Usage/ reactor @ Full Load} - 4.9\text{kW}) \times 0.09/\text{kWh} \times 8760/\text{year} \times 12.783 \quad \text{(Present Worth Factor, 25 years, 6%)}
\]

2.3 DESIGN, CONSTRUCTION AND MATERIALS

A. UV Reactor:

1. The UV reactor shall be manufactured from Type 316L stainless steel. The UV reactor shall be pickled, passivated and bead blasted for uniform external finish.
2. The UV reactor shall be designed to handle a maximum operating pressure of 150 psig (10 bar), and shall be fully assembled and hydrostatically tested to 1.5 times the rated operating pressure, for at least 10 minutes without leakage, in the factory prior to shipment.

3. Each UV reactor shall be supplied with 10\" (250 mm) ANSI 150 lb flanged inlet/outlet connections.

4. Each UV reactor chamber shall be a nominal 16 in. (0.41 m) in diameter.

5. In order to maximize hydraulic efficiency, the UV reactor is to be configured such that flow enters parallel to the lamps and exits through a flange located perpendicular to the UV lamps.

6. Each UV reactor shall contain 18 high-intensity low-pressure amalgam UV lamps arranged horizontally and parallel to the direction of flow.

7. Each lamp shall be enclosed in an individual quartz sleeve, one end of which shall be closed and the other sealed with compressed o-rings.

8. Each UV reactor shall be provided with an end cap and safety switch. Power will be removed to the entire chamber when a reactor end cap is removed.

9. The UV reactor shall be designed such that operating personnel at the plant can change lamps without draining the reactor.

10. The UV reactor shall be provided with access ports for easy access to the quartz sleeves.

11. All access for internal reactor components, including lamps, sleeves and wiping system shall be from the same end. Designs requiring access from more than one side of the reactor are not permitted.

12. Piping shall be designed so that the reactor remains full of water at all times during operation. Air trapped in the reactor will result in reactor shut down to avoid overheating.

13. The UV reactor shall be installed in a horizontal orientation.

14. Dry weight of the reactor shall not exceed 400 lbs (181.4 kg).

15. Wet weight of the reactor shall not exceed 877 lbs (397.8 kg).

16. Contractor shall install pipe supports, if necessary, to withstand the weight of the UV units.

B. UV Lamps:

1. Lamps will be high-intensity low-pressure amalgam. The lamps will be preheated to ensure long lamp life. Lamps that are not amalgam or that are based on driving a low-pressure lamp at amperages greater than 500 milliamps will not be allowed.

2. The filament will use a clamped design and be significantly rugged to withstand shock and vibration.

3. Electrical connections will be at one end of the lamp and have four pins, dielectrically tested for 2,500 volts. Lamps that do not have 4 pins will be considered instant-start. To be considered as an alternate, instant-start lamp systems will supply replacement spare lamps equal to 50% of the total number of lamps in the system.

4. Lamps will be rated to produce zero levels of ozone.

5. Lamps shall be operated by constant output electronic ballasts.

6. Lamps shall be monochromatic with minimum 90% of UVC output at wavelengths between 230 to 275nm.

C. Lamp End Seal and Lamp Holder:

1. The open end of the UV lamp sleeve will be sealed by a compression o-ring.
2. The o-ring compression is made by a sleeve nut that will require no special tools for installation or removal.

D. UV Lamp Quartz Sleeves:
   1. Type 214 clear fused circular tubing as manufactured by General Electric or equal.
   2. Lamp sleeves shall be domed at one end and be accessible through the reactor service entrance.
   3. The nominal wall thickness will be 1.5 mm.

E. UV Intensity Sensor:
   1. One (1) side-mounted sensor shall be provided per reactor chamber.
   2. The sensor will measure only the germicidal portion of the light emitted by a UV lamp. The detection system will be factory calibrated. Sensors that can be field calibrated will not be permitted.

F. Ballasts:
   1. Electronic ballasts shall be used to power UV lamps.
   2. Each ballast shall supply power to and control two (2) low-pressure amalgam lamps.
   3. The power factor shall not be less than 94% between 208 to 277Vrms at 100% power.
   4. The ballasts shall utilize a preheat circuit to ignite the lamps.
   5. The ballasts will continue to operate without suffering damage when a short circuit is present across the ballast output terminals.
   6. The Total Harmonic Current Distortion shall be less than 5%.

G. Power Distribution Center (PDC):
   1. Power distribution for each UV reactor shall be through the associated PDC housing all power supplies. Signal wiring interfacing the UV reactor with the PDC shall be as shown on the contract drawings.
   2. Each PDC shall be designed to operate with the following electrical supply: 240V, 1-phase, 2W+GND, 50/60 Hz, 4.9 kVA.
   3. The PDC enclosure material of construction shall be Mild Painted Steel.
   4. The PDC enclosure shall be Type 12, ventilated with forced air cooling suitable for indoor installation.
   5. The PDC enclosure shall be UL or CSA approved.
   6. The PDC shall be installed within 82’ of the UV reactor (external running cable length).
   7. Each PDC shall be provided with a lockable disconnect handle that will shut down the reactor/cabinet power when the cabinet door is opened.
   8. PDC enclosure shall be wall-mounted.
   9. PDC enclosure dimensions shall not exceed 36 in. (0.9 m) x 48 in. (1.2 m) x 10 in. (0.3 m) (Width x Height x Depth). Weight shall not exceed 250 lbs (113 kg).

H. Controls:
   1. UV reactors shall be controlled by a microprocessor which continuously monitors and controls the UV reactor functions including flow rate, UV intensity, turbidity, UV transmittance, and operational UV dose. Custom electronics, an input flow signal
(supplied by others), and UV sensor(s), provide the microprocessor with the necessary indication of system parameters.

2. A dose-pacing system shall be provided to modulate the lamp UV output in relationship to a 4-20 mA DC signal from an effluent flow meter from the plant PLC and a signal from the UV transmittance meter described in paragraph N below. The system is to be dose-paced such that as the flow and effluent quality change, the design UV dose is delivered while conserving power. The dose-pacing system will allow the operator to vary the design dose setting.

I. Operator Interface

1. Complete control and monitoring of each reactor shall be accomplished through the operator interface located on the PDC.
2. The operator interface shall be a LED digital display.
3. The operator interface shall be menu driven, and shall display the following system information when prompted: reactor status, individual lamp status, lamp operating hours, RED (dose), UV intensity, cumulative number of reactor on/off cycles, cumulative UV disinfection system power consumption, power level, alarms, alarm history and GFI (ground fault interruption)
4. The most recent alarms shall be displayed on the operator interface when prompted, recorded by alarm type, date and time of occurrence, and date and time of correction.

J. Remote Monitoring/Control

1. The monitoring and alarm system design shall meet compliance with the requirements listed under May 2003 NWRI design guidelines.
2. The communication between the UV reactors and the plant control center shall be through the following protocol: Modbus
3. Each reactor shall be able to operate in either Local or Remote (automatic) mode.
4. Each system shall be provided with the following hardwired I/O for operator interface:
   a. Discrete input for Reactor On/Off Control from remote location.
   b. Discrete output indicating Critical Alarm.
   c. Discrete output indicating Major Alarm (including adjacent lamp failure, multiple lamp failure (more than 5% lamps fail in a reactor), low-low UV intensity, low-low UV transmittance, high-high turbidity, low-low operational UV dose and GFI)
   d. Discrete output indicating Minor Alarm (including individual lamp failure, low UV intensity, low operational UV dose, Low UV transmittance and high turbidity)
   e. Discrete output indicating System Ready.
   f. Discrete ON/OFF status.
   g. 4-20ma Flow Signal Analog input.
   h. 4-20ma UVT signal Analog input
   i. 4-20ma RED value Analog output
   j. 4-20ma UV intensity Analog output
   k. 4-20ma ballast power level Analog output
   l. Discrete output indicating warming
K. Safety Features

1. Each UV reactor shall be equipped with a temperature switch to prevent the reactor from overheating. The temperature switch shall be wired to the PDC and, when activated, will shut the reactor down and initiate a critical alarm condition.
2. Each UV reactor service entrance will be covered with a removable end cap to protect the lamps and electrical connections. For Operator safety, the protective cover will be equipped with a switch to disconnect power to the lamps when the cover is removed.

L. Wiping System

1. Each UV reactor shall be equipped with an automatic on-line sleeve wiping system.
2. The wiping system shall be screw-driven.
3. The wiping system shall wipe the lamp sleeves using an automatically initiated and controlled cleaning cycle. The wiping system shall be fully operational while still providing disinfection.
4. Wiping cycle intervals shall be field adjustable via the operator interface. Manual wiping system control shall also be through the operator interface.

M. Temperature Switch

1. A temperature switch shall be fitted to each reactor for protection against heat build-up under no flow or drained chamber conditions.
2. The temperature switch shall cause the UV system to shut down and alarm in event of higher than recommended water temperature (or air temperature if the lamps are operated in a dewatered situation).

N. Online UVT Monitor

1. An on-line UVT monitor shall be provided to automatically and continuously track the UV transmission of the effluent at the 254 nm wavelength.
2. The UVT monitor will measure transmittances from 25 to 100%.
3. A shielded twisted pair cable to be provided for connecting the UVT monitor (4-20 mA signal) to the plant SCADA creating a UV demand feedback loop. The microprocessor will modulate the lamp intensity in response to the effluent UV Transmission received from plant SCADA.
4. Power feed of 100 – 230 VAC ± 10%, 50/60 Hz, 1 phase, 2 wire (plus ground), 50 VA required to the sensor located at the UV channel as shown on the Drawings.

O. Drain

1. Each reactor shall be furnished with a drain valve so the reactor can be dewatered for inspection or cleaning after the inlet and outlet valves are closed.
2. The drainpipe and valve shall be of type 316 stainless steel construction.
PART 3 - EXECUTION

3.1 GENERAL

A. All components of the UV system shall be handled with care during transportation, storage and installation.

3.2 INSTALLATION

A. The UV System must be installed in accordance with manufacturer instructions and approved drawings. All required installation hardware (such as, but not limited to, support braces and saddles, bolts, washers, nuts, and jam nuts) shall be furnished by the Contractor.

B. All components shall be fully tested and verified for service by the UV System Supplier or an authorized representative.

C. The UV System Supplier shall provide one (1) hard copy of operation and maintenance manuals. One (1) additional electronic copy shall be provided upon request.

3.3 START-UP AND FIELD SERVICES

A. A field service technician or start-up engineer of the UV System Supplier shall commission the UV equipment.

B. Local manufacturer’s representatives are not acceptable to perform these tasks unless authorized by the UV System Supplier.

C. The field service technician shall certify that all equipment is properly installed and that the plant operators have been trained on proper operation and maintenance procedures.

D. The minimum recommended man-days / trips for installation inspection, system commissioning, and operator training shall be as follows:

E. Inspection of installation: a minimum of one (2) man-days in (1) trip.

F. Start-up/system commissioning: a minimum of three (3) man-days in (1) trip.

END OF SECTION 466616
APPENDIX A
November 28, 2012
HWA Project No. 2005-150-21 Task 400

Tetra Tech, Inc.
1420 Fifth Avenue, Suite 600
Seattle, Washington 98101

Attention: Mr. Jim Santroch, P.E.

