

**AGREEMENT FOR THE SUPPLY OF
SIDESTREAM PHOSPHORUS RECOVERY EQUIPMENT
PROJECT #10036.e**

THIS AGREEMENT FOR EQUIPMENT / SUPPLIES PROCUREMENT is made this 3rd day of August, 2021, and entered into by and between the City of Meridian, a municipal corporation organized under the laws of the State of Idaho, hereinafter referred to as "CITY", 33 East Broadway Avenue, Meridian, Idaho 83642, and Centrisys/CNP, hereinafter referred to as "SUPPLIER", whose business address is 9586 58th Place, Kenosha, WI 83144.

INTRODUCTION

Whereas, the City has a need for SIDESTREAM PHOSPHORUS RECOVERY EQUIPMENT; and

WHEREAS, the SUPPLIER is specially trained, experienced and competent to provide and has agreed to provide such equipment;

NOW, THEREFORE, in consideration of the mutual promises, covenants, terms and conditions hereinafter contained, the parties agree as follows:

TERMS AND CONDITIONS

1. Equipment / Supply Specifications & Requirements:

1.1 SUPPLIER shall supply the equipment, supplies and services to the City upon execution of this Agreement and receipt of the City's written notice to proceed, all items, and comply in all respects, as specified in the Technical Specifications titled " Wastewater Resource Recovery Facility (WRRF) Side Stream Treatment Project – Reactor Procurement Submittal", Plans titled "Meridian Wastewater Facility Meridian, Idaho", and Budgetary Proposal #06638 dated June 18, 2021, which by this reference are incorporated herein.

1.2 The SUPPLIER shall provide all equipment and services under this Agreement consistent with the requirements and standards established by applicable federal, state and city laws, ordinances, regulations and resolutions and the UCC. The SUPPLIER represents and warrants that it will perform its work in accordance with generally accepted industry standards and practices for the profession or professions that are used in

performance of this Agreement and that are in effect at the time of performance of this Agreement.

2. Consideration

2.1 The SUPPLIER shall be compensated on a Fixed Price basis as provided in Attachment B "Payment Schedule" attached hereto and by reference made a part hereof, for the Not-To-Exceed amount of \$2,139,000.00 F.O.B. the City of Meridian Wastewater Resource Recovery Facility located at 3401. N. Ten Mile Rd, Meridian, ID 83646.

2.2 The SUPPLIER shall provide the City with a detailed invoice upon delivery of all equipment and supplies, which the City will pay within 30 days of receipt of a correct invoice and approval by the City Project Manager. The City will not withhold any Federal or State income taxes or Social Security Tax from any payment made by City to SUPPLIER under the terms and conditions of this Agreement. Payment of all taxes and other assessments on such sums is the sole responsibility of SUPPLIER.

2.3 Except as expressly provided in this Agreement, SUPPLIER shall not be entitled to receive from the City any additional consideration, compensation, salary, wages, or other type of remuneration for services rendered under this Agreement., including , but not limited to, meals, lodging, transportation, drawings, renderings or mockups. Specifically, SUPPLIER shall not be entitled by virtue of this Agreement to consideration in the form of overtime, health insurance benefits, retirement benefits, paid holidays or other paid leaves of absence of any type or kind whatsoever.

3. Term:

3.1 This agreement shall become effective upon execution by both parties, and shall expire upon (a) completion of the agreed upon work, or (b) unless sooner terminated as provided below or unless some other method or time of termination is listed in Attachment A.

3.2 Should SUPPLIER default in the performance of this Agreement or materially breach any of its provisions, City, at City's option, may terminate this Agreement by giving written notification to SUPPLIER.

3.3 Should City fail to pay SUPPLIER all or any part of the compensation set forth in Attachment B of this Agreement on the date due, SUPPLIER, at the SUPPLIER's option, may terminate this Agreement if the failure is not remedied by the City within thirty (30) days from the date payment is due.

4. **Liquidated Damages:**

Each Milestone listed in the Milestone / Payment Schedule below shall be accomplished in the timeframe listed. All days shall be calculated as Calendar Days. Supplier shall be liable to the City for any delay beyond each milestone time period in the amount of \$500 (five hundred dollars) per calendar day. Such payment shall be construed to be liquidated damages by the supplier in lieu of any claim or damage because of such delay and not be construed as a penalty.

5. **Termination:**

If, through any cause, SUPPLIER, its officers, employees, or agents fails to fulfill in a timely and proper manner its obligations under this Agreement, violates any of the covenants, agreements, or stipulations of this Agreement, falsifies any record or document required to be prepared under this agreement, engages in fraud, dishonesty, or any other act of misconduct in the performance of this contract, or if the City Council determines that termination of this Agreement is in the best interest of CITY, the CITY shall thereupon have the right to terminate this Agreement by giving written notice to SUPPLIER of such termination and specifying the effective date thereof at least fifteen (15) days before the effective date of such termination.

Notwithstanding the above, SUPPLIER shall not be relieved of liability to the CITY for damages sustained by the CITY by virtue of any breach of this Agreement by SUPPLIER, and the CITY may withhold any payments to SUPPLIER for the purposes of set-off until such time as the exact amount of damages due the CITY from SUPPLIER is determined. This provision shall survive the termination of this agreement and shall not relieve SUPPLIER of its liability to the CITY for damages.

6. **Independent SUPPLIER:**

6.1 In all matters pertaining to this agreement, SUPPLIER shall be acting as an independent SUPPLIER, and neither SUPPLIER nor any officer, employee or agent of SUPPLIER will be deemed an employee of CITY. Except as expressly provided in Attachment A, SUPPLIER has no authority or responsibility to exercise any rights or power vested in the City and therefore has no authority to bind or incur any obligation on behalf of the City. The selection and designation of the personnel of the CITY in the performance of this agreement shall be made by the CITY.

6.2 SUPPLIER, its agents, officers, and employees are and at all times during the term of this Agreement shall represent and conduct themselves as independent SUPPLIERS and not as employees of the City.

6.3 SUPPLIER shall determine the method, details and means of performing the work and services to be provided by SUPPLIER under this Agreement. SUPPLIER shall be responsible to City only for the requirements and results specified in this Agreement and, except as expressly provided in this Agreement, shall not be subjected to City's control with respect to the physical action or activities of SUPPLIER in fulfillment of this Agreement. If in the performance of this Agreement any third persons are employed by SUPPLIER, such persons shall be entirely and exclusively under the direction and supervision and control of the SUPPLIER.

7. Indemnification and Insurance:

7.1 SUPPLIER shall indemnify and save and hold harmless CITY from and for any and all losses, claims, actions, judgments for damages, or injury to persons or property and losses and expenses and other costs including litigation costs and attorney's fees, arising out of, resulting from, or in connection with the performance of this Agreement by the SUPPLIER, its servants, agents, officers, employees, guests, and business invitees, and not caused by or arising out of the tortuous conduct of CITY or its employees. SUPPLIER shall maintain, and specifically agrees that it will maintain, throughout the term of this Agreement, liability insurance, in which the CITY shall be named an additional insured in the minimum amounts as follow: General Liability One Million Dollars (\$1,000,000) per incident or occurrence, Professional Liability One Million Dollars (\$1,000,000) per incident or occurrence, Automobile Liability Insurance One Million Dollars (\$1,000,000) per incident or occurrence and Workers' Compensation Insurance, in the statutory limits as required by law.. The limits of insurance shall not be deemed a limitation of the covenants to indemnify and save and hold harmless CITY; and if CITY becomes liable for an amount in excess of the insurance limits, herein provided, SUPPLIER covenants and agrees to indemnify and save and hold harmless CITY from and for all such losses, claims, actions, or judgments for damages or injury to persons or property and other costs, including litigation costs and attorneys' fees, arising out of, resulting from , or in connection with the performance of this Agreement by the SUPPLIER or SUPPLIER's officers, employs, agents, representatives or sub-SUPPLIERS and resulting in or attributable to personal injury, death, or damage or destruction to tangible or intangible property, including use of. SUPPLIER shall provide CITY with a Certificate of Insurance, or other proof of insurance evidencing SUPPLIER'S compliance with the requirements of this paragraph and file such proof of insurance with the CITY at least ten (10) days prior to the date SUPPLIER begins performance of it's obligations under this Agreement. In the event the insurance minimums are changed,

SUPPLIER shall immediately submit proof of compliance with the changed limits. Evidence of all insurance shall be submitted to the City Purchasing Agent with a copy to Meridian City Accounting, 33 East Broadway Avenue, Meridian, Idaho 83642.

7.2 Any deductibles, self-insured retention, or named insureds must be declared in writing and approved by the City. At the option of the City, either: the insurer shall reduce or eliminate such deductibles, self-insured retentions or named insureds; or the SUPPLIER shall provide a bond, cash or letter of credit guaranteeing payment of losses and related investigations, claim administration and defense expenses.

7.3 To the extent of the indemnity in this contract, SUPPLIER's Insurance coverage shall be primary insurance regarding the City's elected officers, officials, employees and volunteers. Any insurance or self-insurance maintained by the City or the City's elected officers, officials, employees and volunteers shall be excess of the SUPPLIER's insurance and shall not contribute with SUPPLIER's insurance except as to the extent of City's negligence.

7.4 The SUPPLIER's insurance shall apply separately to each insured against whom claim is made or suit is brought, except with respect to the limits of the insurer's liability.

7.5 All insurance coverages for Suppliers subs shall be subject to all of the insurance and indemnity requirements stated herein.

7.6 The limits of insurance described herein shall not limit the liability of the Supplier and Supplier's agents, representatives, employees or subcontractors.

7.7 The limits of insurance described herein shall not limit the liability of the Contractor and Contractor's agents, representatives, employees or subcontractors.

8. **Bonds:** Payment and Performance Bonds are required.
9. **Warranty:** In addition to any warranty required in the specifications, all equipment, coatings, valves, controls, and other components provided under this agreement shall be guaranteed for two (2) years against defects in workmanship and materials from the successful startup of equipment or 30 months after delivery, whichever comes first. ALL WARRANTY REPAIRS MUST USE NEW PARTS.
10. **Notices:** Any and all notices required to be given by either of the parties hereto, unless otherwise stated in this agreement, shall be in writing and be

deemed communicated when mailed in the United States mail, certified, return receipt requested, addressed as follows:

City of Meridian
Procurement Manager
33 E. Broadway Avenue
Meridian, Idaho 83642
Ph. (208) 489-0417
Email: kwatts@meridiancity.org

Centrisys CNP
Attn: Jerod Swanson, Sales Manager
9586 58th Place
Kenosha, WI 53144
Ph. (612) 401-2006
e-mail: jerod.swanson@centrisys.us

Either party may change their address for the purpose of this paragraph by giving written notice of such change to the other in the manner herein provided.

11. **Attorney Fees:** Should any litigation be commenced between the parties hereto concerning this Agreement, the prevailing party shall be entitled, in addition to any other relief as may be granted, to court costs and reasonable attorneys' fees as determined by a Court of competent jurisdiction. This provision shall be deemed to be a separate contract between the parties and shall survive any default, termination or forfeiture of this Agreement.
12. **Time is of the Essence:** The parties hereto acknowledge and agree that time is strictly of the essence with respect to each and every term, condition and provision hereof, and that the failure to timely perform any of the obligations hereunder shall constitute a breach of, and a default under, this Agreement by the party so failing to perform.
13. **Assignment:** It is expressly agreed and understood by the parties hereto, that SUPPLIER shall not have the right to assign, transfer, hypothecate or sell any of its rights under this Agreement except upon the prior express written consent of CITY.
14. **Discrimination Prohibited:** In performing the Work required herein, SUPPLIER shall not unlawfully discriminate in violation of any federal, state or local law, rule or regulation against any person on the basis of race, color, religion, sex, national origin or ancestry, age or disability.

15. **Reports and Information:**

15.1 At such times and in such forms as the CITY may require, there shall be furnished to the CITY such statements, records, reports, data and information as the CITY may request pertaining to matters covered by this Agreement.

15.2 SUPPLIER shall maintain all writings, documents and records prepared or compiled in connection with the performance of this Agreement for a minimum of four (4) years from the termination or completion of this or Agreement. This includes any handwriting, typewriting, printing, photo static, photographic and every other means of recording upon any tangible thing, any form of communication or representation including letters, words, pictures, sounds or symbols or any combination thereof.

16. **Audits and Inspections:** At any time during normal business hours and as often as the CITY may deem necessary, there shall be made available to the CITY for examination all of SUPPLIER'S records with respect to all matters covered by this Agreement. SUPPLIER shall permit the CITY to audit, examine, and make excerpts or transcripts from such records, and to make audits of all contracts, invoices, materials, payrolls, records of personnel, conditions of employment and other data relating to all matters covered by this Agreement.

17. **Publication, Reproduction and Use of Material:** No material produced in whole or in part under this Agreement shall be subject to copyright in the United States or in any other country. The CITY shall have unrestricted authority to publish, disclose and otherwise use, in whole or in part, any reports, data or other materials prepared under this Agreement.

18. **Compliance with Laws:** In performing the scope of work required hereunder, SUPPLIER shall comply with all applicable laws, ordinances, and codes of Federal, State, and local governments.

19. **Changes:** The CITY may, from time to time, request changes in the Scope of Work to be performed hereunder. Such changes, including any increase or decrease in the amount of SUPPLIER'S compensation, which are mutually agreed upon by and between the CITY and SUPPLIER, shall be incorporated in written amendments which shall be executed with the same formalities as this Agreement.

20. **Construction and Severability:** If any part of this Agreement is held to be invalid or unenforceable, such holding will not affect the validity or enforceability of any other part of this Agreement so long as the remainder of the Agreement is reasonably capable of completion.
21. **Waiver of Default:** Waiver of default by either party to this Agreement shall not be deemed to be waiver of any subsequent default. Waiver or breach of any provision of this Agreement shall not be deemed to be a waiver of any other or subsequent breach, and shall not be construed to be a modification of the terms of this Agreement unless this Agreement is modified as provided above.
22. **Advice of Attorney:** Each party warrants and represents that in executing this Agreement. It has received independent legal advice from its attorney's or the opportunity to seek such advice.
23. **Entire Agreement:** This Agreement contains the entire agreement of the parties and supersedes any and all other agreements or understandings, oral or written, whether previous to the execution hereof or contemporaneous herewith.
24. **Order of Precedence:** The order or precedence shall be this Agreement, the Technical Specifications, I.C. Drawings, and the suppliers proposal #06638 dated June 18, 2021.
25. **Applicable Law:** This Agreement shall be governed by and construed and enforced in accordance with the laws of the State of Idaho, and the ordinances of the City of Meridian.
26. **Approval Required:** This Agreement shall not become effective or binding until approved by the City of Meridian.

CITY OF MERIDIAN

BY: _____
Keith Watts, Procurement Manager

Dated: _____

CENTRISYS CNP

BY: _____


Dated: 07/20/2021

Approved by City Council: _____

Attachment A

SCOPE OF WORK

- TECHNICAL SPECIFICATIONS by Carollo Engineers, Inc.
dated 3/26/2021 (416 pages)
- Instrumentation Drawings by Mountain Waterworks, Inc.
dated January 2021 (23 pages)

Attachment B

MILESTONE / PAYMENT SCHEDULE

Total and complete compensation for this Agreement shall not exceed \$1,808,000. This price includes the optional 10,000-gallon MgCl storage tank and galvanized steel reactor platforms and handrails

MILESTONE DATES/PRICING SCHEDULE			
	DESCRIPTION	DATE (Dependent on Council Approval)	AMOUNT
1.	Contract Execution	Upon Notice-To-Proceed	\$213,900.00
2.	Receipt of Submittals	70 days from NTP	\$0.00
3.	Upon Approval of Shop Drawings	Upon Approval of Submittals*	\$213,900.00
4.	Upon Receipt and Approval of Operation & Maintenance Manuals		\$213,900.00
5.	Upon Receipt of Equipment	40 Weeks from Approval of Submittals - Upon Receipt of Equipment **	\$1,283,400.00
6.	Upon Start Up & Commissioning	Net 30 of Start Up and Commissioning	\$213,900.00
CONTRACT TOTAL.....			<u>\$2,139,000.00</u>

ALL PAYMENTS WILL BE MADE NET 30 OF RECEIPT OF INVOICE, WHICH SHALL NOT BE ISSUED PRIOR TO ACHIEVEMENT OF THE MILESTONE

* Payment will be made no later than 30 days from receipt of submittals

** LD's will begin at 40 weeks from Approval of Submittals, Payment shall not take place prior to receipt of equipment

CITY OF MERIDIAN, IDAHO
WASTEWATER RESOURCE RECOVERY FACILITY (WRRF)
SIDE STREAM TREATMENT PROJECT

CAROLLO PROJECT NO. 11700A.10

TECHNICAL SPECIFICATIONS

REACTOR PROCUREMENT SUBMITTAL
NOT FOR CONSTRUCTION

VOLUME 1 OF 1

MARCH 2021

This document is released for the purpose of information exchange review and planning only under the authority of Timothy R. Tekippe, March 2021, State of Idaho PE License No. 8572. It is not to be used for bidding, permit, or construction purposes.



CITY OF MERIDIAN, IDAHO
WASTEWATER RESOURCE RECOVERY FACILITY (WRRF)
SIDE STREAM TREATMENT PROJECT

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SECTION 01_11_00

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Detailed description of the Work for the Supply of Phosphorous Precipitation System Reactors and related equipment.

1.02 THE WORK

- A. The Work consists of supply of equipment for the Phosphorous Precipitation System as described in Section 46_63_83, including submittals, equipment, programming, start-up, and commissioning services, spare parts, and coordination with the Contractor during installation. Phosphorous Precipitation System will be installed by Contractor.

1.03 LOCATION OF PROJECT

- A. The Work is located at the Meridian Wastewater Resource Recovery Facility, 3401 N. Ten Mile Road, Meridian, ID 83646.

1.04 RESPONSIBLE PARTIES

- A. The following defines the responsible parties associates with the Project:
 - 1. Owner: City of Meridian, Idaho.
 - 2. Contractor: The future building contractor will be determined pending bidding by Owner. However, for the purposes of these pre-purchase specifications, "Contractor" shall mean the same as "Supplier".
 - 3. Engineer: Carollo Engineers, Inc.
 - 4. Supplier: CNP Technology Water and Biosolids Corp.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01_33_00
SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Requirements and procedures for submittals.

1.02 DEFINITIONS

- A. Certificates: Describe certificates that document affirmations by the Contractor or other entity that the work is in accordance with the Contract Documents.
- B. Extra stock materials: Describe extra stock materials to be provided for the Owner's use in facility operation and maintenance.
- C. Maintenance material submittals: Use this article to categorize maintenance materials submittals requiring no Engineer action other than confirmation of receipt under an explanatory heading.
- D. Manufacturer's instructions: Instructions, stipulations, directions, and recommendations issued in printed form by the manufacturer of a product addressing handling, installation, erection, and application of the product; manufacturer's instructions are not prepared especially for the Work.
- E. Product data: Product data usually consists of manufacturers' printed data sheets or catalog pages illustrating the products to be incorporated into the project.
- F. Samples: Samples are full-size actual products intended to illustrate the products to be incorporated into the project. Sample submittals are often necessary for such characteristics as colors, textures, and other appearance issues.
- G. Spare parts: Describe spare parts necessary for the Owner's use in facility operation and maintenance; identify the type and quantity here, but include the actual characteristics of the spare parts in Product as part of the specification of the product.
- H. Shop drawings: Shop drawings are prepared specifically for the project to illustrate details, dimensions, and other data necessary for satisfactory fabrication or construction that are not shown in the contract documents. Shop drawings could include graphic line-type drawings, single-line diagrams, or schedules and lists of products and their application.
- I. Submittals: Submittals are samples, product data, shop drawings, and others that demonstrate how Contractor intends to conform with the Contract Documents.
- J. Tools: Tools are generally defined as items such as special wrenches, gauges, circuit setters, and other similar devices required for the proper operation or maintenance of a system that would not normally be in the Owner's tool kit.