Subject: Geotechnical Report
Port Hadlock Wastewater Treatment Facility
Port Hadlock, Washington

Dear Jim,

This report presents the results of geotechnical engineering studies for the design and construction of the proposed Wastewater Treatment Facility at Port Hadlock, Washington. This report incorporates review comments received before November 28, 2012.

We appreciate the opportunity to provide geotechnical services on this project.

Sincerely,

HWA GeoSciences Inc.

Ralph N. Boirum, P.E.
Geotechnical Engineer, Principal

RNB
Enclosure: Geotechnical Report
# TABLE OF CONTENTS

1.0 INTRODUCTION .................................................................................................................. 1

1.1 GENERAL .......................................................................................................................... 1

1.2 SITE AND PROJECT DESCRIPTION ................................................................................. 1

1.3 AUTHORIZATION .............................................................................................................. 2

2.0 FIELD AND LABORATORY TESTING .............................................................................. 3

2.1 EXPLORATIONS .................................................................................................................. 3

2.2 LABORATORY TESTING ..................................................................................................... 3

3.0 SITE CONDITIONS .............................................................................................................. 5

3.1 GENERAL GEOLOGICAL CONDITIONS ........................................................................... 5

3.2 SUBSURFACE CONDITIONS ............................................................................................ 5

3.3 SEISMICITY ....................................................................................................................... 6

4.0 CONCLUSIONS AND RECOMMENDATIONS ................................................................... 7

4.1 GENERAL .......................................................................................................................... 7

4.2 SEISMIC DESIGN CRITERIA .............................................................................................. 7

4.3 STRUCTURE DESIGN ......................................................................................................... 8

   4.3.1 Allowable Bearing Pressures ..................................................................................... 8

   4.3.2 Mat and Floor Slab Support ..................................................................................... 8

   4.3.3 Subgrade Preparation .............................................................................................. 8

4.4 LATERAL EARTH PRESSURES FOR PERMANENT STRUCTURES .................................. 9

4.5 DRAINAGE AND BUOYANCY CONSIDERATIONS ....................................................... 10

   4.5.1 Drainage .................................................................................................................. 10

   4.5.2 Buoyancy of Buried Structures ................................................................................. 10

4.6 INFLENT PUMP STATION ................................................................................................. 10

4.7 INFLENT PIPELINE .......................................................................................................... 11

4.8 SITE EARTHWORK RECOMMENDATIONS .................................................................... 11

   4.8.1 General Site Preparation and Grading ....................................................................... 11

   4.8.2 Excavations and Cut Slopes ..................................................................................... 11

   4.8.3 Fill Materials .......................................................................................................... 11

   4.8.4 Compaction Criteria ............................................................................................... 12

   4.8.5 Wet Conditions Earthwork ..................................................................................... 12

4.9 DEWATERING ................................................................................................................... 13

4.10 INFLENT STORAGE AND EFFLUENT INFILTRATION POND DIKES ............................ 13

4.11 STORMWATER INFILTRATION ESTIMATES ................................................................ 14

   4.11.1 USDA Soil Textural Classification ........................................................................... 14

   4.11.2 ASTM Grain Size Distribution ............................................................................... 14

   4.11.3 Stormwater Infiltration Estimates .......................................................................... 15

   4.11.4 Pilot Infiltration Testing ......................................................................................... 16

4.12 PIT RESULTS ................................................................................................................... 17

5.0 CONDITIONS AND LIMITATIONS .................................................................................. 18

6.0 REFERENCES ..................................................................................................................... 20
**LIST OF FIGURES (FOLLOWING TEXT)**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Vicinity Map</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Treatment Site and Influent Pipeline Exploration Plan</td>
</tr>
</tbody>
</table>

**APPENDICES**

**Appendix A: Field Exploration**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure A-1</td>
<td>Legend of Terms and Symbols Used on Exploration Logs</td>
</tr>
<tr>
<td>Figures A-2 – A-6</td>
<td>Borehole Logs LB-1 to LB-5</td>
</tr>
<tr>
<td>Figures A-7 – A-26</td>
<td>Test pit Logs LTP-1 through LTP-19</td>
</tr>
</tbody>
</table>

**Appendix B: Laboratory Testing**

| Figures B-1 – B-9 | Particle-Size Analysis of Soils |

**Appendix C: USGS Design Maps Summary Report**
1.0 INTRODUCTION

1.1 GENERAL

This report presents the results of geotechnical studies for the design of a new wastewater treatment plant near Port Hadlock, Washington. The purpose of this study was to evaluate the soil and groundwater conditions at the treatment plant site and along the influent pipeline route, and to provide geotechnical recommendations for design and construction of the proposed facility.

The location of the site is indicated on the Vicinity Map, Figure 1. A site plan showing the topography of the area is shown on Figure 2. Figure 2 also indicates the proposed layout of plant structures and the influent pipeline, and the approximate locations of subsurface explorations performed for the project.

1.2 SITE AND PROJECT DESCRIPTION

The treatment plant will be constructed on what is known as the Lopeman Parcel 2, which is located at 170 Lopeman Road, Port Hadlock, Washington, tax parcel 901023006. The Lopeman site is located about ½ mile east of Highway 19 (Rhody Drive) and 1/4 mile south of Highway 116 (Ness’s Corner Road). It is rectangular, measuring about 1,300 feet by 830 feet, with the long axis in the east-west direction. The site slopes generally down to the east, with about 35 feet of elevation difference.

Approximately the eastern 1/3 of the Lopeman site is a wetland which is typically below elevation 88 feet. The center 1/3 of the site, generally between elevation 90 and 115 elevation, is a mined-out gravel pit. The western 1/3 of the parcel is mostly above elevation 115 feet and is heavily vegetated with trees and brush. The new treatment plant would be primarily located in the gravel pit section of the parcel. The approximate layout of the proposed facilities is indicated on Figure 2.

The new treatment plant would be a membrane bioreactor facility with anoxic basins for nitrogen reduction, aerobic basins for oxygenation, and immersed membranes for clarification. Disinfection would be accomplished using ultraviolet light with possible standby systems using chlorine. Solids handling will include decanting and storage on-site, and solids treatment using contracted haul treatment and disposal. The plant may have a lined basin to provide 3-days’ emergency storage of influent. We understand most of the plant processing will occur in a partitioned, rectangular, reinforced concrete structure that will be about 140 feet long and 30 feet wide. The new plant will also include a separate control, office and laboratory building.

The plant will include pumps and piping from the collection system to the treatment plant through a main influent pump station to be located near the intersection of Ness’ Corner Road and Shotwell Road. Effluent will be piped from the treatment plant to surface percolation basins.
to be located on the Shold property about ¼ miles to the south. Land application will be accomplished using rapid rate surface percolation basins.

The influent pipeline will be built into the site from the north, along county property on the edge of the slope above a broad wetland area. Previous fill had been placed along this margin from operation of an old gravel pit where the Quimper Lane neighborhood is now located. This fill included concrete and asphalt rubble, exposed at the surface or in piles northward from near test pit LTP-18 to Ness’ Corner Road (SR-116).

1.3 AUTHORIZATION

This work was performed under a sub-consultant professional services agreement between Tetra Tech Inc. and HWA GeoSciences Inc. dated June 12, 2011. Purchase Order No. 1073018 was issued for this work.
2.0 FIELD AND LABORATORY TESTING

2.1 EXPLORATIONS

The treatment plant site and influent pipeline route were explored by means of five soil borings and 19 test pits. The borings were designated LB-1 through LB-5, and the test pits were designated LTP-1 through LTP-19. The approximate locations of the explorations are shown on Figure 2.

The borings were drilled by Environmental Drilling, Inc. (EDI) of Snohomish, Washington, under subcontract to HWA, on July 18 and 19, 2011. A truck-mounted Mobile B-61 drill rig with hollow-stemmed auger was used. Testing and sampling was accomplished using Standard Penetration Tests (2-inch OD split-spoon sampler with 140 pound hammer) or non-standard penetration tests (3¼-inch split-spoon sampler with 300 pound hammer). The borings ranged in depth from 11.5 to 49 feet below the existing ground surface. Soil samples were collected at 2.5-foot intervals down to about 20 feet in each boring and at 5-foot intervals at depths below 20 feet.

Test pits LTP-01 through LTP-08 were excavated on July 25, 2011. These test pits were excavated using a Case 9030B excavator provided by Shold Excavating. Supplemental test pits (TP-09 through TP-19) at the treatment plant site and for the influent pipeline route were excavated on October 25, 2012, using a Case 9030B excavator provided by Shold Excavating. All field work was supervised by a geologist from HWA. At each sampling interval, HWA logged the soil samples and obtained and recorded pertinent information including blow counts, soil sample depths, stratigraphy, ground water occurrence, and any visual or olfactory observations regarding the presence of contamination. Soil samples selected for geotechnical analyses were placed into re-sealable plastic bags and labeled according to exploration number and sample depth. Samples were transported to HWA’s laboratory in Bothell for testing.

Boreholes not completed as monitoring wells were grouted to the ground surface using hydrated granular bentonite and the ground surface returned to its original condition.

A Legend of Terms and Symbols Used on Exploration Logs is presented on Figure A-1, Appendix A. Summary soil exploration logs are presented on Figures A-2 through A-25. It should be noted that the stratigraphic contacts shown on the individual exploration logs represent the approximate boundaries between soil types; actual transitions may be more gradual. Moreover, the soil and ground water conditions depicted are only for the specific date and locations reported and, therefore, are not necessarily representative of other locations and times.

2.2 LABORATORY TESTING

Laboratory tests were conducted on selected soil samples to characterize relevant engineering properties of the on-site materials. The laboratory testing program was performed in general accordance with appropriate ASTM Standards as outlined below.
• **Moisture Content of Soil:** The moisture content (percent by dry mass) of selected soil samples was determined in general accordance with ASTM D 2216. The results are shown at the sampled intervals on the boring logs in Appendix A.

• **Particle Size Analysis of Soils:** Selected samples were tested to determine the particle size distribution of material in general accordance with ASTM D 422. The results are summarized on Figures B-1 through B-9, Appendix B, which also provide information regarding the classification of the samples and the moisture content at the time of testing.

• **Organic Content:** The organic content of a buried topsoil layer in test pit LTP-17 was tested in general accordance with ASTM D2974. The results are presented on the test pit log.
3.0 SITE CONDITIONS

3.1 GENERAL GEOLOGICAL CONDITIONS

HWA reviewed geologic information for the subject property vicinity as part of a hydrogeologic evaluation for the vicinity (HWA, 2007). The subject property is located within the north-south trending Chimacum Valley, a relict (bedrock) valley filled with glacial outwash deposits, which become thinner and pinch out at the valley sides. Geologic maps reviewed as part of the evaluation indicate the subject property is underlain by Quaternary Vashon-age recessional glacial outwash. Recessional outwash is typically underlain by lodgment till deposited at the base of a moving glacier; lodgment till in turn overlies advance glacial outwash and older deposits, or bedrock. Recessional outwash was deposited by meltwater streams emanating from retreating glaciers and generally consists of loose to dense, clean, stratified sands and gravels. Recessional outwash was not glacially overridden, and has lower densities than advance outwash or lodgment till. Typically outwash deposits exhibit moderate to high permeability and infiltration rates, depending on silt content.

Based on available logs for wells in the vicinity, shallow sediments consist of sand and gravel, overlying up to 50 feet of till. Typically, water wells are drilled into water-bearing sands underlying the till layers. That ground water is under confined conditions and water levels in the well are often less than 20 feet below ground surface. Regional (deep) ground water flow is likely to the northeast and east towards Puget Sound, although local variations in flow direction may be present due to topography or subsurface features.

3.2 SUBSURFACE CONDITIONS

HWA drilled and sampled five soil borings within or adjacent to the former gravel mining area on the Lopeman parcel for hydrogeologic and geotechnical assessment purposes. Fifteen test pits were excavated in and around the proposed treatment plant location and on the upland area to the west of the mined area.

Borings LB-01, LB-02 and LB-03 were performed in the mined area of the borrow pit, and encountered approximately 10 feet of medium dense to dense sand and gravel overlying dense to very dense sand. The density and consistency of these sands were consistent with recessional outwash. Shallow sands appeared to be slightly oxidized, and graded to gray (reduced) with increasing depth. The sands were present to the total depth of the borings. Underlying till was not encountered in these borings, the deepest of which extended 49 feet, to about elevation 47 feet.

Boring LB-04 was performed adjacent to the southwest side of the gravel pit excavation to assess the character of unexcavated soils. Approximately 20 feet of medium dense to dense gravel and sand with gravel (alluvial outwash) was observed in the boring overlying the medium sands observed at the other boring locations. Test pits completed in the un-mined northern and western portions of the site also consistently encountered gravelly outwash soils. Boring LB-05, located approximately 150 feet south of the site, also encountered undisturbed gravelly outwash soils.
The ground water level has been monitored for the past year (2011-2012) and its highest observed level was about elevation 88 feet. Based on that information, we recommend a design ground water level of 91 feet.

3.3 Seismicity

Western Washington is located in a moderately active seismic zone due to its position at the edge of an active plate margin where subduction is occurring. The historical seismic record (about the last 160 years) is relatively short. Currently, the North American Plate is over-riding the Oceanic, or Juan de Fuca, Plate at a rate of about 1½ inches per year. The converging plates produce typical subduction zone features. These features include a small trench off the west coast of Washington State, where the Juan de Fuca plate begins its descent below the North American plate; and an active volcanic arc in the over-riding plate, where partial melting of the subducted Juan de Fuca Plate generates the geologically young and active volcanoes of the Cascade Mountain Range.

Researchers identify three earthquake source regions in this tectonic setting. The first source region delineated is within the subducted portion of the Juan de Fuca Plate. These earthquakes are produced by down-dip tensional forces within the subducting plate. A source zone 45 to 60 km deep, underlying the entire Puget Sound, is estimated to be capable of producing earthquakes with magnitudes as great as 7.5. Historic occurrences of such earthquakes include the 6.8 M, 2001 Nisqually earthquake; the 6.5 mb, 1965 Sea-Tac earthquake; and the 7.1 Ms, 1949 Olympia earthquake.

The second source region is located at the interface between the converging plates. Large (M > 8) interplate earthquakes could result from differential movement between these converging plates. The last subduction zone earthquake occurred January 31, 1700, according to geologic evidence and Japanese historical records of tsunami events.

The third source zone is in the over-riding North American Plate. This source zone produces shallow crustal earthquakes with focal depths less than 30 km. The actual geographic location of this source zone, possible earthquake magnitudes, and probability of occurrence up until just recently were poorly understood. Recent studies indicate that a large earthquake occurred in the Seattle area, on what is now known as the Seattle Fault Zone, between 500 and 1,700 years ago. The amount of deformation in the vicinity, and other related evidence, indicates that the magnitude was probably larger than 7 on the Richter Scale.

The design earthquake according to IBC 2012 (which makes use of 2008 USGS hazard data) is described in Section 4.2.
4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 GENERAL

The new Port Hadlock WWTF will consist of one large, partially buried, rectangular reinforced-concrete structure, a pump station with wet well, a single story lab/office/admin building and several smaller ancillary structures. The results of our explorations indicate that the native soils at the site consist of sands and gravels which will provide suitable support of the proposed structures on shallow foundations. The soils are typically loose within a foot or so of the surface and are medium dense to very dense below. The existing soils will generally be suitable for reuse as structural fill or backfill.

Previous grading operations at the gravel pit resulted in the placement of localized fill of variable density and thickness. Construction of new structures, partially on such fill and partially on undisturbed native soils could result in undesirable differential settlement. As a result, we recommend that any existing fill be removed. If possible, grades for the new structures should be established to allow removal of any existing fill and to minimize the thickness of any new fills needed to achieve the new foundation subgrades. Exposed structure subgrades should be compacted by at least 6 passes of a heavy vibratory roller or at least 3 complete coverages with an excavator-mounted vibratory plate compactor (hoe-pac).

The highest observed ground water level during the past year was about elevation 88 feet. Ground water was at approximately elevation 85 feet during the summer months. Because of the relatively high permeability of the sands and gravels, dewatering at the site is likely to be difficult. We therefore recommend that grades for the deeper structures be set to minimize, and if possible, avoid excavations below about elevation 85 feet.

Our recommendations pertaining to seismic design considerations and parameters are presented in Section 4.2. Additional recommendations for foundation design and construction are presented in following Sections.

4.2 SEISMIC DESIGN CRITERIA

For seismic design, per 2012 International Building Codes, the site is considered Site Class C, as described in Section 1615.1 of the 2012 IBC. The maximum considered earthquake (a 2,475-year return period event) is consistent with a peak ground acceleration of 0.52g. The design PGA would therefore be 0.35g (2/3 of the MCE PGA).

The design earthquake results in an associated 0.2-second spectral acceleration (S₀) of 1.278g and a 1.0-second spectral acceleration (S₁) of 0.516g (USGS, 2008). For this site class (Site Class C), Fₐ = 1.0 and Fᵥ = 1.3. Design Spectral response acceleration parameters are therefore: S_DS = 0.852g and S_DI = 0.447g. The USGS Design Maps Summary Report for this site is attached as Appendix C.

Soil liquefaction is a phenomenon wherein loose to medium dense, saturated granular deposits temporarily lose strength and behave as a liquid in response to earthquake shaking. The results of our subsurface explorations indicate that the ground water level is below the depth of any soils...
that are loose enough to be considered liquefiable. Consequently, we consider the potential for seismic liquefaction on the site to be low.

Several faults have been identified in the Port Townsend area, but none have been traced to the subject property, and no evidence of Holocene-age faulting has been observed in the mined gravel pit area. We therefore consider the risk of damage due to ground fault rupture to be minimal.

### 4.3 Structure Design

#### 4.3.1 Allowable Bearing Pressures

Footings that bear directly on native dense to very dense or hard soils or on properly compacted structural fill can be designed for allowable bearing pressures up to 6,000 psf. For seismic loading design considerations, an increase of 30% in bearing capacity is allowed. Footings should have a minimum width of 24 inches; and for frost protection, should bear at least 18 inches below the lowest adjacent exterior grade.

Because the bearing soils are granular, and relatively dense, we expect that any settlement that occurs will happen during construction or during the initial loading of the structure. The largest potential for both overall settlement and differential settlement is due to inadequate preparation of the foundation subgrade during construction. In general, settlements under foundation loads should be less than ¾-inches, with less than ½ inch of differential settlement between adjacent footings or over a 20-foot length of footing. In addition to the above, footings on densely compacted fill can be expected to settle as much as ½ of one percent of the thickness of the fill. Larger settlements can be expected where fill is not densely compacted.

#### 4.3.2 Mat and Floor Slab Support

We recommend that concrete floor slabs bear on medium dense to dense native soils or on structural fill placed over these competent native soils. Any topsoil or organic materials should be removed and any loose soils within the building footprint should be densified. All building floor slabs that will be provided with flooring, carpeting, paint, or other surfacing; or which will be in office or other areas that cannot tolerate dampness, should be underlain by a 4-inch (minimum) thickness of 3/8-inch, washed pea gravel (capillary break). A vapor barrier consisting of 10-mil (minimum) thick plastic sheeting should be placed immediately over the capillary break.

Perimeter footing drains should be located at least 24-inches below the top of interior floor slabs.

For design of mat foundations, we recommend a subgrade modulus of 250 pci.

#### 4.3.3 Subgrade Preparation

During foundation construction, all organic material and debris should be removed. Any existing fill and loose soil should be compacted in place or excavated and removed from the exposed bearing surfaces to minimize potential future settlement. Prior to pouring concrete or placing structural fill, the geotechnical engineer should inspect the foundation bearing areas to
verify that medium dense to very dense material has been exposed and the subgrade is properly prepared.

Subgrade preparation along the alignment of roadways, and within parking and at-grade floor slab areas should include the removal of topsoil and organic materials and excavation to desired subgrade elevations. The exposed pavement subgrades should be compacted with a smooth-drum vibratory roller and proof-rolled with a fully-loaded dump truck (or equivalent load). The geotechnical engineer should observe the proof-rolling operation, and any soft or yielding materials identified should be removed and replaced with structural fill. Structural fill should be placed in accordance with the criteria presented in Section 4.8, as needed.

4.4 LATERAL EARTH PRESSURES FOR PERMANENT STRUCTURES

Walls of the proposed below-grade structures should be considered rigid and designed for at-rest earth pressures using allowable stress design methods. The buried walls of the structures above footing drains should be designed for an equivalent fluid pressure of 55 pounds per cubic foot (pcf) and for 88 pounds per cubic foot (pcf) when below the design ground water level. These pressures are for static loading conditions.

The above recommendations regarding at-rest earth pressures assume that the backfill behind the subsurface walls will consist of properly compacted structural fill and no adjacent surcharge loads. They also assume a horizontal ground surface adjacent to the structure. For sloping backfill conditions, the recommended earth pressure design values should be increased by 1 pcf for each degree of backslope increment above horizontal to a maximum backslope angle of 26 degrees.

If below-grade structures or walls will be subjected to the influence of surcharge loading, within a horizontal distance equal to or less than the height of the walls, the walls should be designed for the additional horizontal pressure. For area surcharge loads, we recommend adding a lateral surcharge equal to 0.45 times the vertical surcharge pressure at the face of the wall.

For seismic design, below grade walls should be capable of resisting a line load equal to $30H^2$ lbs/ft acting 0.6H above the base of the wall, where H is the free standing height of the wall. The static and seismic loadings are separate conditions and should not be applied together. We recommend a minimum factor of safety of 1.5 for the static condition and 1.25 for the seismic condition.

Lateral forces will be resisted by passive earth pressure against buried portions of structures and by friction against the bottoms of footings and slabs. The available passive earth resistance can be approximated by an equivalent fluid pressure of 300 pounds per cubic foot (pcf). For base sliding friction, we recommend a coefficient of 0.5 between cast-in-place concrete and soil. The above resistance factors are ultimate values.
4.5 DRAINAGE AND BUOYANCY CONSIDERATIONS

4.5.1 Drainage

Footing drains should be included around the perimeter of all structures where gravity discharge can be provided. Footing drains should be located at least 24-inches below the top of floor slabs. For deep buried structures, where a gravity outfall for the footing drain is not practical, put the footing drain at the lowest practical elevation and use the lateral earth pressures recommended in Section 4.4.