1.03 GENERAL INSTRUCTIONS

- A. Provide submittals that are specified or reasonably required for construction, operation, and maintenance of the Work.
- B. Provide submittal information from only 1 manufacturer for a specified product, unless otherwise approved by Engineer.
- C. Where multiple submittals are required, provide a separate submittal for each specification section.
 - 1. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
 - 2. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section.
- D. For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.
- E. Edit all submittals so that the submittal specifically applies to only the equipment furnished. Neatly cross out all extraneous text, options, models, etc., that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
- F. Prepare submittals in the English language. Do not include information in other languages.
- G. Present measurements in customary American units (feet, inches, pounds, etc.).
- H. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
- I. Indicate project designated equipment tag numbers from P&IDs for submittal of devices, equipment, and assemblies.
- J. Submittals shall be provided in electronic media format:
 - 1. General: Provide all information in PC-compatible format using Windows® operating system.
 - 2. Text: Provide text documents and manufacturer's literature using current version of Adobe® Acrobat® (i.e., PDF extension).
 - 3. Graphics: Provide all graphic submittals (drawings, diagrams) utilizing current version of Adobe® Acrobat® (i.e., PDF extension).
 - 4. Supplier using other software shall be required to provide conclusive evidence of 100 percent data transfer compatibility that is an equal to PDF format.

1.04 SUBMITTAL ORGANIZATION

- A. Fully indexed electronic submittal with a tabbed divider for every component.
- B. Sequentially number pages within the tabbed sections:
 - 1. Submittals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.

- C. Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
- D. For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is used.
- E. Consolidate electronic format submittals with multiples pages into a single file.

1.05 SUBMITTAL COVER SHEETS

- A. Submittal Transmittal Form is provided in Appendix A of this Section.
 - 1. Contractor submittal transmittal form is acceptable provided that it includes information, statements, and certifications comparable to the Submittal Transmittal Form.
 - 2. Submittal Number Field: Required submittal numbering format (unless other format approved by Owner and Engineer): Section number-sequential number-resubmittal number:
 - a. Example: 03_20_00-002-1:
 - 1) "03_20_00" indicates the affected specification is Section 03_20_00.
 - 2) "002" indicates the second submittal under this Section.
 - 3) "1" indicates the first resubmittal of the Submittal.
 - b. Contractor may add a separate numbering scheme for Contractor's internal use. However, all correspondence with Engineer must include the required submittal numbering.
 - 3. "From" Field: Provide name and address of company responsible for preparation of submittal. This could be General Contractor, subcontractor, supplier, manufacturer, etc.
 - 4. "General Contractor Reviewer" Field: Verify that the General Contractor has reviewed the submittal by signature.
- B. Contractor sign and date submittals indicating review and approval:
 - 1. Signature indicates Contractor certifies that they have satisfied submittal review responsibilities and constitutes Contractor's written approval of submittal. Contractor shall note that the submittal complies with the Specification Section.
- C. Attachments:
 - 1. Specification section deviations:
 - a. Provide a list of all numbered deviations, with reference to Specification Section and pertinent paragraph, with a clear explanation and reason for the deviation.
 - 2. Drawings deviations:
 - a. Provide a list of all numbered deviations, with reference to specific Drawing, with a clear explanation and reason for the deviation. Provide field dimensions and relationship to adjacent or critical features of the Work or materials.
- D. Contractor: Prepare submittal information in sufficient detail to show compliance with specified requirements.
 - 1. Determine and verify quantities, field dimensions, product dimensions, specified design and performance criteria, materials, catalog numbers, and similar data.

2. Coordinate submittal with other submittals and with the requirements of the Contract Documents.
3. Check, verify, and revise submittals as necessary to bring them into conformance with Contract Documents and actual field conditions.

1.06 SUBMITTAL CONTENT

- A. Shop Drawings:
 1. Contractor to field verify elevation, coordinates, and pipe material for pipe tie-in prior to the submittal of shop drawings to Owner and Engineer.
 2. Details:
 - a. Fabrication drawings: drawn to scale and dimensioned.
 - b. Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
 - c. Locations of conduit entrances and access plates.
 - d. Component layout and identification.
 - e. Weight.
 - f. Finish.
 - g. Temperature limitations, as applicable.
 - h. Nameplate information.
- B. Product Information:
 1. Product Data:
 - a. Details:
 - 1) Supplier name and address.
 - 2) Subcontractor name and address.
 - b. Include:
 - 1) Catalog cuts.
 - 2) Bulletins.
 - 3) Brochures.
 - 4) Manufacturer's Certificate of Compliance: signed by product manufacturer along with supporting reference data, affidavits, and tests, as appropriate.
 - 5) Manufacturer's printed recommendations for installation of equipment.
 - 6) Quality photocopies of applicable pages from manufacturer's documents.
 2. Completely fill out a Motor Data Sheet, as specified in Section 26_05_09, for every motor furnished:
 - a. Submit 1 copy of the Motor Data Sheet to the Engineer for review as part of the associated equipment submittal.
 3. Samples:
 - a. Details:
 - 1) Submit labeled samples.
 - 2) Samples will not be returned.
 - 3) Provide samples from manufacturer's standard colors, materials, products, or equipment lines.
 4. Minor or incidental products and equipment schedules:
 - a. Details:
 - 1) Shop Drawings of minor or incidental fabricated products will not be required, unless requested.

- 2) Submit tabulated lists of minor or incidental products showing the names of the manufacturers and catalog numbers, with Product Data and Samples as required to determine acceptability.
- C. Design calculations:
1. Details:
 - a. Defined in technical sections.
 - b. For equipment and materials designed and manufactured by a supplier and not the Engineer, calculations are required to be submitted by supplier.
 - c. Calculations must bear the original seal and signature of a Professional Engineer licensed in the state where the project is located and who provided responsible charge for the design.
- D. Qualifications Statements:
1. Details:
 - a. Defined in technical sections.
 - b. Licensing documentation.
 - c. Certification documentation.
 - d. Education documentation.
- E. Quality assurance/control submittals:
1. Mill test reports:
 - a. Details:
 - 1) Submit certified copies of factory and mill test reports.
 - 2) Do not incorporate Products in the Work which have not passed testing and inspection satisfactorily.
 2. Test reports:
 - a. Details:
 - 1) Include the following information:
 - a) A description of the test.
 - b) List of equipment used.
 - c) Name of the person conducting the test.
 - d) Date and time the test was conducted.
 - e) Ambient temperature and weather conditions.
 - f) All raw data collected.
 - g) Calculated results.
 - h) Clear statement if the test passed or failed the requirements stated in Contract Documents.
 - i) Signature of the person responsible for the test.
 3. Factory Acceptance Test:
 - a. Details: Include complete test procedure and all forms to be used during test.
 4. Certificates:
 - a. Details: Defined in technical sections.
 5. Manufacturers' field reports:
 - a. Details: Manufacturer's Certificate of installation and functionality compliance.
 6. Field samples:
 - a. Details: Defined in technical sections.
 7. Test plans:
 - a. Details: Defined in technical sections.

1.07 SUBMITTAL PROCEDURE

- A. Contractor: Send submittal to Engineer.
 - 1. Delivery: Deliver submittals to Engineer.
 - 2. Timeliness: Schedule and make submissions in accordance with the requirements of the individual specification sections and in such a sequence as to cause no delay in Work.
- B. Engineer: Review submittal and provide response.
 - 1. Review description:
 - a. Engineer will be entitled to rely upon the accuracy or completeness of designs, calculations, or certifications made by licensed professionals accompanying a particular submittal whether or not a stamp or seal is required by Contract Documents or Laws and Regulations.
 - b. Engineer's review of submittals shall not release Contractor from Contractor's responsibility for performance of requirements of Contract Documents. Neither shall Engineer's review release Contractor from fulfilling purpose of installation nor from Contractor's liability to replace defective work.
 - c. Engineer's review of shop drawings, samples, or test procedures will be only for conformance with design concepts and for compliance with information given in Contract Documents.
 - d. Engineer's review does not extend to:
 - 1) Accuracy of dimensions, quantities, or performance of equipment and systems designed by Contractor.
 - 2) Contractor's means, methods, techniques, sequences, or procedures except when specified, indicated on the Drawings, or required by Contract Documents.
 - 3) Safety precautions or programs related to safety which shall remain the sole responsibility of the Contractor.
 - e. Engineer can Approve or Not Approve any exception at their sole discretion.
 - 2. Review timeframe:
 - a. Except as may be provided in technical specifications, a submittal will be returned within 10 work days.
 - b. When a submittal cannot be returned within the specified period, Engineer will, within a reasonable time after receipt of the submittal, give notice of the date by which that submittal will be returned.
 - 3. Schedule delays:
 - a. No adjustment of Contract Times or Contract Price will be allowed due to Engineer's review of submittals, unless all of the following criteria are met:
 - 1) Engineer has failed to review and return first submission within the agreed upon time frame.
 - 2) Contractor demonstrates that delay in progress of Work is directly attributable to Engineer's failure to return submittal within time indicated and accepted by Engineer.
 - 4. Review responses: 1 copy of submittal will be returned to Contractor with one of the following reviewer's response.
 - a. Approved:
 - 1) No Exceptions:
 - a) There are no notations or comments on the submittal and the Contractor may release the equipment for production.

- 2) Make Corrections Noted - See Comments:
 - a) The Contractor may proceed with the work, however, all notations and comments must be incorporated into the final product.
 - b) Resubmittal not required.
- 3) Make Corrections Noted - Confirm:
 - a) The Contractor may proceed with the work, however, all notations and comments must be incorporated into the final product.
 - b) Submit confirmation specifically addressing each notation or comment to the Engineer within 15 calendar days of the date of the Engineer's transmittal requiring the confirmation.
- b. Not approved:
 - 1) Correct and Resubmit:
 - a) Contractor may not proceed with the work described in the submittal.
 - b) Contractor assumes responsibility for proceeding without approval.
 - c) Resubmittal of complete submittal package is required within 15 calendar days of the date of the Engineer's submittal review response.
 - 2) Rejected - See Remarks:
 - a) Contractor may not proceed with the work described in the submittal.
 - b) The submittal does not meet the intent of the Contract Documents. Resubmittal of complete submittal package is required with materials, equipment, methods, etc. that meet the requirements of the Contract Documents.
- c. Receipt Acknowledged: Filed for Record:
 - 1) This is used in acknowledging receipt of informational submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc.

C. Contractor: Prepare resubmittal, if applicable.

1. Clearly identify each correction or change made.
2. Include a response in writing to each of the Engineer's comments or questions for submittal packages that are resubmitted in the order that the comments or questions were presented throughout the submittal.
 - a. Acceptable responses to Engineer's comments are listed below:
 - 1) "Incorporated" Engineer's comment or change is accepted and appropriate changes are made.
 - 2) "Response" Engineer's comment not incorporated. Explain why comment is not accepted or requested change is not made. Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
 - b. Reviews and resubmittals:
 - 1) Suppliers shall provide resubmittals which include responses to all submittal review comments separately and at a level of detail commensurate with each comment.
 - 2) Supplier responses shall indicate how the supplier resolved the issue pertaining to each review comment. Responses such as "acknowledged" or "noted" are not acceptable.

- 3) Resubmittals which do not comply with this requirement may be rejected and returned without review.
 - 4) Contractor shall be allowed no extensions of any kind to any part of their contract due to the rejection of non-compliant submittals.
 - 5) Submittal review comments not addressed by the Contractor in resubmittals 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.
- c. Any resubmittal that does not contain responses to the Engineer's previous comments shall be returned for Revision and Resubmittal. No further review by the Engineer will be performed until a response for previous comments has been received.
3. Resubmittal timeframe:
 - a. Contractor shall provide resubmittal within 15 days.
 - b. When a resubmittal cannot be returned within the specified period, Contractor shall notify Engineer in writing.

1.08 SUPPLIER'S PROFESSIONAL ENGINEER (P.E.) CERTIFICATION FORM

- A. Submit a completed Supplier's P.E. Certification Form, provided in this Section, to comply with technical sections requirement for a professional engineer's certification for design of the anchor bolts from an engineer licensed in the state the project is located.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

APPENDIX A
CONTRACTOR SUBMITTAL TRANSMITTAL FORM

DOCUMENT 01_33_00
CONTRACTOR SUBMITTAL TRANSMITTAL FORM

Owner: _____ **Date:** _____

Contractor: _____ **Project No.:** _____

Project Name: _____ **Submittal Number:** _____

Submittal Title: _____

To: _____

From: _____

Specification No. and Subject of Submittal / Equipment Supplier	
Spec ##:	Subject:
Authored By:	Date Submitted:

Submittal Response
Check Either (A) or (B): ☐ (A) We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings with no exceptions. ☐ (B) We have verified that the equipment or material contained in this submittal meets all the requirements specified in the project manual or shown on the contract drawings except for the following deviations (list deviations):
Certification Statement: By this submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and I have checked and coordinated each item with other applicable approved shop drawings and all Contract requirements.
General Contractor's Reviewer's Signature:
Printed Name:
In the event, Contractor believes the Submittal response does or will cause a change to the requirements of the Contract, Contractor shall immediately give written notice stating that Contractor considers the response to be a Change Order.
Firm: Signature: Date Returned:

PM/CM Office Use
Date Received GC to PM/CM: _____
Date Received PM/CM to Reviewer: _____
Date Received Reviewer to PM/CM: _____
Date Sent PM/CM to GC: _____

APPENDIX B

SUPPLIER'S P.E. CERTIFICATION FORM

DOCUMENT 01_33_00
SUPPLIER'S P.E. CERTIFICATION FORM

Owner: _____ **Date:** _____
Contractor: _____ **Registration State:** _____
Project Name: _____ **Project No.:** _____
Responsibilities: _____
Spec Section: _____

Statement of Certification

The undersigned hereby certifies that he/she is a professional engineer registered in the State of _____ and that he/she has been employed by _____

The undersigned further certifies that he/she has performed the said design in conformance with all applicable local, state, and federal codes, rules, and regulations; and, that his/her signature and P.E. stamp have been affixed to all calculation and drawings used in, and resulting from, the design.

The undersigned hereby agrees to make all original design drawings and calculations available to: _____

(Name of Owner, or Owner's representative within 7 days of receiving a written request by the Owner.)

Prof. Engineer
Signature: _____ **Date:** _____

Printed Name: _____ **Company Name:** _____

Contractor's
Signature: _____ **Date:** _____

Printed Name: _____

SECTION 01_75_17

COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Requirements for each Commissioning phase of the equipment/system.
- B. Related sections:
 - 1. Section 01_78_23 - Operation and Maintenance Data.
 - 2. Section 40_80_01 - Testing, Calibration, and Commissioning.

1.02 DEFINITIONS

- A. Clean Water Facility Testing – Testing of complete facility utilizing clean water for purposes of confirming extended equipment/system operation prior to Process Start-up Phase.
- B. Commissioning – The process of planning, testing, and process start-up of the installation for compliance with contract requirements and demonstrating, through documented verification, that the project has successfully met the Contractual requirements. It includes training the Owner's staff to operate the facility.
- C. Commissioning Phases – The work activities of facility commissioning are grouped into the phases defined in the table below.

<u>Commissioning</u>		
<u>Planning Phase</u>	<u>Testing and Training Phase</u>	<u>Process Start-Up Phase</u>
Owner Training Plan and Schedule	Source Testing	Process Start-up
Subsystem Testing Plan	Owner Training	Process Operational Period
Clean Water Facility Testing Plan	Installation Testing	
	Functional Testing	
	Clean Water Facility Testing	
	Closeout Documentation	

- D. Component – A basic building block of equipment, subsystems, and systems that requires installation or functional testing but does not have an electrical connection or internal electronics. (Examples: filter effluent piping and manual isolation valves).

- E. Device – A basic building block of equipment, subsystems, and systems that requires installation or functional testing and does have an electrical connection or internal electronics. (Examples: filter level transmitter or water pump pressure transmitter).
- F. Equipment – An assembly of component(s) and devices(s) that requires installation or functional testing. (Examples: Pump, motor, VFD, Ozone Generator, UV Disinfection System, etc.).
- G. Facility – A grouping of process areas, systems, subsystems, equipment, components, and devices (Examples: treatment plant, pump station, etc.).
- H. Functional Testing – Testing performed on a completed subsystem to demonstrate that equipment/system meets manufacturers' calibration and adjustment requirements and other requirements as specified. Functional testing includes operating equipment/system manually in local, manually in remote (or remote manual), and automatically in remote (in remote auto).
- I. Installation Testing – Testing to demonstrate that subsystem component (piping, power, networks, devices, etc.) is ready and meets the project requirements in advance of functional testing. Installation testing also includes manufacturers' certification of installation and other requirements as specified to prepare equipment/system for Functional Testing. Also referred to as Field Acceptance Testing.
- J. Instrumentation and Controls Fine-Tuning – Improving the performance of the Instrumentation Process Control system by operating for an extended time period.
- K. Manufacturer's Certificate of Source Testing – When applicable, the form is used during Source Testing for the manufacturer to confirm that the applicable source tests have been performed and results conform to the Contract Documents. The form is provided at the end of this Section.
- L. Manufacturer's Certificate of Installation and Functionality Compliance – The form is used during Installation Testing and Functional Testing. It is submitted at the end of Functional Testing to confirm that the equipment/system is installed in conformance with the Contract Documents and that it meets the Functional Testing requirements defined in the Contract Documents. The form is provided at the end of this Section.
- M. Process Area – A grouping of systems, subsystems, equipment, components, and devices that divide a facility into functional areas. (Examples: Filter Process Area or Chemical Area).
- N. Process Operational Period – A period of time after completion of the process start-up set aside for final Operational Testing to verify facility performance meets the Contract Document requirements. This period may specifically limit other construction activities.
- O. Process Start-up Phase - Operating the facility to verify performance meets the Contract Document requirements.
- P. Process Start-Up – Activities conducted after the testing and training phase that are necessary to place systems or process areas into operational service.

- Q. Product – A system, subsystem, or component.
- R. Subsystem – A building block of systems made up from a grouping of components, devices, and equipment that perform a definable function. (Examples: Filter No. 1 Backwash Subsystem, Sedimentation Basin No. 1 Hoseless Sludge Removal Subsystem).
- S. System – A grouping of subsystems, equipment, components, and devices that perform a definable function. (Examples: Filter No. 1, Sedimentation Basin).

1.03 COMMISSIONING COORDINATION (CC)

- A. Contractor, Supplier, Owner and Resident Engineer shall coordinate to provide commissioning coordination for the Project.

1.04 SERVICES OF MANUFACTURER'S REPRESENTATIVES

- A. Qualification of manufacturer's representative as specified in the Contract Documents technical Sections include the following:
 - 1. Authorized representative of the manufacturer, factory trained and experienced in the technical applications, installation, operation, and maintenance of respective equipment/system with full authority by the equipment/system manufacturer to issue the certifications required of the manufacturer.
 - 2. Competent, experienced technical representatives of equipment/system manufacturer for assembly, installation, testing guidance, and training.
 - 3. Additional qualifications may be specified in the individual Sections.
 - 4. Submit qualifications of the manufacturer's representative no later than 30 days in advance of required observations.
 - 5. Representative subject to approval by Owner and Engineer.
 - 6. No substitute representatives will be allowed until written approval by Owner and Engineer has been obtained.
- B. Completion of manufacturer on-site services: Engineer approval required.
- C. Manufacturer is responsible for determining the time required to perform the specified services.
 - 1. Minimum times specified in the Contract Documents are estimates.
 - 2. No additional costs associated with performing the required services will be approved.
 - 3. Manufacturer required to schedule services in accordance with the Contractor's project schedule up to and including making multiple trips to project site when there are separate milestones associated with installation of each occurrence of manufacturer's equipment.
- D. Manufacturer's on-site services as specified in the Contract Documents include the following:
 - 1. Assistance during Commissioning Phase and Process Start-Up Phase.
 - 2. Upon request, provide daily copies of manufacturer's representatives' field notes and data to Engineer.
 - 3. Other requirements as specified in the Contract Documents.