Drainage pipe for footing drains should consist of 3-inch (minimum) diameter, perforated or slotted plastic pipe, appropriately sloped to drain. Bedding and backfill for the pipe should extend at least one-pipe diameter around the pipe, and should consist of 3/8-inch washed pea gravel. Roof drains should not be connected to footing drains.

4.5.2 Buoyancy of Buried Structures

Below-grade structures should be capable of resisting upward (buoyant) forces present when the fluid level inside the structure is lower than the ground water level. Such structures should be designed to resist this upward force and to prevent possible heave and cracking of the base slab of the structure. The weight of the structure and the weight of any soil bearing on the base of the structure outside its walls will provide resistance to the upward force. We recommend a design ground water level of elevation 91 feet; and a factor of safety of at least 1.25 when using the design ground water level for buoyancy calculations.

4.6 INFUSED PUMP STATION

We understand the influent pump station will have a wet well extending down to about elevation 70 feet, 15 or more feet below the ground water level. The excavation for this structure will most likely require both temporary shoring and dewatering.

Temporary shoring consisting of driven, interlocking steel sheet piles could reduce the dewatering requirement to one or two wells located within the sheet pile enclosure. Pre-drilling for the sheet piles would probably be required in order to get adequate penetration through the dense granular soils.

We estimate that at least 4 high capacity dewatering wells (>350gpm) would be required to dewater an unsupported excavation or a soldier pile and lagging excavation.

Alternatively, the wet well could be installed by sinking a caisson. This could be accomplished by excavating to the ground water level, setting the caisson in the bottom of the excavation, and excavating inside the caisson with a clam bucket. A high pressure water jet could be used to facilitate the excavation and move particles toward the center of the caisson where it can be more easily removed. Once the caisson reaches its design depth, a concrete plug would be tremied in place and then the caisson could be dewatered. Note that the tremie plug must be thick enough so that its weight offsets the caisson’s buoyancy.
4.7 *INFLUENT PIPELINE*

The proposed gravity influent pipeline will flow into the plant from the north along the edge of the wetland, as indicated in Figure 2. We understand the pipeline trench will generally be less than 10 feet deep. The soils along much of this alignment consist of fill that was placed along the edge of the wetlands. The fill contains concrete and other debris, and some of it overlies organic soils from the wetlands. Test pits TP-13 and TP-16 through TP-19 indicate that competent native soils will be encountered at pipe grade along most of the alignment; however, the trench excavation should be extended down as necessary to remove any existing fill and organic soils. Structural fill should be placed in any over-excavated areas to achieve the desired pipe grade.

Shoring with trench boxes and steel sheeting will be required to support the pipeline trench excavation. Only moderate caving occurred in test pits along the proposed pipe alignment; as the fill soils tended to contain significant amounts of clay and silt. Caving may be more pronounced when excavating in the native sands and gravels, and excessive caving against the trench box should be expected in excavation below the ground water level. Either or both sides of the trench excavation can be expected to slough or slide against the shoring system, disturbing soils back to a 1 vertical to 1 horizontal inclination.

4.8 *SITE EARTHWORK RECOMMENDATIONS*

4.8.1 *General Site Preparation and Grading*

Based on observed conditions in the borings and test pit explorations, it is anticipated that conventional trackhoe and dozer equipment will be suitable for excavation and grading needs on site. The contractor should be prepared to deal with occasional boulders.

4.8.2 *Excavations and Cut Slopes*

Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. All temporary excavations in excess of 4 feet in depth should be sloped in accordance with Part N of WAC (Washington Administrative Code) 296-155, or be shored. The existing fill and recessional outwash at the plant site classify as Type C soil. Unsupported excavations in Type C soils may be inclined no steeper than 1½H:1V (horizontal to vertical). Flatter slopes may be required where ground water seepage occurs. Temporary slopes should be protected from erosion due to direct precipitation and runoff, as necessary, by covering the cut face with well-anchored plastic sheets.

We recommend that permanent cut and fill slopes be no steeper than 2H:1V. 3H to 1V slopes are recommended where space is available.

4.8.3 *Fill Materials*

The native soils at the site include sands and gravels (recessional outwash deposits) which will generally be suitable for use as structural fill. Portions of the site may contain silts and clay deposits that have accumulated from on-site material processing. These silts and clays will not
be suitable for use as structural fill, but may be useful in the construction of dikes around the
influent storage and infiltration ponds.

Structural fill should consist of relatively clean granular soils that are free from organic matter or
other deleterious materials. Such materials should comprise particles of less than 4-inch
maximum dimension, and their moisture content should be within 3 percent of optimum. We
recommend that backfill around structures and retaining walls contain no more than 12 percent
fines (material passing the No.200 mesh sieve, based on the minus ¼ inch soil fraction).

Where native soils are too wet for proper compaction, they should be removed and replaced with
cleaner, drier material. Alternatively, Portland cement may be mixed with the soil to absorb
excess moisture and improve its compactability. The amount of cement added should not exceed
3 percent of the dry weight of the soil.

4.8.4 Compaction Criteria

Soil to be used as structural fill should be moisture conditioned, placed in loose horizontal lifts
less than 8-inches thick, and compacted to at least 95% of its Modified Proctor maximum dry
density (ASTM D1557). Backfill within 3 feet of walls should be compacted with a hand
operated vibratory plate compactor to avoid potentially over-stressing of the wall.

Achievement of proper density of a compacted fill depends on the size and type of compaction
equipment, the number of passes, thickness of the layer being compacted, and soil moisture-
density properties. In areas where limited space restricts the use of heavy equipment, smaller
equipment can be used, but the soil must be placed in thin enough layers to achieve the required
relative compaction.

Generally, poorly compacted soils result from poor construction technique or improper moisture
content. Soils with high fines contents are particularly susceptible to becoming too wet and
coarse-grained materials may become too dry, for proper compaction. We recommend that
HWA be retained to provide construction inspection and material testing during fill placement.

4.8.5 Wet Conditions Earthwork

The on-site soils are not particularly moisture sensitive; however, general recommendations
relative to earthwork performed in wet weather or in wet conditions are presented below. These
recommendations should be incorporated into the contract specifications and should be required
when earthwork must be performed in wet conditions.

1) Earthwork should be performed in small areas to minimize exposure to wet weather.
   Excavation or the removal of unsuitable soil should be followed promptly by the
placement and compaction of clean structural fill. The size and type of construction
equipment used might have to be limited to prevent soil disturbance.

2) Material used as structural fill should consist of clean granular soil with less than 5%
   passing the No. 200 sieve, based on wet sieving of the material fraction passing the
   ¾-inch sieve. The fine-grained portion of the structural fill soils should be non-
   plastic.
3) The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water. All exposed surfaces should be compacted on completion or at the end of a shift to limit infiltration and softening. No material should be left in a loose uncompacted state that will allow infiltration. Materials that have become wet and softened must be either dried and re-compacted, or removed from the working area and replaced with suitable fill.

Excavation and placement of structural fill material should be monitored by someone experienced in wet weather earthwork to determine that the work is being accomplished in accordance with the project specifications and the recommendations contained herein.

4.9 Dewatering

Excavations deeper than about elevation 85 feet will extend into saturated recessional outwash. Relatively high capacity wells will be necessary to lower the ground water level more than a couple feet below its normal level.

The results of hydrologic studies are presented in a report titled Hydrogeologic Evaluation, Port Hadlock UGA Sewer System Port Hadlock, Washington, by HWA GeoSciences Inc., dated June 29, 2012.

In the event that excavations for structures extend below the ground water table, the contractor should be required to prepare and submit a dewatering plan for review and approval. The contractor should be required to maintain ground water below the base of the temporary excavation until the structure is constructed and backfilled. In addition, the contractor should be responsible for control of surface water and should employ slope protection, ditching, sumps, and other site drainage and erosion control measures, as necessary to satisfy regulatory authorities.

Construction dewatering requirements depend on the time of year, recent rainfall and other factors.

4.10 Influent Storage and Effluent Infiltration Pond Dikes

We anticipate that influent storage and effluent infiltration ponds will be constructed using on-site materials to the extent possible. We recommend that embankments impounding the proposed ponds be constructed with 3H to 1V slopes.

The influent storage pond will require a membrane lining, and its embankments can be constructed entirely of on-site materials.

Because of the relatively high permeability of the on-site materials, a clay core will be required where dikes of the effluent pond are fill embankments. A clay core will not be required where the side of the pond is a cut into an existing slope. The clay core should extend at least 18 inches below the ground surface at the outside toe of the dike and should be keyed at least 3 feet into the cut slope embankment where the fill embankment transitions into cut. We recommend that the clay cores in effluent fill dikes be at least 3 feet in width and be composed of soil having a permeability no greater than $10^{-5}$ cm/sec. All embankment fill should be compacted to at least 92 percent of its modified Proctor maximum density.
4.11 Stormwater Infiltration Estimates


HWA utilized USDA textural analysis and ASTM grain size distribution to estimate stormwater infiltration rates for this project. In addition, a pilot infiltration test was conducted on a nearby property with similar soils, and results from that study were compared with estimates for the Lopeman property.

Based on the results of our analyses, we recommend a stormwater infiltration rate of 4.25 feet per day (ft/day) for stormwater facilities at the site. These rates do not apply to infiltration rates provided for treated effluent, which are given in the HWA hydrogeology report (HWA, 2012). The following paragraphs present a discussion of our analyses and findings.

4.11.1 USDA Soil Textural Classification

Stormwater infiltration rates can be estimated from grain size distribution data using the USDA textural analysis approach. HWA analyzed 12 soil samples, collected from borings LB-01 through LB-04, and test pits LTP-01 through LTP-07, for grain size distribution and textural classification in accordance with the USDA procedures. Borings LB-01 through LB-03 were located in the floor of the previously excavated gravel mine on the site, in the vicinity of the proposed stormwater infiltration pond. Boring LB-04 and the other test pits were located in unexcavated areas north, west, and southwest of the mine location, albeit underlain by very similar soils. These locations are outside of proposed stormwater infiltration areas, but are included for reference.

Table 1 shows the results of the grain size analyses and Appendix B presents the soil laboratory data.

To determine long-term infiltration rates based on the USDA method, Ecology recommends that the short-term infiltration rates be reduced by a correction factor based on the soil textural classification, average degree of long-term facility maintenance, TSS (total suspended solids) reduction through pretreatment, and site subsurface variability.

Based on the USDA grain size method, laboratory test results indicate estimated long-term infiltration rates of around 0.05 to two inches per hour (in/hr) for most of the sandy soils encountered in our explorations at the site, and around 2 in/hr for soils near the proposed stormwater pond.

4.11.2 ASTM Grain Size Distribution

The ASTM grain size distribution method compares infiltration measurements from full-scale infiltration facilities to soil gradation data developed using the ASTM procedure (ASTM D422). Because this method compares data from existing full-scale infiltration facilities, the estimated infiltration rates are presented as estimated long-term infiltration rates. The estimated long-term
infiltration rates assume an average degree of long-term facility maintenance, TSS control, and site variability in the subsurface conditions. Table 1 shows the results of the grain size analyses and Appendix B presents the soil laboratory data.

Based on the ASTM grain size method, our laboratory test results indicate estimated stormwater infiltration rates ranging from unsuitable to nine in/hr at the site, and two to 3.5 in/hr for soils near the proposed stormwater pond.

Table 1  Long-Term Infiltration Rates Based On USDA/ASTM Soil Classifications*

<table>
<thead>
<tr>
<th>Boring or Test Pit</th>
<th>Depth</th>
<th>ASTM Description</th>
<th>USDA Classification</th>
<th>ASTM D10 grain size (mm)</th>
<th>WDOE Long Term Rates</th>
<th>USDA (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB-01</td>
<td>5-6.5</td>
<td>Poorly graded SAND</td>
<td>SAND</td>
<td>0.165</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>LB-02</td>
<td>5-6.5</td>
<td>Poorly graded SAND</td>
<td>SAND</td>
<td>0.208</td>
<td>3.5</td>
<td>2</td>
</tr>
<tr>
<td>LB-03</td>
<td>5-6.5</td>
<td>Poorly graded SAND with silt and gravel</td>
<td>SAND</td>
<td>0.295</td>
<td>3.5</td>
<td>2</td>
</tr>
<tr>
<td>LB-04</td>
<td>2.5-4</td>
<td>Poorly graded SAND with silt and gravel</td>
<td>SAND</td>
<td>0.254</td>
<td>3.5</td>
<td>2</td>
</tr>
<tr>
<td>LB-04</td>
<td>12.5-14</td>
<td>Poorly graded GRAVEL with sand</td>
<td>SAND</td>
<td>0.342</td>
<td>6.5</td>
<td>2</td>
</tr>
<tr>
<td>LTP-01</td>
<td>3-3.5</td>
<td>Poorly graded SAND with gravel</td>
<td>SAND</td>
<td>0.292</td>
<td>3.5</td>
<td>2</td>
</tr>
<tr>
<td>LTP-02</td>
<td>9-9.5</td>
<td>Poorly graded GRAVEL with sand</td>
<td>SAND</td>
<td>0.484</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>LTP-03</td>
<td>4-4.5</td>
<td>Poorly graded SAND with gravel</td>
<td>SAND</td>
<td>0.321</td>
<td>6.5</td>
<td>2</td>
</tr>
<tr>
<td>LTP-04</td>
<td>4-4.5</td>
<td>Silty SAND</td>
<td>Loamy SAND</td>
<td>NA</td>
<td>NS</td>
<td>0.5</td>
</tr>
<tr>
<td>LTP-05</td>
<td>4-4.5</td>
<td>Poorly graded SAND with gravel</td>
<td>SAND</td>
<td>0.303</td>
<td>6.5</td>
<td>2</td>
</tr>
<tr>
<td>LTP-06</td>
<td>4-4.5</td>
<td>Poorly graded SAND</td>
<td>SAND</td>
<td>0.283</td>
<td>3.5</td>
<td>2</td>
</tr>
<tr>
<td>LTP-07</td>
<td>4-4.5</td>
<td>Poorly graded GRAVEL with sand</td>
<td>SAND</td>
<td>0.576</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>


4.11.3 Stormwater Infiltration Estimates

Based on HWA’s grain size testing, long term stormwater infiltration rates for soils encountered at the site are approximately two to three in/hr using the USDA and ASTM methods. Vertical infiltration is limited by the least permeable layer in the soil profile. The infiltration rates
provided herein should therefore be used in conjunction with the boring and test pit logs (Appendix A) to evaluate infiltration feasibility. Explorations near the proposed pond did not show any significant low permeability layers.

Ecology does not recommend rates higher than 2 inches per hour if treatment is desired. In addition, site soils, although not tested for these parameters, and unlikely to contain enough organic carbon, or have a high enough (exceeding 5 meQ/100g) cation exchange capacity to provide stormwater treatment, per the Ecology Stormwater Manual. If treatment is required, additional stormwater treatment facilities (e.g., bioswales and/or amended soils) may be required.

4.11.4 Pilot Infiltration Testing

HWA conducted a pilot infiltration test (PIT) as described in the Ecology *Stormwater Management Manual for Western Washington* (Ecology, 2005) at the Shold property, located south of the subject site. We are including the results for reference due to the similar geology and hydrogeologic conditions shared by the two sites. The PIT consists of adding water to an excavation over time to approximate in situ infiltration rates for design of infiltration facilities. HWA conducted a PIT located near boring SB-01 at the Shold parcel. The dimensions of the PIT were approximately eight feet in diameter by four feet deep. The sidewalls of the excavation were stabilized with a temporary steel ring. The PIT was dug four feet into the ground to remove surficial topsoil and topsoil horizons, and to approximate the design condition of a subsurface infiltration facility.

On September 13 and 14, 2011, HWA conducted the PIT. The testing consisted of introducing water at a known flow rate into the excavation. Water was obtained by pumping from an on-site pond with a centrifugal pump. Slotted pipe was used to dissipate the water into the excavation. Water levels were measured with a staff gauge installed in the excavation. At selected intervals, HWA recorded total flow and calculated the flow rate. The flow rate was adjusted to establish and maintain a water level of approximately three feet above the base of the pit.

After approximately 19 hours of flow, the water was turned off. Water levels in the excavation were monitored until all water had drained out. Rate of water level decline after pumping ceased was used to determine the flow rate as the head approached zero, which is used to determine the short term, field measured vertical infiltration rate.

Discharge into the excavation stabilized approximately nine hours into the testing, at the rate given below. Figure 4 shows flow rates and stage (water levels) graphed over time. Short-term measured infiltration rates are given by the discharge (flow rate) as stage approaches zero, divided by the wetted infiltration (bottom excavation) area.

Results of the PITs indicate short-term infiltration rates as follows:

- Stabilized flow rate = 11 gpm
- Flow rate as stage approached zero = 8.9 gpm
- PIT bottom area = 50 square feet
- Infiltration rate = 34 feet/day
The PIT results are used to conservatively design the facility, using an initial, short term rate of 34 feet/day (to be adjusted further, see below).

### 4.12 PIT Results

The infiltration rates measured during the PIT are considered short-term rates, subject to correction factors to account for site variability, number of tests conducted, degree of long-term maintenance and influent pretreatment/control, and potential for long-term clogging due to siltation and bio-buildup (Ecology, 2005). Additional factors not corrected for explicitly include potential horizontal movement of water during the relatively short term test (i.e., a scaling effect of the small, short test compared with a full scale, continuously operating system).

Suggested correction factors, which are additive, are listed below:

- Site variability and number of locations tested: 1.5 to 6
- Degree of long-term maintenance to prevent siltation and bio-buildup: 2 to 6
- Degree of influent control to prevent siltation and bio-buildup: 2 to 6

The total correction factor used is the sum of all three. HWA assigned the following correction factors, as follows:

- Site variability and number of locations tested: 2
- Degree of long-term maintenance to prevent siltation and bio-buildup: 2
- Degree of influent control to prevent siltation and bio-buildup: 4

Total correction factor: 8

A low correction factor of 2 was assigned for site variability, as our explorations and previous investigations were deemed sufficient to understand the site geology and sufficiently characterize ground water conditions. A correction factor of 2 was assigned for long-term maintenance, based on the ease of access for maintenance of a surface stormwater infiltration system. A correction factor of 4 was assigned for influent control, as the treated stormwater will be of good quality, but may have moderate amounts of suspended solids. Based on the combined correction factor of 8, a long-term rate of 4.25 feet/day is recommended based on the PIT (short term rate of 34 ft/day divided by 10). This compares favorably to the stormwater infiltration rate estimates derived from grain size testing described in Section 4.9.3.
5.0 CONDITIONS AND LIMITATIONS

We have prepared this report for use by Tetra Tech, Inc. and the Jefferson County Department of Community Development in design of a portion of this project. This report should be provided in its entirety to prospective contractors for bidding or estimating purposes; however, the conclusions and interpretations presented should not be construed as a warranty of the subsurface conditions. Experience has shown that subsurface soil and ground water conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations and may not be detected by a geotechnical study. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, HWA should be notified for review of the recommendations of this report, and revision of such if necessary.

We recommend that HWA be retained to review the plans and specifications and to monitor the geotechnical aspects of construction, particularly temporary excavations, foundation subgrade preparation, pipe bedding, backfill placement and compaction, and concrete placement.

The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or ground water at this site. HWA does not practice or consult in the field of safety engineering. We will not direct the contractor’s operations, and we cannot be responsible for the safety of personnel other than our own on the site; the safety of others is the responsibility of the contractor. The contractor should notify the owner if he considers any of the recommended actions presented herein unsafe.
November 28, 2012
HWA Project No. 2005-150-21 Task 400

We trust that this report satisfies your design needs and appreciate this opportunity to be of service.

Sincerely,

HWA GEO SCIENCES INC.

Arnie Sugar, L.G., L.H.G.
Hydrogeologist, President

Ralph N. Boirum, P.E.
Geotechnical Engineer, Principal
6.0 REFERENCES


USGS, NSHMP Hazard Application, Earthquake Ground Motion Parameters, Version 5.1.0 – 02/10/2111, Updated to 2009 IBC


2012 International Building Codes
APPENDIX A

FIELD EXPLORATIONS
### Usual Symbols Used on Exploration Logs

<table>
<thead>
<tr>
<th>Component</th>
<th>Size Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulders</td>
<td>Larger than 12 in</td>
</tr>
<tr>
<td>Cobbles</td>
<td>3 to 12 in</td>
</tr>
<tr>
<td>Gravel</td>
<td>3 to No 4 (4.5 mm)</td>
</tr>
<tr>
<td>Coarse gravel</td>
<td>3 to 0.3 in</td>
</tr>
<tr>
<td>Fine gravel</td>
<td>0.3 in to No 4 (4.5 mm)</td>
</tr>
<tr>
<td>Sand</td>
<td>No 4 (4.5 mm) to No 200 (0.074 mm)</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>No 4 (4.5 mm) to No 10 (2.0 mm)</td>
</tr>
<tr>
<td>Medium sand</td>
<td>No 10 (2.0 mm) to No 40 (0.42 mm)</td>
</tr>
<tr>
<td>Fine sand</td>
<td>No 40 (0.42 mm) to No 200 (0.074 mm)</td>
</tr>
<tr>
<td>Silt and Clay</td>
<td>Smaller than No 200 (0.074 mm)</td>
</tr>
</tbody>
</table>

### Coarse Sand
- Gravel
- Medium Sand
- Fine Sand

### Medium Sand
- Coarse Gravel
- Fine Gravel

### Fine Sand
- Sand
- Silt
- Clay

### Silt and Clay
- Crudely Grained
- Finely Grained

### Moisture Content
- **DRY**: Absence of moisture, dusty, dry to the touch.
- **MOIST**: Damp but no visible water.
- **WET**: Visible free water, usually soil is below water table.