1.05 PLANNING PHASE

- A. Overview of Planning Phase:
 - 1. Defines approach and timing for Commissioning.
- B. Owner training plan and schedule:
 - 1. Training outcomes:
 - a. Owner's operations, maintenance, and engineering staff have the information needed to safely operate, maintain, and repair the equipment/systems provided under this Contract.
 - 2. Training objectives:
 - a. To instruct personnel in the operation and maintenance of the equipment/system. Instruction shall include step-by-step troubleshooting procedures with all necessary test equipment/system.
 - b. To instruct personnel in the removal, inspection, and cleaning of equipment/system as needed.
 - c. Training tailored to the skills and job classifications of the staff attending the classes (e.g., plant superintendent, treatment plant operator, maintenance technician, electrician, etc.).
 - d. Provide supporting documentation, such as vendor operation and maintenance manuals.
 - 3. Training schedule:
 - a. Schedule Owner's staff training within the constraints of their workloads. Those who will participate in this training have existing full-time work assignments, and training is an additional assigned work task, therefore, scheduling is imperative. Operator training shall occur between 7:00 a.m. and 3:30 p.m., Monday through Friday. Maintenance staff training shall occur between 7:00 a.m. and 4:30 p.m. Monday through Thursday.
 - 4. Training plan:
 - a. Coordinate and arrange for manufacturer's representatives to provide both classroom-based learning and field (hands-on) training, based on training module content and stated learning objectives.
 - b. Conduct classroom training at location designated by Owner.
 - c. Scope and sequence:
 - 1) Plan and schedule training in the correct sequence to provide prerequisite knowledge and skills to trainees.
 - a) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.
 - 5. Training scheduling coordination:
 - a. Complete Owner training no sooner than 21 calendar days prior to start of process start-up of each system.
 - 6. Meetings:
 - a. Commissioning progress meetings will be held between Owner, Contractor, Supplier and Resident Engineer throughout construction, to plan, scope, coordinate, and schedule future activities, resolve problems, etc.:
 - 1) Frequency: Monthly minimum. Increase frequency as needed based on complexity and quantity of commissioning activities.
 - 7. Training sessions:
 - a. Provide training sessions for equipment/system as specified in the individual equipment/system Section.

- b. Submit Commissioning Schedule not less than 30 calendar days prior to planned initial commissioning of each subsystem or system.
 - 8. Schedule requirements:
 - a. With input from Supplier, building contractor shall provide detailed schedule of commissioning activities including durations and sequencing requirements:
 - 1) Identify the following activities:
 - a) Testing and Training Phase:
 - (1) Source Testing.
 - (2) Owner Training.
 - (3) Installation Testing.
 - (4) Functional Testing.
 - (5) Clean Water Facility Testing.
 - (6) Closeout Documentation.
 - b) Process Start-Up Phase:
 - (1) Process Start-Up.
 - (2) Process Operational Period.
 - (3) Instrumentation and Controls Fine-Tuning.
 - b. Schedule manufacturer's services to avoid conflict with other on-site testing or other manufacturers' on-site services.
 - c. Verify that conditions necessary to allow successful testing have been met before scheduling services.

C. Subsystem testing plans (by Supplier):

- 1. Provide separate testing plans for each individual subsystem and system that include the following:
 - a. Approach to testing including procedures, schedule, and recirculation requirements.
 - b. Test objective: Demonstrate subsystem meets the design requirements as specified in the technical Sections.
 - c. Test descriptions, forms, temporary systems (pumps, piping, etc.), shutdown requirements for existing systems, test forms, test logs, witness forms, and checklists to be used to control and document the required tests.
 - d. Test forms: Include, but not limited to, the following information:
 - 1) Tag and name of equipment/system to be tested.
 - 2) Test date.
 - 3) Names of persons conducting the test.
 - 4) Names of persons witnessing the test, where applicable.
 - 5) Test data.
 - 6) Applicable project requirements.
 - 7) Check offs for each completed test or test step.
 - 8) Place for signature of person conducting tests and for the witnessing person, as applicable.
 - e. Define start-up sequencing of unit processes:
 - 1) Include testing of alarms, interlocks, permissives, control circuits, capacities, speeds, flows, pressures, vibrations, sound levels, and other parameters.
 - 2) Provide detailed test procedures setting forth step-by-step descriptions of the procedures for systematic testing of equipment/system.

- 3) Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration:
 - a) Perform initial checks in the presence of and with the assistance of the manufacturer's representative.
- 4) Demonstrate proper operation of each control loop function including mechanical, electrical, alarms, local and remote controls, instrumentation, and other equipment/system functions:
 - a) Generate signals with test equipment/system to simulate operating conditions in each control mode.
2. Engineer approval of test plan is required prior to performing test:
 - a. Revise and update test plans based on review comments, actual progress, or to accommodate changes in the sequence of activities.
 - b. Submit test reports for each phase of testing for each equipment/system.
 - c. Engineer approval of preceding test reports is required prior to start of next test.
 - d. Tests will be rescheduled if test plan is not approved by the required deadline.
3. Contractor is responsible to reproduce and distribute final test procedures.
- D. Clean Water Facility Testing Plan (by building contractor, with input from Supplier):
 1. Submit a Clean Water Facility Testing Plan equivalent to the requirements of the subsystem test plans a minimum of 30 calendar days prior to Clean Water Facility Testing. Clean water may be non-potable plant water if acceptable to Owner.

1.06 TESTING AND TRAINING PHASE

- A. Overview of Testing And Training Phase:
 1. General:
 - a. Include specified Source Testing, Owner Training, Installation Testing, Functional Testing, Clean Water Facility Testing, and Closeout Documentation required by this Section and the technical Sections.
 2. Contractor responsibilities:
 - a. Prior to testing, verify equipment protective devices and safety devices have been installed, calibrated, and tested.
 - b. Acceptable tests: Demonstrate the equipment/system performance meets the requirements stated in the Contract Documents:
 - 1) When the equipment/system fails to meet the specified requirements, perform additional, more detailed, testing to determine the cause, correct, repair, or replace the causative components and repeat the testing that revealed the deficiency.
- B. Source testing:
 1. Also referred to as factory testing or factory acceptance testing (FAT).
 2. Test components, devices, and equipment/system for proper performance at point of manufacture or assembly as specified in the technical Sections.
 3. Notify the Engineer in writing when the equipment/system is ready for source inspection and testing.
 4. Source Test Plan:
 - a. As specified in this Section and other technical Sections.
 - b. Source testing requirements as specified in technical Sections:
 - 1) Non-witnessed: Provide Manufacturer's Certificate of Source Testing.

- 2) Witnessed: 1 Owner's representative and 1 Engineer's representative present during testing, unless otherwise specified, and provide Manufacturer's Certificate of Source Testing.
- c. Prepared by Contractor as a result of discussions and planning emerging from regularly conducted commissioning meetings for source tests as specified in the Contract Documents.
- d. Provide the following items for each Source Test (unless determined by Contractor, Owner and Engineer that level of equipment complexity does not warrant all of the following source test plan elements; source plan requirements tailored to level of equipment complexity):
 - 1) Purpose and goals of the test.
 - 2) Identification of each item of equipment/system, including system designation, location, tag number, control loop identifier, etc.
 - 3) Description of the pass/fail criteria that will be used.
 - 4) Listing of pertinent reference documents (Contract Documents and industry standards or Sections applicable to the testing).
 - 5) Complete description, including drawings or photographs, of test stands and/or test apparatus.
 - 6) Credentials of test personnel.
 - 7) Descriptions of test equipment to be used, product information, and all appropriate calibration records for the test equipment.
 - 8) Test set-up procedures.
 - 9) Detailed step-by-step test procedures:
 - a) The level of detail shall be sufficient for the Resident Engineer and Contractor to be able to follow the steps and develop confidence that the tests were being performed as planned.
 - b) All steps are significant, and all steps shall be included in the procedures.
 - 10) Sample data logs and data recording forms.
 - 11) Sample computations or analyses with the results in the same format as the final report to demonstrate how data collected will be used to generate final results:
 - a) Complete disclosure of the calculation methodologies.
 - b) Include a sample for each type of computation required for the test and analysis of the results.
 - 12) Detailed outline of the Source Test report.
 - 13) Sample test reports.
- e. Submit Source Test Plan and forms as specified in the technical Sections:
 - 1) Submit a copy of the Source Test Plan at least 21 days before any scheduled test date.
 - 2) Engineer approval of Source Test Plan required prior to beginning source testing.
 - 3) Schedule the testing after approval of the test procedures submittal.
- f. Indicate the desired dates for source inspection and testing.
 - 1) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.
5. Test results:
 - a. Prepare and submit test results with collected data attached.
6. Owner is responsible for costs associated with Owner's representatives witnessing Source Tests, if required by the equipment specification.
7. Contractor is responsible for providing fuel, chemicals, and other consumables needed for Source Testing.

- C. Owner training:
1. Training instruction format:
 - a. The training for operations and maintenance personnel shall be provided as one entity.
 - b. Instructors shall apply adult education best practices, emphasizing learner participation and activity.
 - c. Training delivery may include problem solving, question/answer, hands-on instruction, practice, evaluation/feedback tools, and lecture.
 - d. Visual aids and hands-on practice sessions must support training objectives.
 - e. Lecturing should be less than 30 percent of class time.
 - f. Conduct hands-on instruction according to the following descriptions:
 - 1) Present hands-on demonstrations of at least the following tasks:
 - a) Proper start-up, shutdown, and normal and alternative operating strategies.
 - b) Common corrective maintenance repairs for each group.
 - c) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.
 - 2) Use tools and equipment provided by manufacturer to conduct the demonstrations:
 - a) Submit requests for supplemental assistance and facilities with the Contractor's proposed lesson plans.
 - 3) Contractor remains responsible for equipment disassembly or assembly during hands-on training situations involving equipment disassembly or assembly by Owner's personnel:
 - a) Provide written certification of proper equipment/system operation to Engineer after completion of hands-on training.
 2. Class agenda:
 - a. Include the following information in the agenda:
 - 1) Instructor name.
 - 2) Listing of subjects to be discussed.
 - 3) Time estimated for each subject.
 - 4) Allocation of time for Owner staff to ask questions and discuss the subject matter.
 - 5) List of documentation to be used or provided to support training.
 - b. Owner may request that particular subjects be emphasized and the agenda be adjusted to accommodate these requests.
 - c. Distribute copies of the agenda to each student at the beginning of each training class.
 3. Number of students:
 - a. Estimated maximum class size: 15 persons:
 - 1) Owner will determine the actual number of students.
 - 2) Engineer will provide an estimated headcount 1 week prior to the class, so that the instructor can provide the correct number of training aids for students.
 4. Instructor qualifications:
 - a. Provide instructors completely knowledgeable in the equipment/system for which they are training.
 - b. Provide instructor's technical preparation and instructional technology skills and experience.

- c. Sales representatives are not qualified instructors unless they possess the detailed operating and maintenance knowledge required for proper class instruction.
 - d. If, in the opinion of the Owner, an appropriately knowledgeable person did not provide the scheduled training, such training shall be rescheduled and repeated with a suitable instructor.
- 5. Training aids:
 - a. Instructors are encouraged to use audio-visual devices, P&IDs, models, charts, and so forth to increase the transfer of knowledge.
 - b. Owner shall provide such equipment (televisions, video recorder/player, computer, projectors, screens, easels, etc.) for each class.
 - c. Instructor is responsible for confirming with Engineer and Owner in advance of each class that the classroom will be appropriate for the types of audiovisual equipment to be employed.
- 6. Classroom documentation:
 - a. Trainees will keep training materials and documentation after the session.
 - b. Operations and maintenance manuals, as specified in technical Sections:
 - 1) Provide a minimum of 2 copies of final Engineer-approved operations and maintenance manuals as specified in Section 01_78_23 for use during the classroom instruction.
 - 2) Owner reserves the right to delay training for a particular equipment item if the operations and maintenance manuals for that equipment are incomplete, inaccurate, or otherwise unsuitable for use by the Owner's staff.
 - 3) No contract extensions or extra costs will be allowed for training delays due to operations and maintenance manual submittal delays.
 - 4) Owner may waive requirement to have operations and maintenance manuals provide prior to training.
 - c. Provide supplemental documentation handouts to support instruction.
 - d. Training modules:
 - 1) Provide a training module for each equipment category.
 - 2) Divide each training module's instructional content into discrete lesson plans.
 - e. Lesson plans:
 - 1) Provide performance-based learning objectives.
 - 2) State learning objectives in terms of what the trainees will be able to do at the end of the lesson.
 - 3) Define student conditions of performance and criteria for evaluating instructional success:
 - a) Provide the following information:
 - 4) Instruction lesson plan outlines for each craft:
 - a) Provide specific components and procedures.
 - 5) Minimum requirements:
 - a) Hands-on demonstrations planned for the instructions.
 - b) Cross-reference training aids.
 - c) Planned training strategies such as whiteboard work, instructor questions, and discussion points or other planned classroom or field strategies.
 - d) Attach handouts cross-referenced by section or topic in the lesson plan.
 - e) Indicate duration of outlined training segments.

- 6) Provide maintenance instruction lesson plans including mechanical, instrumentation, and electrical aspects:
 - a) Equipment operation:
 - (1) Describe equipment's operating (process) function and system theory.
 - (2) Describe equipment's fundamental operating principles and dynamics.
 - (3) Identify equipment's mechanical, electrical, and electronic components and features.
 - (4) Identify support equipment associated with the operation of subject equipment.
 - (5) Detail the relationship of each piece of equipment or component to the subsystems, systems, and process.
 - (6) Cite hazards associated with the operations, exposure to chemicals associated with the component, or the waste stream handled by the component.
 - (7) Specify appropriate safety precautions, equipment, and procedures to eliminate, reduce, or overcome hazards.
 - b) Detailed component description:
 - (1) Define Preventative Maintenance (PM) inspection procedures required on equipment in operation, spot potential trouble symptoms (anticipate breakdowns), and forecast maintenance requirements (predictive maintenance):
 - (a) Review preventive maintenance frequency and task analysis table.
 - (2) Identify each component function and describe in detail.
 - (3) Where applicable, group relative components into subsystems.
 - (4) Identify and describe in detail equipment safety features, permissive and controls interlocks.
- 7) Provide the following information in equipment troubleshooting lesson plans:
 - a) Define recommended systematic troubleshooting procedures as they relate to specific craft problems.
 - b) Provide component specific troubleshooting checklists as they relate to specific craft problems.
- 8) Provide the following information in equipment Corrective Maintenance (CM) troubleshooting lesson:
 - a) Describe recommended equipment preparation requirements as they relate to specific craft problems.
 - b) Identify and describe the use of any special tools required for maintenance of the equipment as they relate to specific craft problems.
 - c) Describe component removal/installation and disassembly/assembly procedures for specific craft repairs.
 - d) Perform at least 2 hands-on demonstrations of common corrective maintenance repairs:
 - (1) Additional demonstrations may be required by the Owner.
 - e) Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.

7. Class logistics:
 - a. Delivery time minimum: 4 hours.
 - b. Delivery time maximum: 8 hours.
 - c. Schedule specific sessions:
 - 1) Minimum of 30 days in advance to allow Owner staffing arrangements to take place.
 - 2) At the times requested by the Owner, within the period 7 a.m. to 7 p.m. Monday through Friday:
 - a) Times scheduled will be at Owner's discretion.
 - 3) Owner approval and confirmation required for session schedules.
 - 4) Provide minimum of 1 session for each class unless otherwise noted.
8. Distribute Training Evaluation Form following each training session:
 - a. Training Evaluation Form is included in this Section.
 - b. Return completed Training Evaluation Forms to Owner's designated training coordinator immediately after session is completed.
 - c. Revise training sessions judged "Unsatisfactory" by a majority of attendees:
 - 1) Conduct training sessions again until a satisfactory rating is achieved at no additional cost to Owner. The Contractor shall be responsible for all costs associated with repeated training sessions including costs for trainee time.
9. Submittals:
 - a. Prior to the training session:
 - 1) Instructor qualifications: 30 calendar days prior to initial training session.
 - 2) Training course materials: 14 calendar days prior to initial training session:
 - a) Training agenda, lesson plan, presentation, and handouts.
 - b) Other audio-visual aids utilized during each training course.
 - c) Format: Electronic submission.
 - b. Post training session:
 - 1) Training course materials: Due 14 calendar days after class completion:
 - a) Class attendance sheet.
 - b) Training agenda, final lesson plan, presentation, and handouts.
 - c) Other audio-visual aids utilized during each training course.
 - d) Provide materials for all sessions of the class in a single transmittal.
 - e) Format: 2 electronic copies and 3 hard copies organized in notebooks.

D. Installation testing:

1. Perform subsystem testing according to approved Subsystem Testing Plans.
2. Initiate the Manufacturer's Certificate of Installation and Functionality Compliance for all equipment:
 - a. Manufacturer's Certificate of Installation and Functionality Compliance form is included in this Section.
 - b. Manufacturer's Certificate of Installation and Functionality Compliance certifies the equipment meets the following requirements:
 - 1) Has been properly installed, adjusted, aligned, and lubricated.
 - 2) Is free of any stresses imposed by connecting piping or anchor bolts.
 - 3) Is able to be operated as necessary for Functional Testing.

- c. Form shall be submitted after completion of Functional Testing, as specified in this Section.
 - 3. Perform mechanical equipment Installation Testing: As specified below and in individual equipment Sections:
 - a. Remove rust preventatives and oils applied to protect equipment during construction.
 - b. Flush lubrication systems and dispose of flushing oils:
 - 1) Recharge lubrication system with lubricant recommended by manufacturer.
 - c. Install and adjust packing, mechanical seals, O-rings, and other seals. Replace defective seals.
 - d. Remove temporary supports, bracing, or other foreign objects installed to prevent damage during shipment, storage, and erection.
 - e. Check rotating machinery for correct direction of rotation and for freedom of moving parts before connecting driver.
 - f. Perform cold alignment and hot alignment to manufacturer's tolerances.
 - g. Adjust V-belt tension and variable pitch sheaves.
 - h. Inspect hand and motorized valves for proper adjustment:
 - 1) Tighten packing glands to ensure no leakage, but permit valve stems to rotate without galling.
 - 2) Verify valve seats are positioned for proper flow direction.
 - i. Tighten leaking flanges or replace flange gasket:
 - 1) Inspect screwed joints for leakage.
 - j. Install gratings, safety chains, handrails, shaft guards, and sidewalks prior to operational testing.
 - 4. Electrical devices and subsystems Installation Testing: As specified in the technical Sections.
 - 5. Instrumentation devices and subsystems Installation Testing: As specified in the technical Sections.
- E. Functional testing:
- 1. Perform subsystem testing according to approved Subsystem Testing Plan.
 - 2. Notify the Engineer 5 days prior to when the Work is ready for Functional Testing:
 - a. Perform testing in the presence of the Engineer.
 - 3. Determine Functional Testing durations with Owner's input.
 - a. Durations will vary depending on the availability of water for testing.
 - b. Target minimum Functional Test duration: 8 hours:
 - 1) Identify equipment/system that cannot be tested for a minimum of 8 hours as specified in technical Sections.
 - 4. Perform Functional Testing as specified in technical Sections.
 - a. Perform Functional Testing in addition to the other tests specified in the technical Sections.
 - b. Perform Functional Testing to demonstrate that the component equipment functions as an entire system in accordance with the design requirements.
 - c. Perform Functional Testing to demonstrate that the unit process has operated in a manner necessary to demonstrate equipment/system functions manually in local, manually in remote (or remote manual), and automatically in remote (in remote auto).
 - d. Repair or replace parts that operate improperly and retest.
 - e. Submit testing results as specified in the technical Sections to the Owner and Engineer for approval of Functional Testing results.

5. Provide completed Manufacturer's Certificate of Installation and Functionality Compliance forms for all equipment:
 - a. Manufacturer's Certificate of Installation and Functionality Compliance form is included in this Section.
 - b. Manufacturer's Certificate of Installation and Functionality Compliance certifies the equipment/system meets the following requirements:
 - 1) Is suitable for satisfactory full-time operation under full-load conditions.
 - 2) Operates within the allowable limits for vibration and noise.
 - 3) Electrical and instrumentation requirements:
 - a) Electrical equipment, instrumentation, and control panels are properly installed, calibrated, and functioning.
 - b) Electrical Installation Testing is complete, and test results have been approved by the Engineer:
 - (1) Noted deficiencies have been corrected.
 - (2) Relays, circuit breakers, and other protective devices are set.
 - c) Control logic for start-up, shutdown, sequencing, interlocks, control, and emergency shutdown has been tested and is properly functioning.
 - d) Motor control is calibrated and tested.

F. Clean Water Facility Testing:

1. Utilize non-potable plant water.
2. Do not begin Clean Water Facility Testing until Engineer has approved submittals for Functional Testing requirements.
3. Test entire facility with recirculating water supply at the design flow for the largest single process or system train to ensure proper complete facility (equipment/system) hydraulic performance.
4. Perform testing in the presence of the Engineer unless such presence is expressly waived in writing.
5. The purpose of Clean Water Facility Testing is to confirm extended equipment/system operation prior to process start-up:
 - a. Testing shall occur for a minimum of 3 days with all systems operational to the extent possible.

G. Closeout documentation:

1. Submittals:
 - a. Provide records generated during Commissioning Phase of Project:
 - 1) Required documents include but are not limited to:
 - a) Training documentation.
 - b) Manufacturer's Certificate of Source Testing.
 - c) Manufacturer's Certificate of Installation and Functionality Compliance.
 - d) Daily logs of equipment/system testing identifying tests conducted and outcome.
 - e) Test forms and documentation.
 - f) Functional Testing results.
 - g) Logs of time spent by manufacturer's representatives performing services on the job site.
 - h) Equipment lubrication records.
 - i) Electrical phase, voltage, and amperage measurements.