### Soil Classifications

#### USCS Soil Classification System

<table>
<thead>
<tr>
<th>Coarse Grained Soils</th>
<th>Group Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel and Gravelly Soils</td>
<td>Clean Gravel (little or no fines)</td>
</tr>
<tr>
<td>GW: Well-graded GRAVEL</td>
<td></td>
</tr>
<tr>
<td>GP: Poorly-graded GRAVEL</td>
<td></td>
</tr>
<tr>
<td>GM: Silty GRAVEL</td>
<td></td>
</tr>
<tr>
<td>GC: Clayey GRAVEL</td>
<td></td>
</tr>
<tr>
<td>SW: Well-graded SAND</td>
<td></td>
</tr>
<tr>
<td>SP: Poorly-graded SAND</td>
<td></td>
</tr>
<tr>
<td>SM: Silty SAND</td>
<td></td>
</tr>
<tr>
<td>SC: Clayey SAND</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fine Grained Soils</th>
<th>Group Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt and Clay</td>
<td>Liquid Limit</td>
</tr>
<tr>
<td>ML: SILT</td>
<td></td>
</tr>
<tr>
<td>CL: Lean CLAY</td>
<td></td>
</tr>
<tr>
<td>OL: Organic SILT/Organic CLAY</td>
<td></td>
</tr>
<tr>
<td>MH: Elastic SILT</td>
<td></td>
</tr>
<tr>
<td>CH: Fat CLAY</td>
<td></td>
</tr>
<tr>
<td>OH: Organic SILT/Organic CLAY</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Highly Organic Soils</th>
<th>Group Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT: PEAT</td>
<td></td>
</tr>
</tbody>
</table>

### Soil Component Proportions

<table>
<thead>
<tr>
<th>Component Proportion</th>
<th>Descriptive Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5%</td>
<td>Clean</td>
</tr>
<tr>
<td>5 - 12%</td>
<td>Slightly (Clayey, Silty, Sandy)</td>
</tr>
<tr>
<td>12 - 30%</td>
<td>Clayey, Silty, Sandy, Gravelly</td>
</tr>
<tr>
<td>30 - 50%</td>
<td>Very (Clayey, Silty, Sandy, Gravelly)</td>
</tr>
</tbody>
</table>

### Notes
- Soil classifications presented on exploration logs are based on visual and laboratory observation.
- Soil descriptions are presented in the following general order:
  - Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content, proportion, gradation, and angularity of constituents, additional comments.
  - (GEOLOGIC INTERPRETATION)
- Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.
NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Boring completed to 49 feet bgs.
Ground water encountered at 16 feet bgs.
Boring completed as monitoring well to 25 feet bgs.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Medium dense, brown, clean, medium SAND, scattered gravel, dry to moist.

(REECESSIONAL OUTWASH)

trace root material

As above, brown to yellow-brown. Grading wet.

Dense, brown, clean, fine gravelly, medium to coarse SAND, wet.

Very dense, gray, clean, medium SAND, wet.

Trace fine gravel

Trace gravel, trace silt.

Boring completed to 26.5 feet bgs.

Ground water encountered at 8 feet bgs.

Boring completed as monitoring well to 17 feet bgs.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Dense, brown, slightly silty, gravelly, medium to coarse SAND, dry to moist.

(RECESSIONAL OUTWASH)

As above, red-brown.

As above, gray-brown. Grading wet.

Very dense, gray-brown, slightly silty, fine gravelly, medium to coarse SAND with fine gravel, wet.

Very dense, gray, clean, gravelly, medium to coarse SAND, wet.

Oxidized layers

Very dense, trace silt.

Boring completed to 26.5 feet bgs.
Ground water encountered at 8 feet bgs.
Boring completed as monitoring well to 16 feet bgs.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Loose, dark red-brown, silty, gravelly SAND, dry grading to moist.

Medium dense, yellow-brown, slightly silty, gravelly, medium SAND, moist.

As above, with gravel to 1"

Grading dense.

Dense, yellow-red, sandy, medium GRAVEL, moist.

Dense, yellow-brown, clean, gravelly, medium to coarse SAND, moist.

As above, occasional yellow-red oxidized bands.
Grading wet.

Very dense, gray, medium SAND, trace silt, wet. 3' heave.

Boring completed to 44 feet bgs.
Ground water encountered at 32 feet bgs.
Boring completed as monitoring well to 40 feet bgs.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
### Soil Log

**Description:**

- **Depth:** feet
- **Symbol:**
  - SM: Dense, red-brown, silty, gravelly SAND, dry.
  - SP: Very dense, gravelly, decreasing silt.
  - SM: Very dense yellowish-red to red-brown, slightly silty, gravelly, medium to coarse SAND, moist.

**Notes:**
- Boring completed to 11.5 feet bgs.
- Ground water not encountered.
- Boring backfilled with hydrated bentonite chips.

**Test Results:**

- **Standard Penetration Test** (140 lb. weight, 30° drop)
  - Blows per foot:
    - 2.5: 11/17/17
    - 5: 7/18/22
    - 7.5: 9/12/21
    - 10: 8/16/24

---

**NOTE:** This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
<th>CORE SAMPLE</th>
<th>MOISTURE CONTENT (%)</th>
<th>OTHER TESTS</th>
</tr>
</thead>
</table>
| 0           | SP     | Light brown, silty SAND with root material, dry.  
(TOPSOIL) |             |          |                  |
| 3           | SP     | Brownish-yellow, gravelly SAND with some roots, dry grading to moist. Gravel to 2”, scattered cobbles.  
(RECESSIONAL OUTWASH) |             |          |                  |
| 6           | SP     | Decreasing roots. | S-1 5 GS |                      |             |
| 9           | GP     | Brownish-yellow, sandy GRAVEL with scattered cobbles, moist.  
Caving at 9 feet, sidewalls sloughing. |             |          |                  |
| 12          | GP     | Test pit completed to 9 feet below ground surface due to caving.  
Ground water not encountered. |             |          |                  |

**NOTE:** This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
LOG OF TEST PIT

EXCAVATION COMPANY: Shold Excavating
EXCAVATING EQUIPMENT: Case 9030B Excavator
SURFACE ELEVATION: 115 ± Feet

LOCATION: Lopeman Property
DATE COMPLETED: 7/25/11
LOGGED BY: V. Atkins

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

DESCRIPTION

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>SYMBOL</th>
<th>USCS SOIL CLASS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>Light brown, silty SAND with root material, dry. (TOPSOIL)</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>Light brown, silty, medium SAND and GRAVEL with roots, dry grading to moist. (RECESSIONAL OUTWASH)</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>Yellow-gray, medium SAND and GRAVEL with oxidixed layers, dry grading moist. Gravel to 2&quot;, occasional cobbles.</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>Sidewalls sloughing.</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>Tree roots.</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>Decreasing oxidation, yellow-gray SAND and GRAVEL, moist.</td>
</tr>
</tbody>
</table>

Test pit completed to 9 feet below ground surface due to caving. Caving at 9 feet. Ground water not encountered.

SAMPLE TYPE | SAMPLE NUMBER | MOISTURE CONTENT (%) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-2 3</td>
<td>GS</td>
<td></td>
</tr>
</tbody>
</table>

PORT HADLOCK UGA SEWER SYSTEM
TREATMENT PLANT AND REUSE SITES
PORT HADLOCK, WASHINGTON

LOG OF TEST PIT
LTP-02

PAGE: 1 of 1
PROJECT NO.: 2005-150
FIGURE: A-8

PICTURE 2005150.GPJ 11/21/12
**DESCRIPTION**

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>SYMBOL</th>
<th>USCS SOIL CLASS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>SM</td>
<td>S-1</td>
<td>Light brown, silty SAND with root material, dry. (TOPSOIL)</td>
</tr>
<tr>
<td>3</td>
<td>SP</td>
<td>S-2</td>
<td>Light yellow-brown, silty, medium SAND and GRAVEL, dry grading to moist. Silt deceasing with depth. (RECESSIONAL OUTWASH)</td>
</tr>
<tr>
<td>6</td>
<td>SP</td>
<td>S-3</td>
<td>Yellow-gray, clean, gravelly, medium to coarse SAND, moist. Scattered gravelly lenses. Tree roots. Sidewalls sloughing.</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>Test pit completed to 9 feet below ground surface due to caving. Caving at 9 feet. Ground water not encountered.</td>
</tr>
</tbody>
</table>

**NOTE:** This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
### Test Pit Photo

**Description:**

- **0 feet:**
  - Light brown, silty SAND with root material, dry.
  - *(TOPSOIL)*

- **3 feet:**
  - Reddish-brown, silty, medium SAND and GRAVEL, with roots, dry grading to moist. Slight oxidation.
  - *(RECESSIONAL OUTWASH)*
  - Roots decreasing with depth.

- **6 feet:**
  - Brownish-yellow, slightly silty, medium SAND and GRAVEL, moist. Scattered cobbles.

- **9 feet:**
  - Sandy lenses.

- **12 feet:**
  - Test pit completed to 10 feet below ground surface due to caving.
  - Caving at 10 feet.
  - Ground water not encountered.

**Notes:**

- This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

**Additional Information:**

- **Location:** Lopeman Property
- **Excavation Equipment:** Case 9030B Excavator
- **Excavation Company:** Shold Excavating
- **Surface Elevation:** 118 ± Feet
- **Date Completed:** 7/25/11
- **Logged By:** V. Atkins

---

**Test Pit Log**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DEPTH (feet)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>0</td>
<td>Light brown, silty SAND with root material, dry. <em>(TOPSOIL)</em></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Reddish-brown, silty, medium SAND and GRAVEL, with roots, dry grading to moist. Slight oxidation. <em>(RECESSIONAL OUTWASH)</em> Roots decreasing with depth.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Brownish-yellow, slightly silty, medium SAND and GRAVEL, moist. Scattered cobbles.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Sandy lenses.</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Test pit completed to 10 feet below ground surface due to caving. Caving at 10 feet. Ground water not encountered.</td>
</tr>
</tbody>
</table>

---

**Table:**

- **Sample Type:** S-1, S-2
- **Moisture Content (%):** 7
- **USCS Soil Class:** GS

---

**Figure:**

- **Figure:** 2005-150.GPJ 11/21/12

---

**Log of Test Pit**

**Project No.:** 2005-150

**Port Hadlock UGA Sewer System**

**Treatment Plant and Reuse Sites**

**Port Hadlock, Washington**

---

**Picture:**

- **Picture:** 2005150.GPJ 11/21/12

---

**Institution:** HWAGEOSCIENCES INC.

---

**Page:** 1 of 1

---

**Figure:** A-10
Light brown, gravelly, silty SAND with root material, dry. (TOPSOIL)

Yellow-brown, clean, gravelly, medium to coarse SAND, dry grading to moist. Gravel to 2". (RECESSIONAL OUTWASH)

Roots decreasing with depth.

Grades to gray-brown, coarse SAND and GRAVEL, moist. Gravel to 3", slight oxidation.

Test pit completed to 11 feet below ground surface due to caving. Caving at 10 feet. Ground water not encountered.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>S-1</td>
<td>Light brown, silty SAND with root material, dry. (TOPSOIL)</td>
</tr>
<tr>
<td>3</td>
<td>SP</td>
<td>Grading yellow-brown, clean, medium to coarse SAND with roots, dry grading to moist. (RECESSIONNAL OUTWASH) Roots decreasing with depth.</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Brownish-yellow, clean, medium to coarse SAND and GRAVEL, moist. Gravel to 2&quot;. Sidewalls sloughing. Fine gravel lenses.</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Test pit completed to 10 feet below ground surface due to caving. Ground water not encountered.</td>
</tr>
<tr>
<td>12</td>
<td>S-2</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>SYMBOL</th>
<th>USCS SOIL CLASS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>GP</td>
<td></td>
<td>Light brown to reddish-brown, silty SAND with root material, dry.</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>Brownish-yellow, clean, medium GRAVEL and SAND with scattered cobbles, moist. Stratified. Gravel to 2'.</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>Fine gravel layers. Sidewalls sloughing.</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>Increasing sand.</td>
</tr>
<tr>
<td>12</td>
<td>S-2</td>
<td></td>
<td>Test pit completed to 10 feet below ground surface due to caving. Ground water not encountered.</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
**EXCAVATION COMPANY:** Shold Excavating  
**LOCATION:** Lopeman Property  
**EXCAVATING EQUIPMENT:** Case 9030B Excavator  
**DATE COMPLETED:** 7/25/11  
**SURFACE ELEVATION:** 89 ± Feet  
**LOGGED BY:** V. Atkins  

---

**DESCRIPTION**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>MOISTURE CONTENT (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-1</td>
<td></td>
</tr>
</tbody>
</table>

**TEST PIT PHOTO**

Light brown, silty SAND with root material, dry. (TOPSOIL)

Yellow-gray, clean, medium SAND and GRAVEL, dry grading to moist. With oxidized layers, trace cobbles. (RECESSIONAL OUTWASH)

Gravel to 2"

Grading wet.

Gray medium SAND, wet, sloughing.

Test pit completed to 6 feet below ground surface due to caving and ground water. Ground water encountered at 4.5 feet below ground surface.

---

**NOTE:** This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
South edge of gravel pit slope; top of test pit at 6 feet below top of slope. Loose grading to medium dense, brown, slightly silty, sandy, fine to coarse GRAVEL, moist. Grades to dry at about 1.5'. Surface probes 4 to 8 inches.

(_GRADED / DISTURBED NATIVE SOILS)

At 2 ft probed 12". At 3 ft probed 6 to 12". Becomes damp to moist below 3 to 4 ft. At 4 ft probed 6".

Chunk of dark brown sod or topsoil at 5 ft.

Medium dense, dark gray and dark brown, clayey, sandy, fine to coarse GRAVEL, moist. Scattered, partly decomposed wood.

(NECESSIONAL OUTWASH)

Loose to medium dense, light olive gray, clean, medium SAND, moist.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>USCS SOIL CLASS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Test pit terminated at 14 feet depth below ground surface on upslope side, 4 feet below ground surface at downslope side. No ground water seepage encountered during exploration. Minor caving occurred from 7’ to 9’ and minor raveling throughout.</td>
</tr>
</tbody>
</table>

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Starting at mid-slope: Surface probed 2 to 6", hitting gravel clasts. Loose, brown, slightly silty, fine to coarse sandy, fine to coarse GRAVEL, dry to moist. Thickness varies, from approx. 2 feet at midslope to maximum of 8 feet at 25 feet in from toe of slope.

(GRADED / DISTURBED NATIVE SOILS)

At 2.5 ft probed 6 to 8". Loose, gray, clean, medium SAND, moist.

(RECESSIONAL OUTWASH)

Test pit terminated at 9 feet. No ground water seepage encountered during exploration. Heavy caving within fill, from surface to depth (5 feet) in two places.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
**EXCAVATION COMPANY:** Shold Excavating  
**EXCAVATING EQUIPMENT:** Case 9030B Excavator  
**SURFACE ELEVATION:** 114 ± Feet  
**LOCATION:** Lopeman Property  
**DATE COMPLETED:** 10/25/12  
**LOGGED BY:** B. Thurber

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
<th>USCS SOIL CLASS</th>
<th>SAMPLE TYPE</th>
<th>MOISTURE CONTENT (%)</th>
<th>OTHER TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>SP</td>
<td>Top of pit at approx. 5 ft from top of slope, and extends to toe (pit approx 30 ft long). Loose, brown, clean, gravelly, SAND, moist. Layer gets thicker downslope, from 0.5 to 2.5 ft deep at 15 ft from toe of slope.</td>
<td>Loamy Sands (GL)</td>
<td>SP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SP</td>
<td>Loose, light olive brown, clean, gravelly SAND and sandy, fine to coarse GRAVEL, moist. Interbedded with 3&quot; to 8&quot; thick beds. Apparent dip to North.</td>
<td>Loamy Sands (GL)</td>
<td>SP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test pit terminated at maximum depth of 5 feet. No ground water seepage encountered during this exploration. Sloughing and ravelling throughout exploration, but no caving.

---

**NOTE:** This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Medium dense, light brown, slightly silty, sandy, fine to coarse GRAVEL, dry to moist. Layer extends down to 6 ft in southeast side, and only 1 foot on northwest (uphill) side. Partly decomposed root/wood at 0.5 to 1 ft. Heavy rust mottling below 2.5 to 3 feet.

Test pit terminated at 7 feet below ground surface. Moderate ground water seepage below about 6 feet. Heavy caving on west side from 0 to 7 feet.
End of pit at 5 feet west of standing water (wetland):
Medium dense, gray, slightly silty, fine gravelly, fine to coarse SAND, moist.

(FILL)
Soft, dark brown, organic SILT, wet. Scattered roots.
Tapers to nothing at 5 feet from east end.  (BURIED TOPSOIL)
Medium dense, reddish brown, slightly silty, fine to medium SAND, moist to wet.

(RECESIONAL OUTWASH)
Dense, dark brown, slightly silty, sandy, fine to coarse GRAVEL, moist.

Test pit terminated at 5 feet below ground surface.
Minor ground water seepage observed from east end at about 2 feet below ground surface.
No caving.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>SYMBOL</th>
<th>USCS SOIL CLASS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>SP</td>
<td></td>
<td>Loose, gray, clean, fine to medium SAND, moist. (GRADED / DISTURBED NATIVE SOILS)</td>
</tr>
<tr>
<td>3</td>
<td>GM</td>
<td></td>
<td>Dense, light brown, silty, sandy, fine to coarse GRAVEL, moist.</td>
</tr>
<tr>
<td>6</td>
<td>GM</td>
<td></td>
<td>Medium dense, olive brown, gravelly SAND and brownish black, open-work GRAVEL, damp to moist. (RECESSINAL OUTWASH)</td>
</tr>
<tr>
<td>9</td>
<td>SP</td>
<td></td>
<td>Medium dense, light olive brown, clean, medium SAND, moist. Finely bedded.</td>
</tr>
</tbody>
</table>

Test pit terminated at 4’ below ground surface.
No ground water seepage encountered during this exploration.
No caving.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Medium dense, brown and olive brown, clean to slightly silty, fine to coarse sandy, fine to coarse GRAVEL, moist. Gravel mostly <1".

Medium dense, olive gray, clean, fine to medium SAND, moist. (Also exposed in portions of pit bottom nearby).

Test pit terminated at 4' below ground surface.
No ground water seepage encountered during this exploration.
No caving.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
At approx. 20 feet east of fill embankment slope:

Loose, dark brown, organic, silty, SAND, dry.
(TOPSOIL)

Loose grading to medium dense, light brown to dark yellow-brown, slightly silty, gravelly, fine to medium SAND, dry grading to moist below about 3 feet. Scattered roots to 5 feet.
(RECESSIONAL OUTWASH)

Bottom 2 feet is finely bedded and near horizontal.

Test pit terminated at 5' below ground surface.
No ground water seepage encountered during this exploration.
No caving.
<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>USCS SOIL CLASS</th>
<th>DESCRIPTION</th>
<th>SAMPLE TYPE</th>
<th>SAMPLE NUMBER</th>
<th>MOISTURE CONTENT (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN</td>
<td>GP</td>
<td>Loose, dark brown, organic, silty, sandy, fine GRAVEL, moist. Scattered roots and rootlets.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>(FILL)</td>
<td>Loose, brown, clean, fine gravelly, fine to coarse SAND, moist.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td></td>
<td>Loose to medium dense, dark brown, silty SAND, moist, with abundant roots. Organic Content = 8.54%.</td>
<td>S-1</td>
<td>4</td>
<td>GS</td>
</tr>
<tr>
<td>SW</td>
<td></td>
<td>Loose, brownish gray, slightly gravelly, silty, fine to coarse SAND, moist grading to wet.</td>
<td>S-2</td>
<td>28</td>
<td>OC</td>
</tr>
<tr>
<td>SM</td>
<td></td>
<td>(RECESSIONAL OUTWASH)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test pit terminated at 9' below ground surface. No ground water seepage encountered during this exploration. No caving.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
**Note:** Large concrete rubble in fill nearby, exposed at surface.

Loose to medium dense, dark yellowish brown, clean, sandy, fine GRAVEL, damp. (Gravel Pit reject screenings?)

(DIFF / TOPSOIL)

Becomes wet.

Test pit terminated at 12’ below ground surface.

Moderate ground water seepage up from bottom at about 11’, and rising after excavation.

Moderate caving below 8’.

**NOTE:** This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Loose, dark brown, organic, silty, SAND, moist.

(TOPSOIL)

Loose to medium dense, light brown, sandy, fine to coarse GRAVEL and silty, gravelly SAND, dry. Scattered cobbles and partly decomposed wood. Scattered rootlets from 0 to 6 feet.

(FILL)

Loose to medium dense, gray, clean, medium to coarse sandy, fine to coarse GRAVEL, dry to moist.