- j) Insulation resistance measurements.
- k) Bearing temperature measurements.

1.07 PROCESS START-UP PHASE

- A. Overview of Process Start-Up Phase:
 - 1. Operating the facility to verify performance meets the Contract Document requirements.
- B. Process Start-Up:
 - 1. Perform process start-up in the presence of the Engineer.
 - 2. Pre-start-up activities:
 - a. Commissioning Documentation and Data Review.
 - b. Start-Up Go/No-Go Decision Criteria.
 - c. Building and Fire Inspection Compliance Check.
 - d. Process Start-Up Sequence Review:
 - 1) Submit a Process Start-Up plan for review by Engineer.
 - 2) Include the following:
 - a) Pre-start-up activities.
 - b) Process Start-Up.
 - c) Process Operational Period.
 - e. Description of Temporary Testing Arrangement, if applicable.
 - f. Final Process Start-Up Forms and Documentations.
 - g. Final Operational Testing Plan.
 - 3. Control loop tuning (by Supplier):
 - a. Perform control loop tuning during system testing with water to the extent possible.
 - 4. Process area start-ups:
 - a. Process start-up individual process areas comprised of multiple interdependent systems where possible and beneficial to reduce complexity and risk of complete facility testing.
 - b. Process area test flows may be limited by upstream and downstream process constraints (i.e., tank and basin volumes) and/or localized recirculation capabilities.
 - 5. Facility-wide process start-up:
 - a. Upon approved completion of pre-start-up activities, perform entire facility process start-up:
 - 1) Supplier shall complete control loop tuning during this phase of process start-up.
 - 2) Continue process start-up operations until facility meets or exceeds the Contract requirements.
 - b. Process control systems testing:
 - 1) Test complete system instrumentation, controls and PLC, HMI, and LOI programming for the facility.
 - c. Remaining equipment/system tests:
 - 1) Conduct remaining specified equipment/system performance tests that could not be performed during the Testing and Training Phase due to inter-system and/or treatment process dependencies.
- C. Process Operational Period:
 - 1. Prior to beginning the Process Operational Period:

- a. Conformance with treatment standards is required prior to Operational Testing, if applicable.
 - b. Correct any outstanding punchlist items that are related to process operation prior to the Operational Testing.
2. Duration: 10 calendar days.
3. Engineer will be present for process operational period unless such presence is expressly waived in writing.
4. Prove facility conformance with Contract Document requirements.
5. Contractor to provide:
 - a. Specified start-up materials and operating supplies.
 - b. Necessary craft of labor assistance, in the event of an emergency equipment failure requiring immediate attention (emergency is defined as a failure of function which precludes the further operation of a critical segment of or the whole of the Work) with a response time of not more than 4 hours from the time of notification.
 - c. Manufacturer's authorized representative to supervise placing equipment/systems in operation and provide guidance during Operational Testing per applicable Section.
 - d. Necessary manufacturer's representatives and operating supplies for retesting systems that fail to pass the initial Operational Testing due to deficiencies in products of workmanship at no additional cost to the Owner.
 - e. List of 24-hour "on-call" representative supervisory persons who will monitor the Operational Testing and serve as liaison for the Engineer and Owner.
6. Owner will provide:
 - a. Operations personnel for duration of test.
 - b. Initial purchase of chemicals for Operational Period testing, meeting the anticipated chemical use stated in the Specifications. Supplier to provide any additional chemical required as a result of failed or delayed testing, at no additional cost to Owner.
7. Prior to date of Substantial Completion of Installation, the following construction coordination shall occur:
 - a. Owner staff will operate the completed Project construction.
 - b. Entire system shall continuously meet performance requirements and shall operate without fault, failure, or defect for a continuous period.
 - c. Individual equipment/system failures that are corrected within 24 hours and do not prevent the entire project from continuously satisfying the established operational requirements shall not require the consecutive day test to be restarted unless the failure recurs.
 - d. Restart the consecutive test period for any of the following conditions:
 - 1) Any failure of the complete Project construction to meet operational requirements.
 - 2) When malfunctions or deficiencies cause shutdown or partial operation of the facility, or results in failure of the complete Project construction to meet operational requirements.
 - 3) Any individual equipment/system failure that meets any of the following conditions:
 - a) Requires more than 24 hours to correct, unless otherwise specified in Section 40_80_01.
 - b) Recurs within the 24-hour correction period requiring further correction.

- 4) Immediately correct defects in material, workmanship, or equipment/system which became evident during Operational Testing.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

OWNER _____ EQPT/SYSTEM _____
PROJECT NAME _____ EQPT TAG NO. _____
PROJECT NO. _____ EQPT SERIAL NO. _____
SPECIFICATION NO. _____
SPECIFICATION TITLE _____

Comments: _____

I hereby certify Source Testing has been performed on the above-referenced equipment/system as defined in the Contract Documents, and results conform to the Contract Document requirements. Testing data is attached.

Date of Execution: _____, 20____

Manufacturer: _____

Manufacturer's Authorized Representative Name (*print*): _____

(Authorized Signature)

If applicable, Witness Name (*print*): _____

(Witness Signature)

**MANUFACTURER'S CERTIFICATE OF
INSTALLATION AND FUNCTIONALITY COMPLIANCE**

OWNER _____ EQPT/SYSTEM _____
PROJECT NAME _____ EQPT TAG NO. _____
PROJECT NO. _____ EQPT SERIAL NO. _____
SPECIFICATION NO. _____
SPECIFICATION TITLE _____

I hereby certify that the above-referenced equipment/system has been: (Check Applicable)

- ☐ Installed in accordance with manufacturer's recommendations.
- ☐ Inspected, checked, and adjusted.
- ☐ Serviced with proper initial lubricants.
- ☐ Electrical/instrumentation and mechanical connections meet quality and safety standards.
- ☐ All applicable safety equipment has been properly installed.
- ☐ Functionally tested.
- ☐ System has been performance tested, and meets or exceeds specified performance requirements.

NOTES:

Attach test results with collected data and test report.

Attach written certification report prepared by and signed by the electrical and/or instrumentation subcontractor.

Comments: _____

I, the undersigned manufacturer's representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate this equipment/system, and (iii) authorized to make recommendations required to ensure that the equipment/system furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____, 20 ____

Manufacturer: _____

Manufacturer's Authorized Representative Name (*print*): _____

By Manufacturer's Authorized Representative: _____
(Authorized Signature)

COMMISSIONING

TRAINING EVALUATION FORM

EQUIPMENT/SYSTEM ITEM: _____

VENDOR/MANUFACTURER: _____

DATE: _____ NAME OF REPRESENTATIVE: _____

1. Was representative prepared?	Acceptable	Unacceptable	or	N/A
2. Was an overview description presented?	Acceptable	Unacceptable	or	N/A
3. Were specific details presented for system components?	Acceptable	Unacceptable	or	N/A
4. Were alarm and shutdown conditions clearly presented?	Acceptable	Unacceptable	or	N/A
5. Were step-by-step procedures for starting, stopping, and troubleshooting presented?	Acceptable	Unacceptable	or	N/A
6. Were routine/preventative maintenance items clearly identified?	Acceptable	Unacceptable	or	N/A
7. Was the lubrication schedule (if any) discussed?	Acceptable	Unacceptable	or	N/A
8. Was the representative able to answer all questions?	Acceptable	Unacceptable	or	N/A
9. Did the representative agree to research and answer unanswered questions?	Acceptable	Unacceptable	or	N/A
10. Comments: _____				

11. Overall Rating:	Satisfactory	Unsatisfactory

Note:

Sessions judged "Unsatisfactory" by a majority of attendees shall be revised and conducted again until a satisfactory rating is achieved.

COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
Testing and Training Phase				
Source Testing				
1	Source Testing	Witness	Lead	Witness, Review
Installation Testing				
2	Electrical Conductor Testing	No Action	Lead	Witness
3	Electrical Field Acceptance Tests	No Action	Lead	Witness
4	Instrument Field Calibration	No Action	Lead	Witness
5	Network Installation Testing	Witness	Lead	Witness
6	Loop Testing	Witness	Lead	Witness
7	Pressure Testing	No Action	Lead	Witness
8	Leak Testing	No Action	Lead	Witness
9	Holiday Testing	No Action	Lead	Witness
10	HVAC Testing	No Action	Lead	Witness
11	Motor Electrical Testing	No Action	Lead	Witness
Functional Testing				
12	Network Operational Testing	Witness	Lead	Review
13	Preliminary Run Testing Local/Manual Control	Witness	Lead	Review
14	PCIS Functional Demonstration Testing - Local/Auto Control Testing - Remote/Manual Contact Testing - Alarm Testing - Control Loop Testing	Witness	Lead	Review
15	Subsystem Start-Up and Testing	Witness	Lead	Review
16	Equipment/System Start-Up and Testing	Witness	Lead	Review
17	HVAC Start-Up and Testing	Witness	Lead	Review
18	Corrosion Control Start-Up and Testing	Witness	Lead	Review
19	Wide Area Network Communications Testing	Support	Lead	Witness
20	Manufacturer's Certificate of Installation and Functionality Compliance	No Action	Lead	Witness, Review
Clean Water Facility Testing				
21	Test Water Management Plan Finalization	Support	Lead	Review
22	Clean Water Facility Testing	Witness	Lead	Witness, Review

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
Process Start-Up Phase				
Process Start-Up				
23	Commissioning Documentation and Data Review	Review	Lead	Review
24	Start-Up Go/No-Go Decision Criteria	Lead	Support	Review
25	Building and Fire Inspection Compliance Check	No Action	Lead	Witness
26	HVAC Functionality Check	No Action	Lead	Witness
27	Start-Up Sequence Review	Support	Lead	Review
28	Temporary Testing Arrangement Finalization	Support	Lead	Support
29	Start-Up Forms Finalization	Support	Lead	Support
30	Operation Testing Plan Finalization	Review	Support	Lead
31	Test Water Management Plan Finalization	Support	Lead	Review
32	System Testing	Support	Lead	Witness
33	Control Loop Tuning	Support	Lead	Witness
34	Process Area Start-Ups	Lead	Support	Witness
35	Facility-Wide Start-Up	Lead	Support	Witness
36	Process Control Systems Testing	Support	Lead	Witness
38	HVAC Final Testing, Adjust, and Balancing	Witness	Lead	Witness, Review
Process Operational Period				
39	Operational Testing	Support	Lead	Witness
40	Final Testing Reports	Support	Lead	Review
41	Water Quality Testing and Documentation	Support	Lead	Review
Instrumentation and Controls Reliability Phase				
Instrumentation and Controls Reliability Period				
42	As specified in Section 40_80_01			
Legend: Lead: Primarily responsible for organization, coordination, and execution of task work product or result. Support: Assist the lead with organization, coordination, and execution of task work product or result. Witness: Observe and document completion of task work product or result. Review: As necessary to accept task work product result. No Action: Limited or no involvement. Notes: Responsibilities can be modified via coordination between Owner, Contractor, and Engineer. Responsibilities are project specific.				

SECTION 01_78_23

OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Preparation and submittal of Operation and Maintenance Manuals.
- B. Related sections:
 - 1. Section 46_05_94 - Mechanical Equipment Testing.

1.02 SUBMITTALS

- A. Submit Operation and Maintenance Manuals before field quality control testing and before training of each piece of equipment or system.
- B. Submit manuals for each piece of equipment or system:
 - 1. Submit Manuals electronically until all comments from Owner and Engineer have been incorporated. Indicate section and tab divisions on electronic Manuals.
 - 2. Provide one (1) hard copy and one (1) electronic copy in .pdf format of final manuals.
 - 3. Make manuals available at project site for use by construction personnel and Owner.
 - 4. Make additions and revisions to the Manuals in accordance with Owner's review comments.

1.03 OPERATION AND MAINTENANCE MANUALS

- A. Preparation:
 - 1. Provide Operations and Maintenance Manuals in 3-ring binders with rigid covers. Utilize numbered tab sheets to organize information.
 - 2. Provide original and clear text on reproducible non-colored paper.
 - 3. Provide all dimensions in English units.
 - 4. Coordinate with Contractor to define Operations and Maintenance Manual compliance with Owner's Computer Maintenance Management System (CMMS).
- B. Contents of Operation and Maintenance Manuals:
 - 1. Cover page: Equipment name, equipment tag number, project name, Owner's name, appropriate date. Manufacturer's name, address, phone number, and email address. Local Representative's name, address, phone number, and email address. Contractor's name, address, phone number, and email address. Spare Parts Supplier name, address, phone number, and email address.
 - 2. Table of Contents: General description of information provided within each tab section.

3. Equipment Summary Form: Completed form in the format shown in Appendix A. The manufacturer's standard form will not be acceptable.
4. Instrumentation Data Sheet.
5. Information from submittal that specifically applies to that equipment – i.e., pump curves, shop drawing with final dimensions.
6. Lubrication information: Required lubricants and lubrication schedules.
7. Control diagrams:
 - a. Internal and connection wiring, including logic diagrams, wiring diagrams for control panels, ladder logic for computer-based systems, and connections between existing systems and new additions, and adjustments such as calibrations and set points for relays, and control or alarm contact settings.
 - b. Complete set of control schematics.
8. Programming: Copies of all Contractor furnished programming.
9. Start-up procedures: Recommendations for installation, adjustment, calibration, and troubleshooting.
10. Operating procedures:
 - a. Step-by-step procedures for starting, operating, and stopping equipment under specified modes of operation.
 - b. Include safety precautions and emergency operating shutdown instructions.
11. Preventative maintenance procedures: Recommended steps and schedules for maintaining equipment.
12. Overhaul instructions: Directions for disassembly, inspection, repair, and reassembly of the equipment; safety precautions; and recommended tolerances, critical bolt torques, and special tools that are required.
13. Parts list:
 - a. Complete parts list for all equipment being provided.
Catalog data for all products or equipment furnished including generic title and identification number of each component part of equipment:
 - 1) Include bearing manufacturer, model and ball or roller pass frequencies for every bearing.
14. Spare parts list: Recommended number of parts to be stored at the site and special storage precautions.
15. Drawings:
 - a. Exploded view or plan and section views with detailed callouts.
 - b. Provide electrical and instrumentation schematic record drawings.
16. Source (factory) quality control test results: Provide copies of factory test reports as specified in Section 46_05_94 or the equipment section.
17. Field quality control test results: After field-testing is completed, insert field test reports as specified in Section 46_05_94 or the equipment section.
18. Control Description and Final Start-Up checklist, plus any tests completed by the manufacturer.
19. Certificate of proper installation.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

APPENDIX A
EQUIPMENT SUMMARY FORM

1. EQUIPMENT ITEM _____
2. EQUIPMENT P&ID TAG NUMBER(S) _____
(maps equipment number)
3. LOCATION OF EQUIPMENT _____
4. Make, Model, Serial No. _____
5. NAMEPLATE DATA
Manufacturer _____

Horsepower _____

Amperage _____

Voltage _____

Service Factor (S.F.) _____

Speed _____

ENC Type _____

Capacity _____

Other _____
6. MANUFACTURER'S LOCAL REPRESENTATIVE

Manufacturer _____

Name _____

Address _____

Telephone Number _____
7. MAINTENANCE REQUIREMENTS (include page number inside O&M) _____

8. LUBRICANT LIST (include page number inside O&M) _____

9. SPARE PARTS (recommendations) (include page number inside O&M) _____

10. COMMENTS _____

SECTION 01_78_36

WARRANTIES AND BONDS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Warranty and bonds requirements.

1.02 SUBMITTALS

- A. For each item of material or equipment furnished under the Contract:
 - 1. Submit form of manufacturer's warranty prior to fabrication and shipment of the item from the manufacturer's facility.
 - 2. Submit form of manufacturer's special warranty when specified.
- B. Provide consolidated warranties and bonds within 15 calendar days of Substantial Completion:
 - 1. Contents:
 - a. Organize warranty and bond documents:
 - 1) Include Table of Contents organized by specification Section number and the name of the product or work item.
 - b. Include each required warranty and bond in proper form, with full information, are certified manufacturer as required, and are properly executed by Contractor, or subcontractor, supplier, or manufacturer.
 - c. Provide name, address, phone number, and point of contact of manufacturer, supplier, and installer, as applicable.
 - 2. Hardcopy format:
 - a. Submit 2 copies.
 - b. Assemble in 3 D-side ring binders with durable cover.
 - c. Identify each binder on the front and spine with typed or printed title "Warranties and Bonds"; Project Name or Title, and the Name Address and Telephone Number of the Contractor.
 - 3. Electronic copy in PDF format:
 - a. Submit 1 copy.

1.03 OWNER'S RIGHTS

- A. Owner reserves the right to reject warranties.
- B. Owner reserves the right to refuse to accept Work for the project if the required warranties have not been provided.

1.04 RELATIONSHIP TO GENERAL WARRANTY AND CORRECTION PERIOD

- A. Warranties specified for materials and equipment shall be in addition to, and run concurrent with, both Contractor's general warranty and the correction period requirements.

- B. Disclaimers and limitations in specific materials and equipment warranties do not limit Contractor's general warranty, nor does such affect or limit Contractor's performance obligations under the correction period.

1.05 MANUFACTURER'S WARRANTY MINIMUM REQUIREMENTS

- A. Written warranty issued by item's manufacturer.
- B. Project-specific information, properly executed by product manufacturer, and expressly states that its provisions are for the benefit of the Owner.
- C. Covers all costs associated with the correction of the defect, including but not limited to removal of defective parts, new parts, labor, and shipping:
 - 1. When correcting warranted Work that has failed, remove and replace other Work that had been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted Work.
- D. Provides a timely response to correct the defect:
 - 1. Manufacturer shall provide, in a timely fashion, temporary equipment as necessary to replace warranted items requiring repair or replacement, when warranted items are in use and are critical to the treatment process, as defined by Owner.
 - 2. In the case that Owner has to provide temporary equipment to replace function of warranted item requiring repair or replacement, manufacturer shall reimburse Owner for such costs associated with the temporary equipment.
- E. Warranty commence running on the date of final completion:
 - 1. For items of Work for which acceptance is delayed beyond Date of Final Completion, submit warranty within 10 calendar days after acceptance, listing date of acceptance as beginning of warranty period.
- F. Duration of Warranty: 2 years.

1.06 MANUFACTURER'S SPECIAL WARRANTY

- A. Manufacturer's special warranty is a written warranty published by the manufacturer which includes the requirements specified in the Section where the item is specified:
 - 1. Includes Project-specific information and requirements, properly executed by product manufacturer, and expressly states that its provisions are for the benefit of the Owner. Technical sections indicate Project-specific requirements that differ from the minimum warranty requirements for that item:
 - a. Examples include extending the duration of manufacturer's warranty or to provide increased rights to Owner.
 - 2. Manufacturer's warranties commence on the date that the Project is certified by Engineer as finally complete.

1.07 WARRANTY WORK

- A. Contractor's responsibilities:
 - 1. Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the warranty on the work that incorporates the product, nor does it relieve suppliers, manufacturers, and subcontractors required to countersign special warranties with Contractor.

- B. Replacement cost:
 - 1. Upon determination that work covered by warranty has failed, replace or rebuild the work to an acceptable condition complying with requirement of the Contract Documents:
 - a. Contractor is responsible for the cost of replacing or rebuilding defective work regardless of whether Owner has benefited from the use of the work through a portion of its anticipated useful service life.
- C. Related damages and losses:
 - 1. When correcting warranted work that has failed, remove and replace other work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted work.
- D. Owner's recourse:
 - 1. Written warranties are in addition to implied warranties, and shall not limit the duties, obligations, rights, and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitation on time in which Owner can enforce such other duties, obligations, rights, or remedies.
- E. Reinstatement of warranty:
 - 1. When work covered by a warranty has failed and has been corrected by replacement or rebuilding, reinstate the warranty by written endorsement:
 - a. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

1.08 IMPLIED WARRANTIES

- A. Warranty of title and intellectual rights:
 - 1. Except as may be otherwise indicated in the Contract Documents, implied warranty of title required by Laws and Regulations is applicable to the Work and to materials and equipment incorporated therein.
 - 2. Provisions on intellectual rights, including patent fees and royalties, are in the General Conditions, as may be modified by the Supplementary Conditions.
- B. Implied warranties: Duration in accordance with Laws and Regulations.