(RECESSIONAL OUTWASH)

Test pit terminated at 7' below ground surface.
No ground water seepage encountered during this exploration.
No caving.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
APPENDIX B

LABORATORY TESTING
<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLE</th>
<th>DEPTH (ft)</th>
<th>CLASSIFICATION OF SOIL - ASTM D2487 Group Symbol and Name</th>
<th>% MC</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Fines %</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td>LB-01</td>
<td>5</td>
<td>(SP) Grayish brown, poorly graded SAND</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>0.8</td>
<td>95.0</td>
<td>4.2</td>
</tr>
<tr>
<td>■</td>
<td>LB-01</td>
<td>15</td>
<td>(SM) Olive brown, silty SAND</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>75.8</td>
<td>24.1</td>
</tr>
<tr>
<td>▲</td>
<td>LB-01</td>
<td>27.5</td>
<td>(SP-SM) Dark grayish brown, poorly graded SAND with silt</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>93.2</td>
<td>6.7</td>
</tr>
</tbody>
</table>

**PARTICLE-SIZE ANALYSIS OF SOILS METHOD ASTM D422**

PORT HADLOCK UGA SEWER SYSTEM TREATMENT PLANT AND REUSE SITES PORT HADLOCK, WASHINGTON

PROJECT NO.: 2005-150 FIGURE: B-1
### GRAVEL, SAND, SILT, CLAY

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLE</th>
<th>DEPTH (ft)</th>
<th>CLASSIFICATION OF SOIL - ASTM D2487 Group Symbol and Name</th>
<th>% MC</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Fines %</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td>LB-01</td>
<td>47.5</td>
<td>(SP-SM) Gray, poorly graded SAND with silt</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
<td>93.9</td>
<td>6.1</td>
</tr>
<tr>
<td>■</td>
<td>LB-02</td>
<td>5</td>
<td>(SP) Olive brown, poorly graded SAND</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>7.7</td>
<td>88.0</td>
<td>4.3</td>
</tr>
<tr>
<td>▲</td>
<td>LB-02</td>
<td>20</td>
<td>(SP) Dark gray, poorly graded SAND</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td>5.4</td>
<td>91.4</td>
<td>3.1</td>
</tr>
</tbody>
</table>

### U.S. STANDARD SIEVE SIZES

<table>
<thead>
<tr>
<th>PARTICLE-SIZE ANALYSIS OF SOILS</th>
<th>METHOD ASTM D422</th>
</tr>
</thead>
</table>

PORT HADLOCK UGA SEWER SYSTEM
TREATMENT PLANT AND REUSE SITES
PORT HADLOCK, WASHINGTON

PROJECT NO.: 2005-150
FIGURE: B-2
PORT HADLOCK UGA SEWER SYSTEM
TREATMENT PLANT AND REUSE SITES
PORT HADLOCK, WASHINGTON

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422
PORT HADLOCK UGA SEWER SYSTEM
TREATMENT PLANT AND REUSE SITES
PORT HADLOCK, WASHINGTON

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLE</th>
<th>DEPTH (ft)</th>
<th>CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name</th>
<th>% MC</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Fines %</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td>LTP-01</td>
<td>3.0 - 3.5</td>
<td>(SP) Dark yellowish brown, poorly graded SAND with gravel</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>32.0</td>
<td>64.9</td>
<td>3.1</td>
</tr>
<tr>
<td>●</td>
<td>LTP-02</td>
<td>9.0 - 9.5</td>
<td>(GP) Dark yellowish brown, poorly graded GRAVEL with sand</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>58.6</td>
<td>40.3</td>
<td>1.1</td>
</tr>
<tr>
<td>▲</td>
<td>LTP-03</td>
<td>4.0 - 4.5</td>
<td>(SP) Dark yellowish brown, poorly graded SAND with gravel</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>32.1</td>
<td>65.5</td>
<td>2.4</td>
</tr>
<tr>
<td>SYMBOL</td>
<td>SAMPLE</td>
<td>DEPTH (ft)</td>
<td>CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name</td>
<td>% MC</td>
<td>LL</td>
<td>PL</td>
<td>PI</td>
<td>Gravel %</td>
<td>Sand %</td>
<td>Fines %</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>------------</td>
<td>----------------------------------------------------------</td>
<td>------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>-----------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>●</td>
<td>LTP-07</td>
<td>4.0 - 4.5</td>
<td>(GP) Dark yellowish brown, poorly graded GRAVEL with sand</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>57.1</td>
<td>41.0</td>
<td>1.9</td>
</tr>
<tr>
<td>■</td>
<td>LTP-09</td>
<td>2.0 - 2.5</td>
<td>(GP-GM) Brown, poorly graded GRAVEL with silt and sand</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>49.7</td>
<td>44.4</td>
<td>6.0</td>
</tr>
<tr>
<td>▲</td>
<td>LTP-09</td>
<td>11.0 - 12.0</td>
<td>(SP) Dark yellowish brown, poorly graded SAND with gravel</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>44.4</td>
<td>55.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>
### Soil Classification

**Symbol:** LTP-10, LTP-13, LTP-17

**Sample:** S-1

**Depth (ft):** 1.0 - 2.0

**Classification of Soil (ASTM D2487 Group Symbol and Name):**

- **LTP-10 (GP-GM):** Yellowish brown, poorly graded GRAVEL with silt and sand
- **LTP-13 (SW-SM):** Dark brown, well graded SAND with silt and gravel
- **LTP-17 (SP):** Brown, poorly graded SAND with gravel

**Particle-Size Analysis (Method ASTM D422):**

- **% MC:** 4
- **LL:** 53.2
- **PL:** 41.2
- **PI:** 5.6
- **Gravel %:** 18
- **Sand %:** 73.2
- **Fines %:** 10.1

**Sample Locations:**
- **PORT HADLOCK UGA SEWER SYSTEM**
- **TREATMENT PLANT AND REUSE SITES**
- **PORT HADLOCK, WASHINGTON**

**Project No.:** 2005-150

**Figure:** B-8
<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLE</th>
<th>DEPTH (ft)</th>
<th>CLASSIFICATION OF SOIL - ASTM D2487 Group Symbol and Name</th>
<th>% MC</th>
<th>LL</th>
<th>PL</th>
<th>PI</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Fines %</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td>LTP-18</td>
<td>S-1</td>
<td>(SP) Dark yellowish brown, poorly graded SAND with gravel</td>
<td>3</td>
<td>36.7</td>
<td>60.2</td>
<td>3</td>
<td>36.7</td>
<td>60.2</td>
<td>3.0</td>
</tr>
<tr>
<td>●</td>
<td>LTP-19</td>
<td>S-1</td>
<td>2.0 - 4.0</td>
<td>3</td>
<td>51.1</td>
<td>38.8</td>
<td>10.0</td>
<td>51.1</td>
<td>38.8</td>
<td>10.0</td>
</tr>
</tbody>
</table>

(SW-GM) Light brown, well graded GRAVEL with silt and sand

11/20/12

PROJECT NO.: 2005-150   FIGURE: B-9

PORT HADLOCK UGA SEWER SYSTEM
TREATMENT PLANT AND REUSE SITES
PORT HADLOCK, WASHINGTON

PORT HADLOCK UGA SEWER SYSTEM
TREATMENT PLANT AND REUSE SITES
PORT HADLOCK, WASHINGTON

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422
APPENDIX C

USGS DESIGN MAPS SUMMARY REPORT
USGS “DesignMaps” Summary Report

User-Specified Input

(which makes use of 2008 USGS hazard data)

Site Coordinates: 48.0249°N, 122.7685°W

Site Soil Classification: Site Class C – "Very Dense Soil and Soft Rock"

Site Risk Category: Risk Category III – "Substantial Hazard"

USGS-Provided Output

\[ S_a = 1.278 \text{ g} \quad S_{sm} = 1.278 \text{ g} \quad S_{sm} = 0.852 \text{ g} \]
\[ S_1 = 0.516 \text{ g} \quad S_{ns} = 0.671 \text{ g} \quad S_{ns} = 0.447 \text{ g} \]

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.

MCE\text{\textsubscript{a}} Response Spectrum

Design Response Spectrum

Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.
Section 1613.3.1 — Mapped acceleration parameters

From Figure 1613.3.1(1)\(^{[1]}\)

\[ S_s = 1.278 \text{ g} \]

From Figure 1613.3.1(2)\(^{[2]}\)

\[ S_s = 0.516 \text{ g} \]

Section 1613.3.2 — Site class definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class C, based on the site soil properties in accordance with Section 1613.

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$\nu_s$</th>
<th>$N$ or $N_h$</th>
<th>$s_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Hard Rock</td>
<td>&gt;5,000 ft/s</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B. Rock</td>
<td>2,500 to 5,000 ft/s</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C. Very dense soil and soft rock</td>
<td>1,200 to 2,500 ft/s</td>
<td>&gt;50</td>
<td>&gt;2,000 psf</td>
</tr>
<tr>
<td>D. Stiff Soil</td>
<td>600 to 1,200 ft/s</td>
<td>15 to 50</td>
<td>1,000 to 2,000 psf</td>
</tr>
<tr>
<td>E. Soft clay soil</td>
<td>&lt;600 ft/s</td>
<td>&lt;15</td>
<td>&lt;1,000 psf</td>
</tr>
</tbody>
</table>

Any profile with more than 10 ft of soil having the characteristics:
- Plasticity index $PI > 20$,
- Moisture content $w \geq 40\%$, and
- Undrained shear strength $\bar{\delta}_u < 500$ psf

F. Soils requiring site response analysis in accordance with Section 21.1

For SI: 1 ft/s = 0.3048 m/s 1 lb/ft$^2$ = 0.0479 kN/m$^2$
Section 1613.3.3 — Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped Spectral Response Acceleration at Short Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_z \leq 0.25$</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.2</td>
</tr>
<tr>
<td>D</td>
<td>1.6</td>
</tr>
<tr>
<td>E</td>
<td>2.5</td>
</tr>
<tr>
<td>F</td>
<td>See Section 11.4.7 of ASCE 7</td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_z$

For Site Class = 2 and $S_z = 1.278$, $F_z = 1.000$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped Spectral Response Acceleration at 1-s Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_z \leq 0.1$</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.7</td>
</tr>
<tr>
<td>D</td>
<td>2.4</td>
</tr>
<tr>
<td>E</td>
<td>3.5</td>
</tr>
<tr>
<td>F</td>
<td>See Section 11.4.7 of ASCE 7</td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_z$

For Site Class = 2 and $S_z = 0.516$, $F_z = 1.300$
Equation (16-37): \[ S_{ts} = F_s S_s = 1.000 \times 1.278 = 1.278 \text{ g} \]

Equation (16-38): \[ S_{st} = F_v S_i = 1.300 \times 0.516 = 0.671 \text{ g} \]

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39): \[ S_{os} = \frac{3}{5} S_{ts} = \frac{3}{5} \times 1.278 = 0.852 \text{ g} \]

Equation (16-40): \[ S_{ot} = \frac{3}{5} S_{st} = \frac{3}{5} \times 0.671 = 0.447 \text{ g} \]
Section 1613.3.5 – Determination of seismic design category

### TABLE 1613.3.5(1)

**SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATIONS**

<table>
<thead>
<tr>
<th>VALUE OF $S_{0s}$</th>
<th>I or II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{0s} &lt; 0.167g$</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>$0.167g \leq S_{0s} &lt; 0.33g$</td>
<td>B</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>$0.33g \leq S_{0s} &lt; 0.50g$</td>
<td>C</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>$0.50g \leq S_{0s}$</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

For Risk Category = III and $S_{0s} = 0.852$, Seismic Design Category = D

### TABLE 1613.3.5(2)

**SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATIONS**

<table>
<thead>
<tr>
<th>VALUE OF $S_{01}$</th>
<th>I or II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{01} &lt; 0.067g$</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>$0.067g \leq S_{01} &lt; 0.133g$</td>
<td>B</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>$0.133g \leq S_{01} &lt; 0.20g$</td>
<td>C</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>$0.20g \leq S_{01}$</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

For Risk Category = III and $S_{01} = 0.447$, Seismic Design Category = D

Note: When $S_i$ is greater than 0.75g, the Seismic Design Category is E for buildings in Risk Categories I, II, and III, and F for those in Risk Category IV, irrespective of the above.

Seismic Design Category = "the more severe design category in accordance with Table 1613.3.5(1) or 1613.3.5(2)" = D

Note: See Section 1613.5.1 for alternative approaches to calculating Seismic Design Category.

### References

1. **Figure 1613.3.1(1):** http://earthquake.usgs.gov/hazards/designmaps/pdfs/IBC-2006-Figure1613_5 (01).pdf
2. **Figure 1613.3.1(2):** http://earthquake.usgs.gov/hazards/designmaps/pdfs/IBC-2006-Figure1613_5 (02).pdf