1.09 BONDS

- A. Bond requirements as specified in the Agreement between Owner and Supplier.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01_81_01

PROJECT DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Criteria for use in selection of equipment and appurtenances specified in subsequent Sections of these Specifications, or on the Drawings.
 - 2. Criteria for design of tanks and other equipment fabricated off site and shipped to the Work for installation.
 - 3. Criteria for use in design of anchors for connecting process, mechanical and electrical equipment and appurtenances to supporting structures.
- B. The criteria included in this Section are general criteria that apply throughout the Work unless more restrictive or more stringent criteria are indicated on the Drawings or in technical Specifications. See Drawings and Specifications for additional criteria relevant to specific locations, materials and equipment.
- C. Related sections:
 - 1. Section 46_63_83.01 - Phosphorous Precipitation System.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. 7-10 - Minimum Design Loads for Buildings and Other Structures (ASCE 7).
- B. ASHRAE, Incorporated (ASHRAE).
- C. International Code Council (ICC):
 - 1. International Building Code (IBC).
 - 2. International Energy Conservation Code (IECC).
 - 3. International Fire Code (IFC).
 - 4. International Fuel Gas Code (IFGC).
 - 5. International Mechanical Code (IMC).
- D. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA):
 - 1. Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd edition - 2008.

1.03 SUBMITTALS

- A. Design of supports and anchorage for structures:
 - 1. Shop drawings and calculations:
 - a. Complete shop drawings and calculations.
 - b. Calculations shall be signed and sealed by a Professional Engineer licensed in the State of Idaho.

2. Seismic design calculations:
 - a. Where seismic design calculations are specified in this Specification, such requirements will be waived for structures or equipment determined to be in Seismic Design Category A.
3. Wind design calculations:
 - a. Where wind design calculations are specified in this Specification, such requirements will be waived for structures or equipment located inside other structures.

1.04 PROJECT DESIGN CRITERIA - SITE INFORMATION

- A. Location:
 1. Address: 3401 North Ten Mile Road, Meridian, ID 83646.
 2. Site coordinates (approximate): Latitude 43.637829 N; Longitude - 116.437424W.
- B. Elevation:
 1. Operating elevation for equipment: 2,551 feet above mean sea level (approximate).

1.05 PROJECT DESIGN CRITERIA - REGULATORY REQUIREMENTS

- A. Building Codes:
 1. Building Code:
 - a. International Building Code (IBC), 2015.
 2. Electrical code:
 - a. National Electrical Code (NEC), 2017.
 3. Energy code:
 - a. International Energy Conservation Code (IECC), 2015.
 4. Fire code:
 - a. Idaho Fire Code (IFC), 2015.
 5. Fuel gas code:
 - a. International Fuel Gas Code (IFGC), 2012.
 6. Mechanical code:
 - a. International Mechanical Code (IMC), 2012.
 7. Plumbing code:
 - a. 2017 Idaho State Plumbing Code.

1.06 PROJECT DESIGN CRITERIA - OPERATING ENVIRONMENT

- A. Equipment and materials for the Work shall be suitable for performance in a wastewater treatment plant environment, and under conditions specified in the following paragraphs:
 1. See technical specifications for each type of equipment for additional requirements.

1.07 PROJECT DESIGN CRITERIA - STRUCTURAL

- A. Scope:
 1. These paragraphs provide criteria for structural design of submittal items such as stairs and platforms, equipment, equipment supports and bracing, and attachment or anchorage of such items to building and non-building structures.

2. Design criteria for individual structures are indicated on the General Structural Notes Drawing and the Contract Drawings for each structure.
 3. Specifications for manufactured or prefabricated structures may include design criteria in addition to the items in this Section.
- B. Design in accordance with requirements of the following:
1. The building code specified in this section.
 2. ASCE 7-10.
 3. Specific project requirements listed in the following paragraphs.
- C. Structure description and risk category.
1. Determine importance factors, develop design loads, and provide detailing in accordance with the provisions of ASCE 7 based on structure description, risk category indicated in Table 3:

Table 3: Project Structures - Risk Categories⁽¹⁾	
Description	Risk Category⁽¹⁾
Side Stream Treatment Building	III
Phosphorus Precipitation System Reactors	III
Other equipment and project components not specifically listed	III
Notes: (1) Categories are based on and for use with ASCE 7 unless otherwise noted.	

- D. Groundwater design criteria:
1. Design groundwater elevation: Approximately 3 feet below grade. (See project geotechnical report for groundwater elevations at specific boring locations.)
- E. Flood design criteria:
1. FEMA Flood Insurance Rate Map Zone X – “Other Flood Areas”. (Map No. 16001C0139 H, Panel 139 of 875.)
- F. Wind design criteria (for structures and for equipment located outdoors or under open canopies):
1. Basic wind speed:
 - a. Velocity = 120 miles per hour (33 feet, 3-second gust).
 2. Exposure category: C.
 3. Topographic factor, K_{zt} : 1.0.
 4. Wind pressure for design of "components and cladding":
 - a. Calculated per building code based on criteria in this Section.
 - b. Use maximum pressure on any wall for all components at the building.
 - c. Includes pressure for design of doors, windows, siding panels and other elements.
- G. Seismic design criteria:
1. Design spectral response acceleration, 5 percent damped:
 - a. Short period, $S_s = 0.290g$.
 - b. One second period, $S_1 = 0.106g$.

2. Seismic Design Category:
 - a. As indicated on the Drawings for each structure (by area) and in Table 4.

Table 4: Project Structures - Seismic Design Categories		
Structures and Buildings (by Drawing Area Number)		Seismic Design Category⁽¹⁾
Structures founded on Site Class D soils⁽¹⁾:		
NA	All Buildings and Equipment included in the Work	C
Notes: (1) Categories are based on and for use with ASCE 7 unless otherwise noted.		

3. Mechanical and electrical equipment, including equipment supports and anchorage to structures or foundations, and including associated distribution systems such as piping, ductwork, conduits, cable trays, bus ducts, etc.:
 - a. Design in accordance with the provisions of ASCE 7-10, Chapter 13, except as modified herein.
 - b. Seismic design category B exemptions:
 - 1) Exemptions in ASCE 7, paragraph 13.1.4 for anchoring and bracing of mechanical, and electrical components in Seismic Design Category B are permitted for this Work.
 - c. Component amplification factor (a_p) and component response modification factor (R_p): In accordance with ASCE 7, Table 13.6-1.
 - d. Overstrength factor for anchorage to concrete (Ω_o): In accordance with ASCE 7, Table 13.6-1.
 - e. Component importance factor, I_p : In accordance with the provisions of ASCE 7, Chapter 13 unless otherwise specified in Table 5 of this Section.

Table 5: Mechanical and electrical equipment, Component importance factor, I_p		
Component	Description	I_p
Electrical	Equipment and appurtenances provided and installed under Divisions 26 and 40.	1.5
Mechanical (HVAC)	Equipment and appurtenances provided and installed under Division 40.	1.0
Process	Equipment and appurtenances provided and installed under Divisions 43 and 46.	1.0

- f. "Statement of seismic qualification" or "special seismic certification":
 - 1) Requirements are based on the Seismic Design Category (SDC) of the facility where the equipment is installed.
4. Tanks, including pre-fabricated tank structures, tank supports, and anchorage to structures or foundations:
 - a. Consider impulsive and convective "sloshing" effects.
 - b. Component response modification factor for impulsive effects, R_i : In accordance with ASCE 7, Table 15.4-2.
 - c. Component response modification factor for convective effects, $R_c = 1.0$.

- d. Component importance factor, I_e : Determine in accordance with ASCE 7, Section 15.4.1.1.
 - e. Seismic design category ("SDC"):
 - 1) See Table 4 of this Section.
- H. Snow design criteria for structures and for equipment located outdoors):
- 1. Ground snow load: $p_g = 20$ pounds per square foot.
 - 2. Exposure factor, minimum: $C_e = 1.0$ (partially exposed).
 - 3. Thermal factor, minimum: $C_t = 1.0$ (all structures except structures kept just above freezing and cold, ventilated roofs, unheated and open air structures, structures kept below freezing, and continuously heated greenhouses).
 - 4. Importance factor, minimum: Based on risk category of the structure where the equipment is located.
 - 5. Minimum snow load, $p_m = 25$ pounds per square foot.
- I. Atmospheric icing design criteria (for structures and for equipment located outdoors):
- 1. Equivalent radial/nominal uniform ice thickness: 0.25 inch / 40 miles per hour wind.
 - 2. Ice density for calculating ice weight, minimum: 56 pounds per cubic foot.
 - 3. Importance factor, minimum: Based on risk category of the structure adjacent to the equipment.

PART 2 PRODUCTS

2.01 GENERAL

- A. Equipment and materials for the project shall be suitable for the following conditions:
 - 1. Wastewater treatment plant conditions.
 - 2. Site, environmental and structural loading conditions as specified in this Section.
 - 3. Specific conditions listed in the relevant sections of the Contract Documents for the equipment and products under consideration.
- B. Anchoring and fastening: See the following Sections for materials and installation requirements.

PART 3 EXECUTION

3.01 GENERAL

- A. Design in accordance with the requirements of the building code and the references and project-specific design criteria listed in this Section.
- B. In the event of conflicts between design criteria, the more restrictive or severe shall govern.

3.02 DESIGN OF SUPPORTS AND ANCHORAGE FOR EQUIPMENT AND TANKS.

A. General:

1. Anchor bolts used to resist seismic loads and wind forces shall have a standard hex bolt head.
 - a. Do not use anchor bolts fabricated from rod stock with an L or J shape.
 - b. Do not use post-installed anchors (including concrete anchors, sleeve anchors, flush shells, chemical anchors, powder actuated fasteners, or other types of anchor) unless indicated on the Drawings or accepted in writing by the Engineer.
2. Anchor bolt and fastener calculations:
 - a. Design for ductile failure (anchor bolt yield).
 - b. Anchor bolts and fasteners embedded cast into plastic concrete or installed into cured concrete:
 - 1) Design based on a minimum specified 28-day concrete compressive strength of 4,000 pounds per square inch ($f'_c = 4,000$ psi).

B. Seismic loads:

1. Do not use friction to resist sliding resulting from seismic forces. Resist such forces only by direct application of loads to fasteners as bearing, shear, tension, or compression force(s).
2. Do not use more than 60 percent of the weight of the mechanical and electrical equipment for designing anchors for resisting overturning due to seismic forces.
3. For tanks and equipment with varying weight based on the volume of material contained, design anchorage to accommodate both filled and empty conditions:
 - a. Do not use more than 60 percent of the weight of the tank for resisting overturning due to seismic forces.

C. Wind loads:

1. Design load combinations shall be as specified in ASCE 7.
2. For tanks and equipment with varying weight based on volume of material contained, evaluate anchorage considering both filled and empty conditions.

END OF SECTION

SECTION 05_12_00
STRUCTURAL STEEL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Structural steel shapes and plate.
 - 2. Fasteners:
 - a. All thread rods.
 - b. Assembly bolts.
 - c. High strength bolts.
 - d. Powder actuated fasteners.
 - 3. Isolation sleeves and washers.
 - 4. Thread coating.
 - 5. Welding.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC):
 - 1. 303-05 - Code of Standard Practice for Steel Buildings and Bridges.
 - 2. 360-05 - Specification for Structural Steel Buildings.
- B. American Iron and Steel Institute (AISI):
 - 1. Steel and stainless steel alloys ("types") as indicated.
- C. American National Standards Institute (ANSI):
 - 1. B212-15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.
- D. ASTM International (ASTM):
 - 1. A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling.
 - 2. A36 - Standard Specification for Carbon Structural Steel.
 - 3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
 - 4. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
 - 5. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 6. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 7. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High-Temperature or High Pressure Service and Other Special Purpose Applications.
 - 8. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - 9. A276 - Standard Specification for Stainless Steel Bars and Shapes.

10. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
 11. A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
 12. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 13. A489 - Standard Specification for Carbon Steel Lifting Eyes.
 14. A490 - Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
 15. A496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
 16. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 17. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
 18. A992 - Standard Specification for Structural Steel Shapes.
 19. B633 - Standard Specification for Aluminum-Alloy Rolled Tread Plate.
 20. E94 - Standard Guide for Radiographic Examination.
 21. E164 - Standard Practice for Contact Ultrasonic Testing of Weldments.
 22. E165 - Standard Practice for Liquid Penetrant Examination for General Industry.
 23. E709 - Standard Guide for Magnetic Particle Testing.
 24. E1032 - Standard Test Method for Radiographic Examination of Weldments.
 25. F436 - Standard Specification for Hardened Steel Washers.
 26. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 27. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
 28. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
- E. American Welding Society (AWS):
1. A 5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
 2. A 5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
 3. A 5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
 4. D 1.1 - Structural Welding Code - Steel.
 5. D 1.6 - Structural Welding Code - Stainless Steel.
 6. D 10.4 - Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing.
- F. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements.
 2. AC58 - Acceptance Criteria for Adhesive Anchors in Masonry Elements.
 3. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.
 4. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.
- G. Occupational Safety and Health Administration (OSHA):
1. Code of Federal Regulations, Title 29 – Labor, Chapter XVII.
 - a. Part 1926 - Safety and Health Regulations for Construction.

- H. Research Council on Structural Connections (RCSC)
(c/o American Institute of Steel Construction):
 - 1. Specification for Structural Joints Using ASTM A325 or A490 Bolts.
- I. Steel Structures Painting Council (SSPC):
 - 1. SP1 - Solvent Cleaning.
 - 2. SP7 - Brush-off Blast Cleaning.
 - 3. SP10 - Near White Abrasive Blasting.
 - 4. SP11 - Power Tool Cleaning to Bare Metal.

1.03 DEFINITIONS

- A. All thread rod: Straight steel rod continuously threaded from end to end.
- B. Anchor bolt: Straight steel rod embedded in concrete and having one integrally forged headed end and one threaded end. Installed with headed end cast into concrete with embedment as indicated on the Drawings or specified, leaving threaded end projecting clear of concrete face as required for the connection to be made.
- C. Anchor rod: Straight steel rod embedded in concrete and having threads on each end. Fit threaded end to be embedded in concrete with nuts or plates as indicated on the Drawings and providing embedment as indicated on the Drawings or specified. Leave threaded end projecting clear of the concrete face as required for the connection to be made.
- D. Cast-in anchor: Fastener or assembly installed in position before placing plastic concrete or installing masonry units and grout around the anchor.
- E. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of a chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.
- F. Wet and moist locations: When used with reference to anchors and fasteners, locations that are subject to deterioration and corrosion. Includes:
 - 1. Liquid-containing structures:
 - a. Locations at or below the maximum operating liquid surface elevation.
 - b. Locations above the maximum operating liquid surface elevation and:
 - 1) below the top of the walls containing the liquid; and
 - 2) at the underside of a structure (including roofs, slabs, beams or walkways) spanning over the liquid.
 - 2. Bases of pumps and equipment that handles liquids.
 - 3. Indoor locations exposed to moisture or splashing during normal operations.

1.04 SUBMITTALS

- A. General: Submit in accordance with Section 01_33_00.
- B. Quality control submittals:
 - 1. Fabricator shall submit evidence of AISC Quality Certification.
 - 2. Submit shop drawings of members to be fabricated before starting their fabrication.

- C. Test reports:
 - 1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.
 - 2. For each type of post-installed anchor to be included in the Work, current International Code Council ES Report (ICC-ES) demonstrating conformance to the Acceptance Criteria (AC) indicated for that anchor.

1.05 QUALITY ASSURANCE

- A. Qualifications:
 - 1. The fabricator shall participate in the AISC Quality Certification Program and shall be designated an AISC-Certified Plant, Category STD at the time of bid.
 - 2. Perform welding of structural metals with welders who have current American Welding Society certificate for the type of welding to be performed.
 - 3. Notify Engineer at least 24 hours minimum before starting shop or field welding.
 - 4. Engineer may check materials, equipment, and qualifications of welders:
 - a. Remove welders performing unsatisfactory Work, or require re-qualification.
 - 5. In addition to specified Quality Control testing by the Contractor, Engineer may request that Contractor's testing laboratory use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
 - 6. Contractor shall bear costs of retests on defective welds.
 - 7. Contractor shall also bear costs in connection with qualifying welders.
- B. Regulatory requirements:
 - 1. Conform to OSHA requirements for steel erection.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.
- B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Unless otherwise specified or indicated on the Drawings, materials shall conform to the following:

Table 05_12_00-A: Steel materials		
Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Steel		
Plate, bars, rolled shapes, and miscellaneous items (except W and WT shapes)	A 36	--
Rolled W and WT shapes	A 36 or A 992	Grade 50
Tubing, cold-formed	A 500	--
Tubing, hot-formed	A 501	--
Round HSS	A 500	Grade B
Steel pipe	A 53	Grade B
Stainless steel		
Plate, sheet, and strip	A 240	Type 316*
Bars and shapes	A 276	Type 316*
* Use Type 316L if material will be welded.		

2.02 FASTENERS

- A. General: Furnish threaded fasteners, except high strength bolts, with flat washers, and self-locking nuts, or lock washers and nuts:
 1. Bolt heads and nuts: Hex-type.
 2. Bolts, nuts, and washers: Of domestic manufacture.
- B. Materials:
 1. Provide stainless steel or galvanized steel fasteners based on exposure conditions listed in the following paragraphs:
 2. Stainless steel: For use at the following locations, unless otherwise noted:
 - a. At locations indicated on the Drawings.
 - b. At "wet and moist locations" as defined herein, unless otherwise noted.
 - c. For connecting aluminum or stainless steel to concrete or masonry.
 3. Galvanized:
 - a. For use at all locations not requiring stainless steel.
 - b. Where bolts, including anchor bolts, nuts, washers, and similar fasteners are specified to be galvanized, galvanize in accordance with ASTM A153.
- C. All thread rods (includes all thread rods epoxy bonded into concrete as specified in Section 03_21_17 and as indicated on the Drawings):
 1. Description.
 2. Materials:
 - a. Stainless steel: Type 316 stainless steel conforming to ASTM F593.
 - b. Galvanized: ASTM A36 galvanized in accordance with ASTM A123.
- D. Assembly bolts:
 1. Description: Bolts, nuts, and washers for connections in wood or fiberglass-reinforced plastic baffles, collectors, and other field-assembled construction.

- 2. Materials:
 - a. Stainless steel: Type 316 stainless steel in accordance with ASTM F593.
Galvanized: ASTM A307.
- E. High strength bolts:
 - 1. Description: Steel bolts, nuts and washers for steel-to-steel connections between structural steel framing members.
 - 2. Acceptance criteria:
 - a. Conform to the requirements of ASTM A325 or ASTM A490, as indicated on the Drawings.
 - b. At pre-tensioned and slip-critical joints, provide:
 - 1) Direct-tension-indicator washers conforming to the requirements of ASTM F959.
 - 2) Flat washers conforming to ASTM F436 behind the element being turned for tightening.
 - 3. Materials:
 - a. Hot-dip galvanized.
 - b. Carbon steel.
- F. Powder actuated fasteners:
 - 1. Do not use unless directed by the Engineer.

2.03 ISOLATING SLEEVES AND WASHERS

- A. Manufacturers: One of the following or equal:
 - 1. Central Plastics Company, Shawnee, Oklahoma.
 - 2. Corrosion Control Products, PSI Inc., Gardena, CA.
- B. Sleeves: Mylar, 1/32 inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending halfway into both steel washers:
 - 1. One sleeve required for each bolt.
- C. Washers: The inside diameter of all washer shall fit over the isolating sleeve and both the steel and isolating washers shall have the same inside diameter and outside diameter:
 - 1. Proper size to fit bolts. Two insulating washers are required for each bolt.
 - 2. Two 1/8-inch thick steel washers for each bolt.
 - 3. G3 phenolic:
 - a. Thickness: 1/8 inch.
 - b. Base material: Glass.
 - c. Resin: Phenolic.
 - d. Water absorption: 2 percent.
 - e. Hardness (Rockwell): 100.
 - f. Dielectric strength: 450 volts per mil.
 - g. Compression strength: 50,000 pounds per square inch.
 - h. Tensile strength: 20,000 pounds per square inch.
 - i. Maximum operating temperature: 350 degrees Fahrenheit.

2.04 GALVANIZED SURFACE REPAIR

- A. Manufacturers: One of the following or equal:
 - 1. Galvinox.
 - 2. Galvo-Weld.

2.05 THREAD COATING

- A. Manufacturers: One of the following or equal:
 - 1. Never Seez Compound Corporation, Never-Seez.
 - 2. Oil Research, Inc., WLR No. 111.

2.06 SUPPLEMENTARY PARTS

- A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

2.07 FABRICATION

- A. Shop assembly:
 - 1. Fabricate structural steel in conformance with AISC 303 and AISC 360 unless otherwise specified or modified by applicable regulatory requirements.
 - 2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
 - 3. Round off sharp and hazardous projections and grind smooth.
 - 4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
 - 5. Take responsibility for correct fitting of all work.
- B. Stainless steel shapes and assemblies:
 - 1. For structural members such as W shapes, S shapes, channels, angles, and similar rolled shapes not available in quantity, size, and type of stainless steel specified or indicated on the Drawings:
 - a. Make full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as members indicated on the Drawings.
 - b. Fabricate shapes using laser-fused full penetration joints. Fabricate shapes from dual grade stainless steel. Fabricate beams and channels to ASTM A6 tolerances:
 - 1) Manufacturers: One of the following, or equal:
 - a) Stainless Structurals, LLC; Jacksonville FL.
 - 2. Cleaning and passivation:
 - a. Following shop fabrication of stainless steel members, clean and passivate fabrications.
 - b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
 - c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated:
 - 1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.

- d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping:
 - 1) Passivation by citric acid treatment is not allowed:
 - a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
 - 2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380
 - 3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A380.
- e. Inspect after cleaning using methods specified for "gross inspection" in ASTM A380.
- f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the site.

C. Galvanizing:

- 1. Where galvanizing is required, hot-dip galvanize structural steel after fabrication in accordance with ASTM A123:
 - a. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
 - b. Re-straighten galvanized items that bend or twist during galvanizing.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 ERECTION

- A. General:
 - 1. Fabricate structural and foundry items to true dimensions without warp or twist.
 - 2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
 - 3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
 - 4. Do not re-drill, re-shape, force out of alignment, or force fit fabricated items.
 - 5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
 - 6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
 - 7. Erect structural steel in conformance with AISC 303 and AISC 360 unless otherwise specified or modified by applicable regulatory requirements.
 - 8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.

- B. Round off sharp or hazardous projections and grind smooth. Bolting:
1. General:
 - a. Install bolts, to project 2 threads minimum, but 1/2 inch maximum beyond nut.
 2. High-strength steel bolting:
 - a. Connections with high strength bolts shall conform to RCSC Specification for Structural Joints Using ASTM A325 or A 490 Bolts.
 - b. Consider connections with high strength bolts to be snug-tightened joints unless pre-tensioned joints or slip-critical joints are indicated on the Drawings.
 - c. Snug-tightened connections:
 - 1) Furnish hardened flat washers at joints with sloping faces or with slotted holes as required by RCSC.
 - d. Pre-tensioned and slip-critical connections:
 - 1) Furnish hardened flat washer:
 - a) Under element (nut or bolt head) being turned during tightening.
 - b) On outer plies for short slotted holes.
 - 2) Furnish direct-tension-indicator washer. Verify adequate tightening of bolts at pre-tensioned and slip critical connections by means of tension indicator washers placed as indicated in ASTM F959, Figure 1.
 - 3) At slip-critical connections, provide uncoated faying surfaces as specified by RCSC.
- C. Welding - general:
1. Make welds full penetration type, unless otherwise indicated on the Drawings.
 2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.
 3. Obtain Engineer's acceptance of welds in repaired or field-modified work.
- D. Welding stainless steel:
1. General: Field welding of stainless steel not allowed. Comply with AWS D1.6:
 - a. Perform with electrodes and techniques in accordance with AWS D10.4.
 2. Passivation of welded surfaces:
 - a. Provide cleaning, pickling, and passivating as specified under Part 2 Fabrication.
- E. Welding carbon steel:
1. General: Comply with AWS D1.1:
 - a. Weld ASTM A36 and A992 structural steel, ASTM A500 and A 501 structural tubing, and ASTM A53 pipe with E70XX electrodes conforming to AWS A5.1; F7X-EXXX electrodes conforming to AWS A5.17; E7XT-X electrodes conforming to AWS A5.20:
 - 1) Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.
- F. Interface with other products:
1. Where steel fasteners come in contact with aluminum or other dissimilar metals, bolt with stainless steel bolts and separate or isolate from dissimilar metals with isolating sleeves and washers:
 - a. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

3.03 PRIMING AND COATING

- A. General:
 - 1. Paint or coat steel items as specified in Section 09_96_01.

3.04 FASTENERS: CAST-IN AND POST-INSTALLED

- A. General:
 - 1. Install bolts, to project 2 threads minimum, but 1/2 inch maximum beyond nut.
 - 2. Tightening requirements:
 - a. Unless otherwise specified, tighten bolts to the "snug-tight" condition, defined as tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.
- B. All thread rods - epoxy bonded in concrete:
 - 1. Install as specified in Section 03_21_17 and as indicated on the Drawings.
- C. Powder actuated fasteners:
 - 1. Use powder actuated fasteners only for applications indicated on the Drawings or specified.

3.05 FIELD QUALITY CONTROL

- A. Provide Contractor quality control as specified in Section 01_45_00.
- B. Field tests and inspections:
 - 1. High-strength bolting:
 - a. Confirm use of specified bolts and nuts.
 - b. Snug-tightened connections:
 - 1) Confirm use of washers as required by RCSC for sloping surfaces at joints and for slotted holes.
 - 2) Confirm that all plies of the connected elements have been brought into firm contact by the tightened connections.
 - c. For pre-tensioned and slip-critical connections, perform testing in the presence of the Engineer.
 - d. Pre-tensioned connections:
 - 1) Prior to pre-tensioning, confirm that the appropriate feeler gage is accepted in at least half the spaces between protrusions of the direct-tension indicator, and that the protrusions are properly oriented away from the work.
 - 2) If feeler is accepted in fewer than half the spaces, remove direct-tension indicator and replace before tightening.
 - 3) After pre-tensioning, confirm that the at least half the spaces between protrusions refuse entry of the feeler gage.
 - e. Slip-critical connections:
 - 1) Before assembly, confirm that faying surfaces (planes of contact between any 2 plies within the joint, including those of filler plates and finger shims) are free of mill scale and coatings in areas within 1 inch of the edge of any hole and between all holes in the bolt pattern.
 - 2) Test for entry of feeler gage into protrusions of direct tension indicators before and after tightening, as specified for pre-tensioned connections.

- f. Test results:
 - 1) Submit records of testing to Engineer within 24 hours after testing.
- 2. Welding – Field welds:
 - a. Perform testing in the presence of the Engineer.
 - b. Visual observation:
 - 1) Examine all welds in accordance with AWS D1.1. Quality of welds and standards for acceptance shall be in accordance with AWS D1.1, Section 6.9.
 - c. Radiographic testing:
 - 1) Conform to AWS D1.1, Section 6.12, and ASTM E94, and ASTM E1032 as applicable.
 - 2) Provide radiographic testing of welds as specified in the following paragraphs:
 - a) Complete joint penetration groove welds with weld thickness of 3/4 inch or less: 10 percent of welds.
 - b) Complete joint penetration groove welds with weld thickness from 3/4 inch to 1 1/2 inches: 50 percent of welds.
 - c) Complete joint penetration groove welds with weld thickness greater than 1 1/2 inches: All welds.
 - d. Ultrasonic testing:
 - 1) Conform to AWS D1.1, Section 13 and ASTM E164 as applicable.
 - 2) Provide ultrasonic testing of welds as specified in the following paragraphs:
 - a) Complete joint penetration groove welds not accessible for radiographic testing, when accepted by the Contractor's Engineer.
 - b) Frequency of testing shall be as specified for radiographic testing.
 - e. Magnetic particle inspection:
 - 1) Conform to ASTM E709.
 - 2) Provide magnetic particle testing of welds as specified in the following paragraphs:
 - a) Complete joint penetration groove welds of tee and corner joints: 20 percent of welds.
 - b) Partial joint penetration groove welds: 10 percent of welds.
 - c) Fillet welds: 10 percent of welds
 - f. Liquid penetrant inspection:
 - 1) Conform to ASTM E165.
 - 2) Provide for detecting discontinuities that are open to the surface.
 - g. Test results:
 - 1) Submit records of testing to Engineer within 24 hours after testing.

3.06 FIELD QUALITY ASSURANCE

- A. Provide Owner quality assurance as specified in Section 01_45_00.
- B. Special tests and inspections: As required by Section 01_45_24.
- C. Field inspections:
 - 1. Required inspections:
 - a. Observe construction for conformance to the Contract Documents and the accepted Shop Drawings.

- b. Make observations of items in the following tables at frequencies not less than that indicated in the tables.
- 2. Records of inspections:
 - a. Provide record of each inspection.
 - b. Submit copies to Engineer upon request.

3.07 NON-CONFORMING WORK

- A. Remove and replace damaged and non-conforming work to the satisfaction of the Engineer:
 - 1. Bolting:
 - a. Snug-tightened connections: Provide additional tightening.
 - b. Pre-tensioned and slip-critical connections: Remove bolts. Replace with new bolts and direct-tension indicators, and re-tighten.
 - c. Re-inspect and re-test all repaired or corrected bolts.
 - 2. Welding:
 - a. Repair non-conforming welds in accordance with AWS D1.1, Section 5.26.
 - b. Re-inspect and re-test all repaired or corrected welds.

END OF SECTION

SECTION 26_05_00

COMMON WORK RESULTS FOR ELECTRICALGENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements applicable to all Electrical Work.
 - 2. General requirements for electrical submittals.
- B. Related sections:
 - 1. Section 01_14_00 - Work Restrictions.
 - 2. Section 01_33_00 - Submittal Procedures.
 - 3. Section 01_35_21 - Selective Alterations and Demolition.
 - 4. Section 01_45_00 - Quality Control.
 - 5. Section 01_60_00 - Product Requirements.
 - 6. Section 01_75_17 - Commissioning.
 - 7. Section 01_77_00 - Closeout Procedures.
 - 8. Section 01_78_23 - Operation and Maintenance Data.
 - 9. Section 01_81_01 - Project Design Criteria.
 - 10. Section 26_05_02 - Hazardous Classified Area Construction.
 - 11. Section 26_05_33 - Conduits.
 - 12. Section 26_05_53 - Identification for Electrical Systems.
 - 13. Section 26_08_50 - Field Electrical Acceptance Tests.
- C. Interfaces to equipment, instruments, and other components:
 - 1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
 - 2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - 3. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
 - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
- D. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
 - 1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
 - 2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.

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

1.02 REFERENCES

- A. Code compliance:
1. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
 2. The standards listed are hereby incorporated into this Section:
 - a. American National Standards Institute (ANSI).
 - b. American Society of Civil Engineers (ASCE):
 - 1) ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
 - c. ASTM International (ASTM).

- d. Illuminating Engineering Society (IES).
- e. Institute of Electrical and Electronics Engineers (IEEE).
- f. Insulated Cable Engineers Association (ICEA).
- g. International Code Council (ICC):
 - 1) International Code Council Evaluation Service (ICC-ES):
 - a) AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
- h. International Society of Automation (ISA).
- i. National Electrical Manufacturers Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- j. National Fire Protection Association (NFPA):
 - 1) 70 - National Electrical Code (NEC).
- k. National Institute of Standards and Technology (NIST).
- l. Underwriters' Laboratories, Inc. (UL).

1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations as set forth by:
 - 1. IEEE.
 - 2. NETA.
 - 3. IES.
 - 4. ISA.
 - 5. NEC.
 - 6. NEMA.
 - 7. NFPA.
 - 8. NIST.
- B. Specific definitions:
 - 1. FAT: Factory acceptance test.
 - 2. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
 - 3. PLC Cabinet: An enclosure containing the PLC.
 - 4. PCIS: Process control and instrumentation system.
 - 5. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
 - 6. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
 - 7. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
 - 8. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
 - a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.
5. Demolition:
 - a. Where demolition is specified or indicated on the Drawings, disconnect all associated electrical equipment and render the equipment safe.
 - b. Remove and dispose of all conduit, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
 - c. Salvage electrical equipment as specified in Section 01_35_21.
 - d. For each piece of equipment to be removed, remove all ancillary components (e.g. instruments, solenoid valves, disconnect switches, etc.).
 - e. Conduit:
 - 1) Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
 - a) Remove exposed conduit to the point of encasement or burial.
 - b) Cut conduit flush and plug or cap encased or buried conduit.
 - 2) Where conduits are to remain in place and removal is not indicated on the Drawings:
 - a) Cap conduit open ends.
 - b) Re-label empty conduits as spare.
 - f. Remove all wire back to the source for all conduits to be removed or abandoned in place.
 - g. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.
 - h. Provide new typewritten schedules for all modified panelboards.
6. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
 - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.)

- before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
 - b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
 - 7. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
 - a. As specified in the Contract Documents.
- B. New System”
 - 1. Provide new circuit breakers, cable, and conduits as shown on the contract documents to facilitate power and SCADA monitoring/Control connections between existing power generator and control equipment and new side-stream Phosphorous Precipitation System Reactor equipment.
- C. Operating facility:
 - 1. Meridian Water Resource Recovery Facility (WRRF) is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
 - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
 - b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
 - c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
 - 2. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
 - 3. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01_33_00 and this Section.
- B. General:
 - 1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
 - 2. Furnish the submittals required by each section in the Electrical Specifications.
 - 3. Adhere to the wiring numbering scheme specified in Section 26_05_53 throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on all Equipment Drawings.
 - 4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

- C. Seismic requirements:
 - 1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Section 01_81_01.
- D. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_23.
 - 2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.
- E. Record Documents:
 - 1. Furnish as specified in Section 01_77_00.
 - 2. Provide Record Documents of all Electrical Drawings.
 - 3. Record Drawing requirements:
 - a. Update Record Drawings weekly.
 - b. Record Drawings must be fully updated as a condition of the monthly progress payments.
 - c. Submit Record Drawings upon completion of the Work for final review.
 - d. Clearly and neatly show all changes including the following:
 - 1) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
 - 4. Shop drawings:
 - a. Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
 - 1) Provide as-built shop drawings for all electrical equipment on 11-inch by 17-inch paper:
 - a) Size all drawings to be readable and legible on 11-17 inch media.
 - 2) Provide electronic copies of these documents on CD-ROM or DVD disks in PDF format.
 - 5. Review and corrections:
 - a. Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
 - b. Promptly correct and re-submit record documents returned for correction.
- F. Test reports:
 - 1. As specified in Section 01_33_00.
 - 2. Include the following:
 - a. A description of the test.
 - b. List of equipment used.
 - c. Name of the person conducting the test.
 - d. Date and time the test was conducted.
 - e. All raw data collected.
 - f. Calculated results.
 - g. Each report signed by the person responsible for the test.
 - 3. Additional requirements for field acceptance test reports are specified in Sections 01_75_17 and 26_08_50.

- G. Calculations:
 - 1. Where required by specific Electrical Specifications:
 - a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.06 QUALITY ASSURANCE

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

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00.

1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
 - 1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
 - 2. Seismic load resistance:
 - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01_81_01.
 - 3. Wind load resistance:
 - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01_81_01.
 - 4. Altitude, temperature and humidity:
 - a. As specified in Section 01_81_01.
 - b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
 - c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:
 - 1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.
 - 5. Outdoor installations:
 - a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
 - b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
 - 1) Provide all wiring necessary to power these devices.

- B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
 2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
 3. NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.
 4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
 5. NEMA Type 6: Rated for submergence.
 6. NEMA Type 6P: Rated for prolonged submergence.
 7. NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 26_05_02.
 8. NEMA Type 8: Intended for installation in either indoor or outdoor locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) and the equipment is oil-immersed, meeting the requirements outlined in Section 26_05_02 - Hazardous Classified Area Construction.
- C. Plant area Electrical Work requirements:
1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Electrical Room	1, 12	GRC	C	GALV STL
Side Stream Building	4	PCS	W	SST
Digester Building	7	PCS	H	SST
Outdoors	4X SS	PCS	W	SST
Reactor Tank*				
* Refer to Section 26_05_02 Hazardous Areas for description of the Class I Division 2 space around the Reactor Tank.				

2. Modify exposed conduit runs as specified in Section 26_05_33.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. General:

1. Testing requirements are specified in Section 01_75_17, 26_08_50, and other sections.
2. Work restrictions and other scheduling requirements are specified in Section 01_14_00.
3. Commissioning requirements as specified in Section 01_75_17.

1.11 WARRANTY

- ### **A.**
- Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

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

1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

- ### **A.**
- Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- ### **B.**
- Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- ### **A.**
- Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.
- ### **B.**
- Stainless steel:

1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
2. Provide exposed screws of the same alloys.
3. Provide finished material free of any burrs or sharp edges.
4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION

- A. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.
- B. Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
 1. Verify all dimensions indicated on the Drawings:
 - a. Actual field conditions govern all final installed locations, distances, and levels.

2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
 4. Provide a complete electrical system:
 - a. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. Cutting and patching:
1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
 - a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
 - 1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
 - a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
 - b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
 - b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
 2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
 - a. 3M: CP 25WB+: Caulk.
 - b. 3M: Fire Barrier: Putty.
 3. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.
- D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
1. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.
 - a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
 2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
 - a. Adjust equipment locations as necessary to avoid any obstruction or interferences.
 3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.

4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
- E. Earthwork and concrete:
 1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
 - a. Requirements as specified in the Contract Documents.
- F. Roof penetrations:
 1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.
- G. Terminations:
 1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.
- H. Miscellaneous installation requirements:
 1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer.
 2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
 3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
 4. Circuits of different service voltage:
 - a. Voltage and service levels:
 - 1) Medium voltage: greater than 1.0 kV.
 - 2) Low voltage: 120 V to 480 V.
 - 3) Instrumentation: Less than 50 VDC.
- I. Labeling:
 1. Provide all nameplates and labels as specified in Section 26_05_53.
- J. Equipment tie-downs:
 1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01_75_17.

- B. For Owner and Engineer witnessed FAT:
 - 1. Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in Section 01_75_17.
- C. Owner training:
 - 1. As specified in Section 01_75_17 and in this Section.

3.08 FIELD QUALITY CONTROL

- A. Inspection:
 - 1. Allow for inspection of electrical system installation as specified in Section 01_45_00.
 - 2. Provide any assistance necessary to support inspection activities.
 - 3. Engineer inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect installation for compliance with the Drawings and Specifications.
 - c. Inspect installation for obstructions and adequate clearances around equipment.
 - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - e. Inspect equipment nameplate data to verify compliance with design requirements.
 - f. Inspect raceway installation for quality workmanship and adequate support.
 - g. Inspect cable terminations.
 - 4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 26_08_50.
- B. Field acceptance testing (Functional Testing):
 - 1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
 - 2. Perform the field acceptance tests as specified in Section 26_08_50.
 - 3. Record results of the required tests along with the date of test:
 - a. Use conduit identification numbers to indicate portion of circuit tested.
- C. Workmanship:
 - 1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
 - a. Neatly coil and label spare wiring lengths.
 - b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 01_77_00.
- B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.

- C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
 - 1. Use of compressors or air blowers for cleaning is not acceptable.
- D. Clean and re-lamp all new and existing luminaries that were used in the areas affected by the construction, and return all used lamps to the Owner.
- E. As specified in other sections of the Contract Documents.

3.11 PROTECTION

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

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_09

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage motors up to 500 horsepower (hp).

1.02 REFERENCES

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. American Bearing Manufacturers Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. American Petroleum Institute (API):
 - 1. 670 - Vibration, Axial Position, and Bearing Temperature Monitoring Systems.
- D. ASTM International (ASTM).
 - 1. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
- E. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - 2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
 - 3. 841 - IEEE Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
- F. National Electrical Manufacturers' Association (NEMA):
 - 1. MG-1 - Motors and Generators.
 - 2. MG-2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.
- G. Underwriters Laboratories Inc. (UL):
 - 1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Furnish and install electric motors and accessories as specified in this Section and the Sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures and 26_05_00 - Common Work Results for Electrical.
- B. Submit completed motor data sheets for each motor supplied:
 - 1. Conform to data sheet in the appendix of this Section.
 - 2. Manufacturer's or other data sheets are not acceptable.
- C. Product data:
 - 1. Descriptive bulletins.
 - 2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.
 - 3. Complete electrical data.
 - 4. Torque, current, and power factor versus speed curves:
 - a. At 100 percent rated voltage for all full voltage started and VFD-driven motors.
 - b. For motors on reduced voltage start at 70, 80, 90, and 100 percent rated voltage.
 - 5. Additional data for motors installed in classified areas:
 - a. Temperature code.
 - b. Hazardous area approval indicating Class, Division, and Group:
 - 1) For motors driven by variable frequency drives, provide manufacturer's certification that the motor is suitable for operation in the hazardous area when driven by a variable frequency drive.
 - 6. Accessories data:
 - a. Power factor correction capacitors:
 - 1) Size in KVAR, for all motors not connected to variable frequency drives.
 - b. Motor winding heaters:
 - 1) Voltage.
 - 2) Watts.
 - c. Winding temperature detectors:
 - 1) Type.
 - 2) Rating.
 - d. Moisture detectors.
 - 7. Mechanical data:
 - a. Bearing design and bearing life calculations.
 - b. Resonant frequencies for all VFD-driven motors 50 hp or greater.
- D. Shop drawings:
 - 1. Motor weight.
 - 2. Frame size.
 - 3. Conduit box(es), size(s), and location(s).
 - 4. Outline drawings with dimensions.
 - 5. Installation details for the project seismic criteria.

- E. Test reports:
 - 1. Factory test reports with test reference standard identified.
- F. Certification:
 - 1. When motors are driven by variable speed drive systems, submit certification that selected motor:
 - a. Is capable of satisfactory performance under the intended load.
 - b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.
- G. Calculations:
 - 1. Where site conditions specified in Section 26_05_00 - Common Work Results for Electrical exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. US Motors.
 - 2. General Electric.
 - 3. Reliance.
 - 4. Toshiba.
 - 5. Baldor.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. 3-phase induction motors - general:

1. Voltage:
 - a. All motors 1/2 hp and larger shall be rated 460 V, 3-phase unless otherwise indicated on the Drawings.
 - b. Dual voltage motors rated 230/460 V, 3-phase are acceptable provided all leads are brought to the conduit box.
2. Motors driving identical machines shall be identical.
3. All motors greater than 1 hp and up to 500 hp shall meet the "NEMA Premium Efficiency" percent listed in NEMA MG-1.
4. Horsepower as indicated on the Drawings:
 - a. Horsepower ratings indicated on the Drawings are based on vendor's estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
5. Service factor:
 - a. 1.15 service factor on sine wave power.
 - b. 1.0 when driven by VFD.
6. Torque:
 - a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
 - b. When started using reduced voltage starters:
 - 1) Provide motors that develop sufficient torque for acceleration to full speed.
 - c. NEMA Design B except where driven load characteristics require other than normal starting torque:
 - 1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
7. Enclosures:
 - a. As specified in the individual equipment Specifications or in this Section.
 - b. Totally enclosed fan cooled:
 - 1) Cast iron conduit box.
 - 2) Tapped drain holes with Type 316 stainless steel plugs for frames 286 and smaller, and automatic breather and drain devices for frames 324 and larger.
 - c. Explosion-proof:
 - 1) Tapped drain holes with corrosion resistant plugs for frames 286 and smaller and automatic breather and drain devices for frames 324 and larger.
 - d. Lifting devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.
8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer's standard material for the specified rating.

9. Nameplates:
 - a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
 - 1) NEMA standard motor data.
 - a) Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
 - 2) AFBMA bearing numbers and lubrication instructions.
10. Hardware:
 - a. Type 316 stainless steel.
11. Conduit boxes:
 - a. Cast iron or stamped steel.
 - b. Split from top to bottom.
 - c. Provide gaskets at the following interfaces:
 - 1) Frames and conduit boxes.
 - 2) Conduit boxes and box covers.
 - d. Rotatable through 360 degrees in 90-degree increments.
 - 1) Where available based on the size of the conduit box.
 - e. Exceeding the dimensions defined in NEMA MG-1.
 - f. Provide grounding lugs inside conduit boxes for motor frame grounding.
12. Motor bearings:
 - a. Antifriction.
 - b. Regreasable and initially filled with grease for horizontal motors and vertical motors per manufacturer's standard design.
 - c. Bearings and lubrication suitable for ambient temperature and temperature rise.
 - d. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.
 - e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
 - f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.
13. Insulation systems:
 - a. Motors installed in ambient temperatures 40 degrees Celsius or less:
 - 1) Provide Class F insulation.
 - 2) Design temperature rise consistent with Class B insulation.
 - 3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
 - b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:
 - 1) Provide Class F insulation.
 - 2) Design temperature rise consistent with Class B insulation.
 - 3) Rated to operate at an ambient temperature of 50 degrees Celsius at the altitude where the motor will be installed.
 - c. Motors installed in ambient temperatures between 50 degrees Celsius and 65 degrees Celsius:
 - 1) Provide Class H insulation.
 - 2) Design temperature rise consistent with Class F insulation.
 - 3) Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motors will be installed.

14. Motor leads:
 - a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
 15. Noise:
 - a. Maximum operating noise level in accordance with NEMA MG-1.
- B. Motors driven by variable frequency drives:
1. Compatible with the variable frequency drives specified.
 2. Inverter duty rated and labeled.
 3. Meet the requirements of NEMA MG-1 Part 31.
 4. Winding insulation meets the requirements of NEMA MG-1 Part 31.4.4.2.
 5. Capable of running continuously at 1/10th of full speed, with no harmful effects or overheating.
 6. All motors except explosion proof motors:
 - a. Shaft grounding ring:
 - 1) Provide a shaft grounding ring for each VFD-driven motor.
 - 2) Aluminum frame and internal components.
 - 3) Conductive microfiber brushes.
 - 4) Maintenance free design.
 - 5) Aegis Bearing Protection ring as manufactured by Electro Static Technology or equal.
- C. Motors installed in hazardous locations:
1. Class I, Division 1 or Class II, Division 1 areas:
 - a. Enclosures:
 - 1) Explosion proof for 3-phase motors.
 - 2) UL listed in conformance with UL-674.
 - 3) UL approval with nameplate and serial number.
 2. Other hazardous areas:
 - a. Enclosures:
 - 1) TEFC for motors in Class I, Division 2 areas.
 - 2) Vertical motors as specified in this Section.
 - 3) Hazardous area and temperature code approval stamped on nameplate.
 3. Single-phase motors: Explosion proof motor enclosure.
- D. Single-phase motors:
1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified or as indicated on the Drawings.
 2. Totally enclosed fan cooled (TEFC) motors manufactured in accordance with NEMA MG 1.
 3. Ball bearings: Sealed.
 4. 1/2 hp or less fan motors:
 - a. Split-phase or shaded pole type when standard for the equipment.
 - b. Open type when suitably protected from moisture, dripping water, and lint accumulation.
 5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.
 6. Integral overload protection.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Motor winding heaters:
 - 1. Provide all 3-phase motors with belted or cartridge space heaters mounted within the motor enclosure.
 - 2. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the P&IDs.
 - 3. Power leads for heaters wired into conduit box.
 - 4. Installed within motor enclosure adjacent to core iron.
- B. Winding temperature detectors:
 - 1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
 - a. Where required by the driven equipment Specification or as indicated on the Drawings.
 - b. RTD type, 2 per phase, 100-ohm platinum.
 - 2. Temperature switches with normally closed contacts as indicated on the P&IDs.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Install motors in accordance with manufacturer's instructions.
- C. Install shaft grounding ring on VFD-driven motors in accordance with the manufacturer's instructions.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING AND PROCESS START-UP

- A. As specified in Section 01_75_17 - Commissioning.

- B. Factory testing:
 - 1. Motors less than 250 hp:
 - a. Perform manufacturer's standard production tests including but not limited to:
 - 1) No load current.
 - 2) High potential test.
 - 3) Winding resistance.
 - b. Furnish copies of standard test reports on prototype or identical units.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
 - 1. Windings energized to 1,000 volts DC for 1 minute.
 - 2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.
 - 3. Inform the Engineer of any unusual or unacceptable test results.
 - 4. This test is in addition to the acceptance tests in Section 26_08_50 - Field Electrical Acceptance Tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

END OF SECTION

MOTOR DATA SHEET			
MOTOR/ EQUIPMENT TAG _____		MOTOR NUMBER _____	
SPECIFICATION NUMBER OF DRIVEN MACHINE _____			
MOTOR NAMEPLATE DATA			
MANUFACTURER _____	MODEL/SERIES _____	MODEL NO. _____	
FRAME _____	ENCLOSURE _____	NEMA DESIGN _____	
HP _____	SERVICE FACTOR _____	RPM _____	
INSULATION CLASS _____	VOLTS _____	FULL LOAD AMPS _____	
AMBIENT TEMP _____	PHASE _____	NO LOAD AMPS _____	
DESIGN TEMP _____	HERTZ _____	LOCK ROTOR AMPS _____	
INRUSH CODE LETTER _____			
		100% LOAD	75% LOAD
		50% LOAD	
GUARANTEED MINIMUM EFFICIENCIES:	_____	_____	_____
GUARANTEED MINIMUM POWER FACTOR:	_____	_____	_____
MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: _____ KVAR			
ACCESSORIES			
MOTOR WINDING HEATER _____		VOLTS _____	WATTS _____
WINDING THERMAL PROTECTION _____			
WINDING TEMP SWITCHES (YES/NO) _____			
RTD:			
TYPE _____	QUANTITY PER PHASE _____	# OF WIRES _____	
NOMINAL RESISTANCE _____	NOMINAL TEMP _____	COEFFICIENT _____	
RECOMMENDED ALARM _____	DEGREES CELSIUS _____	RECOMMENDED TRIP _____	DEGREES CELSIUS _____
SPECIAL APPLICATIONS			
INVERTER DUTY* (YES/NO) _____		PART WINDING (YES/NO) _____	
WYE - DELTA (YES/NO) _____			
2 SPEED, 1 WINDING (YES/NO) _____		2 SPEED, 2 WINDING (YES/NO) _____	
AREA CLASSIFICATION:			
CLASS _____	DIVISION _____	GROUP _____	TEMP CODE _____
* Conforms to NEMA MG-1 Part 31.			

SECTION 26_05_18

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
 - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. CSA International (CSA).
- D. Insulated Cable Engineers Association (ICEA):
 - 1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - 2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
- E. National Fire Protection Association (NFPA):
 - 1. 72 - National Fire Alarm and Signaling Code.
 - 2. 101 - Life Safety Code.
- F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
 - 1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
 - 2. 569-B – Commercial Building Standards for Telecommunications Pathways and Spaces.
 - 3. 1005 – Industrial Cabling Standard.
- G. Underwriter's Laboratories Inc., (UL):
 - 1. 44 - Thermoset-Insulated Wires and Cables.
 - 2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - 3. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
 - 4. 1569 - Standard for Metal-Clad Cables.
 - 5. 2196 - Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.
 - 6. 2225 - Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Specific definitions and abbreviations:
 - 1. AWG: American wire gauge.
 - 2. BCCS: Bare copper-covered steel.
 - 3. CPE: Chlorinated polyethylene.
 - 4. FEP: Fluorinated ethylene propylene.
 - 5. FHDPE: Foam high-density polyethylene.
 - 6. FPE: Foam polyethylene.
 - 7. OD: Outside diameter.
 - 8. PVC: Polyvinyl chloride.
 - 9. XHHW: Cross-linked high heat water resistant insulated wire.
- C. Definitions of terms and other electrical considerations as set forth in the:
 - 1. ASTM.
 - 2. ICEA.

1.04 SYSTEM DESCRIPTION

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

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures and 26_05_00 - Common Work Results for Electrical.
- B. Product data:
 - 1. Manufacturer of wire and cable.
 - 2. Insulation:
 - a. Type.
 - b. Voltage class.
 - 3. AWG size.
 - 4. Conductor material.
 - 5. Pulling compounds.
- C. Shop drawings:
 - 1. Show splice locations.
 - a. For each proposed splice location provide written justification describing why the splice is necessary.
- D. Test reports:
 - 1. Submit test reports for meg-ohm tests.
- E. Calculations:
 - 1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
 - a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.

- b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. 600 volt class wire and cable:
 - a. General Cable.
 - b. Okonite Co.
 - c. Southwire Co.
 - d. Service Wire.
 - 2. 600 volt VFD cable:
 - a. General Cable.
 - b. Southwire Co.
 - c. Service Wire.
 - 3. Instrumentation class wire and cable:
 - a. Alpha Wire Co.
 - b. Belden CDT.
 - c. General Cable.
 - d. Okonite Co.
 - e. Rockbestos Surprenant Cable Corp.

4. Network cables:
 - a. General Cable.
 - b. Belden.
 - c. CommScope.
5. Fire alarm wire and cable:
 - a. West Penn Wire.
 - b. Olympic Wire and Cable.
 - c. Rockbestos Surprenant Cable Corp.
 - d. Draka, Lifeline.
6. Tray cables:
 - a. General Cable.
 - b. Southwire Co.
 - c. Okonite Co.
 - d. Service Wire.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Conductors:
 1. Copper in accordance with ASTM B3.

2.04 MANUFACTURED UNITS

- A. General:
 1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
 2. Permanently mark each wire and cable with the following at 24-inch intervals:
 - a. AWG size.
 - b. Voltage rating.
 - c. Insulation type.
 - d. UL symbol.
 - e. Month and year of manufacture.
 - f. Manufacturer's name.
 3. Identify and mark wire and cable as specified in Section 26_05_53 - Identification for Electrical Systems:
 - a. Use integral color insulation for #2 AWG and smaller wire.
 - b. Wrap colored tape around cable larger than #2 AWG.
- B. 600 volt class wire and cable:
 1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
 - a. When not indicated on the Drawings, size wire as follows:
 - 1) In accordance with the NEC:
 - a) Use 75 degree Celsius ampacity ratings.
 - b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
 - 2) Provide #12 AWG minimum for power conductors.
 - 3) Provide #14 AWG minimum for control conductors.
 2. Provide Class B stranding in accordance with ASTM B8:
 - a. Provide Class C stranding where extra flexibility is required.

3. Insulation:
 - a. XHHW-2.
 - b. 90 degree Celsius rating.
 4. Multiconductor cables:
 - a. Number and size of conductors as indicated on the Drawings or in the Conduit Schedules.
 - b. Individual conductors with XHHW-2 insulation.
 - c. Overall PVC jacket.
 - d. Tray cable rated.
 - e. Color-coding for control wire in accordance with ICEA Method 1, E-2 in accordance with NEMA WC 57/ICEA S-73-532.
 - f. Ground conductor: Bare:
 - 1) Sized in accordance with NEC.
- C. 600 volt VFD cables:
1. Conductor:
 - a. Provide Class B stranding in accordance with ASTM B8.
 2. Insulation:
 - a. Cross-linked Polyethylene.
 - b. 90 degree Celsius rating.
 - c. UL 44 Type RHH/RHW-2 or XHHW-2.
 3. Ground:
 - a. Provide Class B stranding in accordance with ASTM B8.
 - b. 3 symmetrically placed bare copper conductors in direct contact with shield.
 4. Metallic shield:
 - a. Overall 5 mil bare copper tape shield with 50 percent overlap.
 5. Outer jacket:
 - a. UL 1277 Type PVC.
 6. Cable tray rated, UL Type TC-ER.
- D. Instrumentation class cable:
1. Type TC.
 2. Suitable for use in wet locations.
 3. Voltage rating: 600 volts.
 4. Temperature rating:
 - a. 90 degree Celsius rating in dry locations.
 - b. 75 degree Celsius rating in wet locations.
 5. Conductors:
 - a. Insulation:
 - 1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
 - b. #16 AWG stranded and tinned.
 - c. Color code: ICEA Method 1:
 - 1) Pair: Black and white.
 - 2) Triad: Black, white and red.
 - 3) Multiple pairs or triads:
 - a) Color-coded and numbered.
 6. Drain wire:
 - a. #18 AWG.
 - b. Stranded, tinned.

7. Jacket:
 - a. Flame retardant, moisture and sunlight resistant PVC.
 - b. Ripcord laid longitudinally under jacket to facilitate removal.
 8. Shielding:
 - a. Individual pair/triad:
 - 1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
 - b. Multiple pair or triad shielding:
 - 1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
 - 2) Completely isolate group shields from each other.
 - 3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
 - c. All shielding to be in contact with the drain wire.
- E. Network cables:
1. Category 5e:
 - a. General:
 - 1) Provide Cat 5e cables meeting the standards set by TIA/EIA-568-C.2 and verified by third-party testing laboratory.
 - b. Conductors:
 - 1) #24 AWG solid bare annealed copper.
 - c. Insulation:
 - 1) Polyolefin.
 - 2) 4 non-bonded twisted pair cables formed into a cable core.
 - d. Shielding:
 - 1) SF/FTP.
 - e. Color code (T568B):
 - 1) Pair 1: White/blue stripe and blue.
 - 2) Pair 2: White/orange stripe and orange.
 - 3) Pair 3: White/green stripe and green.
 - 4) Pair 4: White/brown stripe and brown.
 - f. Outer jacket:
 - 1) PVC with ripcord.
 - g. Electrical characteristics
 - 1) Voltage rating: 600VAC.
- F. Tray cable:
1. Provide minimum size #1/0 AWG for single wires, for CT use:
 - a. Listed and identified on its surface as suitable for cable tray use.
 2. Provide multi-conductor cable listed and identified on its surface as suitable for cable tray use, Type TC cable in accordance with the NEC:
 - a. Provide with an integral white insulated conductor where a neutral is required.
 3. Ambient temperature adjustment in accordance with the NEC.
- G. Fire alarm cable:
1. Number of pairs: As indicated on the Drawings or as necessary for the application.
 2. Voltage rating: 300 V minimum.
 3. 2-hour fire rating in accordance with UL 2196.
 4. Provide fire alarm cable in accordance with the requirements of UL 1424.

5. Provide Type FPLP (power-limited plenum rated) for all cabling within ducts, plenums, and all spaces used for air handling:
 - a. Cable must meet NEC standards, and must have adequate fire-resistant and low smoke-producing characteristics.
6. Provide Type FPLR (power-limited riser rated) for all vertical runs that pass from floor to floor:
 - a. FPLR cable must meet NEC standards, and must have fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.
7. FPL (power-limited general purpose) is only suitable for general-purpose fire alarm use and shall not be used for risers, ducts, plenums, and in air-handling spaces:
 - a. FPL cable must meet NEC standards, and must be listed as resistant to the spread of fire.
8. Cable substitutions are not permitted unless approved by Engineer.
9. Meets code requirements of NFPA 72 and NFPA 101.
10. Conductor insulation:
 - a. Low smoke PVC.
 - b. Minimum 105 degree Celsius rating.
11. Conductor jacket:
 - a. Low smoke PVC.
 - b. Ripcord and surface-printed with year of manufacture and cable description at maximum 24-inch intervals.
 - c. Minimum 105 degree Celsius rating.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Wire ties:
 1. One of the following or equal:
 - a. T&B, "Ty-Rap" cable ties.
 - b. Panduit, cable ties.
- B. Wire markers:
 1. As specified in Section 26_05_53 - Identification for Electrical Systems.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.
- B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Color-coding:
 - 1. Color-coding shall be consistent throughout the facility.
 - 2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Single phase system: Black for 1 hot leg, red for the other.
 - e. Neutral: White.
 - f. High phase or wild leg: Orange.
 - g. Equipment ground: Green.
 - 3. The following color code shall be followed for all 480/277 volt systems:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray.
 - e. Equipment ground: Green.
 - 4. The following color code shall be followed for all 120 VAC control wiring:
 - a. Power: Red.
 - b. Neutral: White.
 - 5. The following color code shall be followed for all general purpose DC control circuits:
 - a. Grounded conductors: White with blue stripe.
 - b. Ungrounded conductors: Blue.
 - 6. Switch legs shall be violet. 3-way switch runners shall be pink.
 - 7. Wires in intrinsically safe circuits shall be light blue.
 - 8. Wire colors shall be implemented in the following methods:
 - a. Wires manufactured of the desired color.
 - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
 - 1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.
- C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
 - 1. Install wires only in approved raceways.
 - 2. Do not install wire:
 - a. In incomplete conduit runs.
 - b. Until after the concrete work and plastering is completed.

- D. Properly coat wires and cables with pulling compound before pulling into conduits:
 - 1. For all #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
 - a. Ideal Products.
 - b. Polywater Products.
 - c. 3M Products.
 - d. Greenlee Products.
 - e. Or equal as recommended by cable manufacturer.
 - f. Do not use oil, grease, or similar substances.
- E. Cable pulling:
 - 1. Prevent mechanical damage to conductors during installation.
 - 2. For cables #1 AWG and smaller, install cables by hand.
 - 3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
 - 4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
 - 5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
 - 6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
 - a. Make splices in manholes or pull boxes only.
 - b. Leave sufficient slack to make proper connections.
- F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.
- G. Install and terminate all wire in accordance with manufacturer's recommendations.
- H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
 - 1. Do not lace wires in gutter or panel channel.
 - 2. Install all wire ties with a flush cutting wire tie installation tool:
 - a. Use a tool with an adjustable tension setting.
 - 3. Do not leave sharp edges on wire ties.
- I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
 - 1. Use ring type lugs if box lugs are not available on the equipment.
- J. Lighting circuits:
 - 1. Each circuit shall have a dedicated neutral.
- K. Splices:
 - 1. Provide continuous circuits from origin to termination whenever possible:
 - a. Obtain Engineer's approval prior to making any splices.
 - 2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.

3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
 - a. Splice box NEMA rating requirements as specified in Section 26_05_00 - Common Work Results for Electrical.
 - b. Make splices in labeled junction boxes for power conductors.
 - c. Make splices for control and instrument conductors in terminal boxes:
 - 1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
 4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
 5. Clearly label junction and terminal boxes containing splices with the word "SPlice LOCATED WITHIN".
 6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
 7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
 - a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
 8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
 - a. A heat shrink insulating system listed for submersible applications.
 - b. Or an epoxy resin splicing kit.
- L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.
- M. Instrumentation class cable:
1. Install instrumentation class cables in separate raceway systems from power cables:
 - a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
 - b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
 2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
 3. Shield grounding requirements as specified in Section 26_05_26 - Grounding and Bonding.
- N. Copper Ethernet cables:
1. Comply with TIA/EIA-568-C.2.
 2. Pathways:
 - a. For initial installation, the maximum fill capacity for pathways (i.e. conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
 - b. Conduit should be run in the most direct route possible with no more than two 90 degree bends between pull boxes and serve no more than 3 outlet boxes.
 3. Cable bend radius:
 - a. Proper cable bend radius control must be maintained throughout the pathways. The bend radius needs to be at a minimum 10 times the cable diameter.

4. Cable pulling:
 - a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
 - b. The maximum pulling tension is not to exceed manufacturer recommendations. Cable installation should not in any way deform the cable jacket.
 - c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
5. Cable management:
 - a. Organize and manage cables for quick and easy moves, adds and changes.
6. Testing:
 - a. All cables and termination hardware shall be 100 percent tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements of TIA/EIA-568-C.1 Section 11.
 - 1) All pairs of each installed cable shall be verified prior to system acceptance.
 - 2) Any defect in the cabling system installation including but not limited to cable, connectors, feed through couplers, patch panels, and connector blocks shall be repaired or replaced in order to ensure 100 percent useable conductors in all cables installed.
 - b. All twisted-pair copper cable links shall be tested for compliance to the requirements in TIA/EIA/568-C.2 for the appropriate Category of cabling installed.
 - c. All cables shall be tested in accordance with the contract documents, TIA/EIA standards, and best industry practice.
 - d. The field test equipment shall meet the requirements of TIA/EIA-568-C. The appropriate level III tester shall be used to verify Category 6 cabling.
 - e. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-C.1.
 - f. Visually inspect cable placement, cable termination, grounding and bonding, equipment and labeling of all components.
 - g. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors.
 - 1) Test operation of shorting bars in connection blocks.
 - 2) Test cables after termination but not cross-connection.
 - a) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-C.2.
 - (1) Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex.
 - (2) Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

7. Separation from EMI sources:
 - a. Comply with TIA/EIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches
 - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
 - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
 - e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
- O. Multi-conductor cable:
 1. Where cable is not routed in conduit with a separate ground conductor, use 1 conductor in the cable as a ground conductor:
 - a) Use an internal ground conductor, if it is no smaller than as indicated on the Drawings and in accordance with NEC requirements for equipment ground conductor size.
 - b) Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with one of the full-sized conductors serving as ground.
- P. Fire alarm cable:
 1. Install fire alarm cable in dedicated metallic raceways as indicated on the Drawings.
- Q. Signal cable:
 1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

- R. Wiring allowances:
1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
 2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Grounding:
1. As specified in Section 26_05_26 - Grounding and Bonding.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_21

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
 - 1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- C. CSA International (CSA):
 - 1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

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

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures and 26_05_00 - Common Work Results for Electrical.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Installation instructions.

1.06 QUALITY ASSURANCE

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Control connections:

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

- B. Joints, splices, taps, and connections:
 - 1. 600-volt conductors:
 - a. Use solderless connectors.
 - b. Use only plated copper alloy connectors or lugs:
 - 1) Aluminum connectors or lugs are not acceptable for copper conductors.
 - c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
 - d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
 - 1) Manufacturers: The following or equal:
 - a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
 - e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
 - 1) Manufacturers: One of the following or equal:
 - a) Burndy.
 - b) Thomas and Betts.
 - f. Heat shrink tubing:
 - 1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
 - 2) Minimum shrink ratio: 4 to 1.
 - 3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
 - 4) Internally applied adhesive sealant.
 - 5) Cross-linked polyolefin:
 - a) Manufacturers: One of the following or equal:
 - (1) 3M, ITCSN.
 - (2) Thomas & Betts, Shrink-Kon.
 - 2. Instrumentation class cable splices:
 - a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
 - b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
 - c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
 - d. Two-part mold body with tongue and groove seams and built in spacer webbing.
 - e. Manufacturers: The following or equal:
 - 1) 3M, Scotchcast 72-N.
- C. Insulating tape:
 - 1. General purpose insulating tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
 - c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
 - d. Flame retardant, hot- and cold- weather resistant, UV resistant.
 - e. For use as a primary insulation for wire cable splices up to 600 VAC.
 - f. Meeting and complying with:
 - 1) ASTM D3005 Type I.
 - 2) UL 510.
 - 3) CSA C22.2.

- g. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number Super 33+.
- 2. General-purpose color-coding tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application on PVC and polyethylene jacketed cables.
 - c. For use indoors and outdoors in weather protected enclosures.
 - d. Available with the following colors:
 - 1) Red.
 - 2) Yellow.
 - 3) Blue.
 - 4) Brown.
 - 5) Gray.
 - 6) White.
 - 7) Green.
 - 8) Orange.
 - 9) Violet.
 - e. For use as phase identification, marking, insulating, and harnessing.
 - f. Meeting and complying with:
 - 1) UL 510.
 - 2) CSA C22.2.
 - g. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number 35.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Load connections:
 - 1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 26_05_18 - 600-Volt or Less Wires and Cables.
- C. Zero to 600-volt systems:
 - 1. Make all connections with the proper tool and die as specified by the device manufacturer.

2. Use only tooling and dies manufactured by the device manufacturer.
 3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
 4. Number all power and control wires before termination.
- D. Motor connections (600 volts and below):
1. Terminate all leads and wires with compression type ring lugs.
 2. Terminations on all motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
 3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
 - a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
 - b. Shrink cap with low heat as recommended by manufacturer.
 4. Wire markers shall be readable after boot installation.
 5. Manufacturers: The following or equal:
 - a. Raychem, MCK.
 - b. Elastimold.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_26
GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Grounding materials and requirements.

1.02 REFERENCES

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
 - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 3. B33 – Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures and 26_05_00 - Common Work Results for Electrical.
- B. Product data:
 - 1. Catalog cut sheets.

1.05 QUALITY ASSURANCE

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. All grounding components and materials shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.07 PROJECT/SITE CONDITIONS (NOT USED)

1.08 SEQUENCING (NOT USED)

1.09 SCHEDULING (NOT USED)

1.10 WARRANTY

- A. As specified in Section 26_05_00 - Common Work Results for Electrical

1.11 SYSTEM START-UP

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.12 OWNER'S INSTRUCTIONS (NOT USED)

1.13 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

2.02 SYSTEM DESCRIPTION

- A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.

- B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
 - 1. Grounding electrodes.
 - 2. Bonding jumpers.
 - 3. Ground connections.
- C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
- D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 26_08_50 - Field Electrical Acceptance Tests, shall be:
 - 1. 5 ohms or less for industrial systems.
 - 2. 1 ohm or less for electrical buildings.

2.03 EXISTING PRODUCTS (NOT USED)

2.04 MATERIALS

- A. Ground rod:
 - 1. Minimum: 3/4-inch diameter, 10 feet long.
 - 2. Uniform 10 mil covering of electrolytic copper metallurgically bonded to a rigid steel core:
 - a. The copper-to-steel bond shall be corrosion resistant.
 - 3. In accordance with UL 467.
 - 4. Sectional type joined by threaded copper alloy couplings.
 - 5. Fit the top of the rod with a threaded coupling and steel-driving stud.
- B. Ground cable:
 - 1. Requirements:
 - a. Soft drawn (annealed).
 - b. Concentric lay, coarse stranded in accordance with ASTM B8.
 - c. Bare copper in accordance with ASTM B3.
 - d. Bare tinned-copper in accordance with ASTM B33.
 - 2. Size is as indicated on the Drawings, but not less than required by the NEC. Use the following type of wire unless otherwise indicated on the Drawings:
 - a. Size #6 AWG and smaller; solid conductor.
 - b. Size #4 AWG and larger; stranded conductor.
- C. Compression connectors:
 - 1. Manufactured of high copper alloy specifically for the particular grounding application.
 - 2. Suitable for direct burial in earth and concrete.
 - 3. Identifying compression die number inscription to be impressed on compression fitting.
 - 4. Barrels prefilled and sealed with oxide-inhibiting and anti-seizing compound.
- D. Exothermic welds:
 - 1. Current carrying capacity equal to that of the conductor.
 - 2. Permanent molecular bond that cannot loosen or corrode over time.
 - 3. Will not deteriorate with age.
 - 4. Use low emission welds for indoor installations.

- E. Equipment grounding conductors:
 - 1. Conductors shall be the same type and insulation as the load circuit conductors:
 - a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
 - 2. Minimum size in accordance with the NEC.
- F. Grounding electrode conductors:
 - 1. Minimum size in accordance with the NEC.
- G. Main bonding jumpers and bonding jumpers:
 - 1. Minimum size in accordance with the NEC.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

- A. Precast ground well boxes:
 - 1. Minimum 10 inch interior diameter.
 - 2. Traffic-rated cast iron cover.
 - 3. Permanent "GROUND" marking on cover.

2.09 MIXES (NOT USED)

2.10 FABRICATION (NOT USED)

2.11 FINISHES (NOT USED)

2.12 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
 - 1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
 - 2. Provide a separate grounding conductor in each individual raceway for parallel feeders.

- C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
 - 1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.
- D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
 - 1. Individually bond these raceways to the ground bus in the equipment.
- E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.
- F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.
- G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.
- H. Duct bank ground system:
 - 1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
 - 2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.
- I. Grounding at service (600 V or Less):
 - 1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.
- J. Ground connections:
 - 1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors or exothermic welds as indicated on the Drawings, UL listed, and labeled for the application.
 - 2. Make ground connections in accordance with the manufacturer's instructions.
 - 3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.
- K. Grounding electrode system:
 - 1. Ground ring:
 - a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
 - b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
 - c. Minimum burial depth 36 inches or as indicated on the Drawings.
 - d. Re-compact disturbed soils to original density in 6-inch lifts.

2. Ground rods:
 - a. Locations as indicated on the Drawings.
 - b. Length of rods forming an individual ground array shall be equal in length.
 - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
 - d. Install all ground rods, coupled, to result in an overall length of 20 foot each.
 3. Metal underground water pipe:
 - a. Bond metal underground domestic water pipe to grounding electrode system.
 4. Metal frame of building or structure:
 - a. Bond metal frame of building or structure to grounding electrode system.
 5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
 6. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.
 7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.
- L. Shield grounding:
1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
 2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
 3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
 4. Terminate the signal cable shield on a dedicated grounding terminal block.
- M. Where indicated on the Drawings, install ground rods in precast ground wells.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.09 ADJUSTING

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

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_05_53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Identification of electrical equipment, devices, and components.
 - 2. Material, manufacturing, and installation requirements for identification devices.
- B. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 01_75_17 - Commissioning.
 - 3. Section 26_05_00 - Common Work Results for Electrical.
 - 4. Section 26_05_33 - Conduits.
 - 5. Section 26_06_01 - Conduit Schedule.

1.02 REFERENCES

- A. As specified in Section 26_05_00.
- B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

- A. As specified in Section 26_05_00.

1.04 SYSTEM DESCRIPTION

- A. Nameplates:
 - 1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components in accordance with Owner Standard.
 - 2. Provide all nameplates of identical style, color, and material throughout the facility.
 - 3. Device nameplates information:
 - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
 - b. All nameplates shall be reviewed and approved by Owner.
- B. Wire numbers:
 - 1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
 - a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
 - b. Wire numbers shall correspond to the documented drawings of the control panel.

- c. Internal panel wires on a common terminal shall have the same wire number.
- d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
 - 1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 26_05_33.
- 2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PLC), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

(ORIGIN LOC.)–(ORIGIN TERM.)/(DEST. LOC.)–(DEST. TERM.)

OR

(ORIGIN LOC.)–(ORIGIN TERM.)
(DEST. LOC.)–(DEST. TERM.)

Where:

ORIGIN LOC.	= Designation for originating panel or device
ORIGIN TERM.	= Terminal designation at originating panel or device
DEST. LOC.	= Designation for destination panel or device
DEST. TERM.	= Terminal designation at destination panel or device or PLC

I/O address at destination panel:

- a. Identify equipment and field instruments as the origin.
- b. PLCs are always identified as the destination.
- c. Location is the panel designation for VCP, LCP, or PLC. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
- d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
- e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
- f. Refer to final loop drawings provided by Owner for wire labeling.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 26_05_00.

- B. Product data:
 - 1. Nameplates:
 - a. Color.
 - b. Size:
 - 1) Outside dimensions.
 - 2) Lettering.
 - c. Material.
 - d. Mounting means.
 - 2. Nameplate schedule:
 - a. Show exact wording for each nameplate.
 - b. Include nameplate and letter sizes.
 - 3. Wire numbers:
 - a. Manufacturer's catalog data for wire labels and label printer.
- C. Record documents:
 - 1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 26_05_00.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 26_05_00.

1.12 SYSTEM START-UP

- A. As specified in Section 26_05_00.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Nameplates and signs:
 - 1. One of the following or equal:
 - a. Brady, Identoline detectable warning tapes for underground installations, Brady fiberglass or phenolic plastic for area signs.
 - b. Seton.

- B. Conductor and cable markers:
 - 1. Heat-shrinkable tubing:
 - a. One of the following or equal:
 - 1) Raychem.
 - 2) Brady.
 - 3) Thomas & Betts.
 - 4) Kroy.
 - 2. Marker printer:
 - a. The following or equal:
 - 1) Brady.
 - 3. Pre-printed slip-on sleeve markers:
 - a. The following or equal:
 - 1) Grafoplast.
 - 2) Engineer knows of no equal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Nameplates:
 - 1. Fabricated from white-center and blue face laminated plastic engraving stock:
 - a. 3/32-inch thick material.
 - b. Two-ply.
 - c. With chamfered edges.
 - d. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
 - 1) No characters smaller than 1/8-inch in height.
- B. Signs:
 - 1. Automatic equipment and high voltage signs:
 - a. Suitable for exterior use.
 - b. In accordance with OSHA regulations.
- C. Conduit and raceway markers:
 - 1. Stainless Steel.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Nameplates:
 - 1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
 - a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 26_05_00.
- B. Nameplates:
 - 1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
 - 2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
 - 3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
 - a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.
- C. Conductor and cable markers:
 - 1. Apply all conductor and cable markers before termination.
 - 2. Heat-shrinkable tubing:
 - a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
 - b. Tubing shall be tight on the wire after it has been heated.
 - c. Characters shall face the open panel and shall read from left to right or top to bottom.
 - d. Markers shall be aligned and be in an unobstructed view.
- D. Conduit markers:
 - 1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
 - a. Conduit markings shall match the conduit schedule.
 - 2. Mark conduits at the following locations:
 - a. All conduits routing below grade.
 - b. All conduits that cannot be traced visually.
 - 3. Mark conduits after the conduits have been fully painted.
 - 4. Position conduit markers so that they are easily read from the floor.

5. Attach tags with Type 316 stainless steel wires.
6. Mark conduits before construction review by Engineer for punch list purposes.
7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

E. Signs and labeling:

1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
 - a. Fasten warning signs with round head stainless steel screws or bolts.
 - b. Locate and mount in a manner to be clearly legible to operations personnel.
2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc., where the voltage exceeds 600 volts.
3. Furnish and install warning signs on equipment that has more than one source of power.
 - a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
 - a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01_75_17.

3.08 FIELD QUALITY CONTROL

- A. Replace any nameplates, signs, conductor markers, cable markers, or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 26_28_01

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. AB 3. - Molded Case Circuit Breakers and Their Application.
- C. Underwriter's Laboratories (UL):
 - 1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 - 2. 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

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

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures and 26_05_00 - Common Work Results for Electrical.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

1.06 QUALITY ASSURANCE

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.
- B. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

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

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:

1. Conforming to UL 489.
2. Operating mechanism:
 - a. Quick-make, quick-break, non-welding silver alloy contacts.
 - b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
 - c. Mechanically trip free from the handle.
 - d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
 - e. Lockable in the "OFF" position.

3. Arc extinction:
 - a. In arc chutes.
 4. Voltage and current ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Minimum frame size 100A.
 5. Interrupting ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).
- B. Motor circuit protectors:
1. Instantaneous only circuit breaker as part of a listed combination motor controller.
 2. Each pole continuously adjustable in a linear scale with 'LO' and 'HI' settings factory calibrated.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

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

2.07 ACCESSORIES

- A. Lockable handle:
 - 1. Provide assembly to lock operating handle in 'OPEN' position.
 - 2. Where a molded case circuit breaker is located in a dedicated enclosure, provide a lockable handle. Reference the Electrical Specifications for additional locking requirements associated with other mounting installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

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

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 26_05_00 - Common Work Results for Electrical.

3.09 ADJUSTING

- A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.
- B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 26_05_00 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_05_57.23

ELECTRIC ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Electric motor-driven actuators for gate valves as identified in the actuator schedule.
- B. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 46_05_10 - Common Work Results for Mechanical Equipment.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C540 - AWWA Standard for Power-Actuating Devices for Valves and Slide Gates.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

- A. NEMA:
 - 1. Type 4X enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

- A. Submit as specified in Sections 01_33_00 and 46_05_10.
- B. Provide a complete list/schedule of all actuators being provided with their associated tag names as indicated on the design Drawings and/or Specifications, service process area and the size of the valve they are actuating.
- C. Clearly identify any exceptions in terms of quantities and/or quality of actuator(s) being submitted.
- D. Product data:
 - 1. Electrical ratings:
 - a. Voltage and number of phases.
 - b. Starting and running current.
 - c. Voltage levels and source for control and status.
 - 2. Description of integral control interface.
 - 3. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
 - 4. Gear ratios for both manual and motorized actuation.
 - 5. Opening and closing directions.
 - 6. Allowable starts per hour.

7. List of all included options and accessories.
 8. Full travel times.
 9. Gearbox data including gear ratio, and gearbox efficiency.
 10. Affidavit in accordance with AWWA C540.
- E. Shop drawings:
1. Wiring diagrams:
 - a. Include all options and expansion cards furnished with each actuator.
 2. Dimensioned drawings of each valve and actuator combination.
 3. Dimensioned drawings of each valve gearbox.
 4. Electric motor data.
- F. Calculations: Submit the following for each valve/gate size and class signed by Professional Engineer:
1. Operating torque calculations.
 2. Maximum torque calculations for seating and unseating.
 3. Maximum operating torque at starting and normal operation.
- G. Test reports:
1. Factory test report and certificate.
 2. Each actuator must be performance tested with a simulated load at the factory and individual test certificates and detailed test reports shall be provided:
 - a. The test equipment used should simulate a typical valve load.
- H. Manufacturer's instructions:
1. Include manufacturer's instructions, description of system operation, start-up data, and troubleshooting checklist.
- I. Operations and maintenance data:
1. Include manufacturer's literature; cleaning procedures, replacement part lists, wiring diagrams, and repair data.
 2. Include a list of all configurable parameters, and the final values for each.
 3. List of recommended spare parts.
 4. List of special tools necessary for proper operation and/or maintenance.
 5. Exploded view drawings that illustrate all assemblies, sub-assemblies, and components.
 6. Routine test procedures for all electronic and electrical circuits.
 7. Troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.
 8. Certified factory and field-test results.

1.05 QUALITY ASSURANCE

- A. Obtain required information from the valve/gate supplier, including but not limited to:
1. Interface to gate or valve.
 2. Operating range (In degrees).
 3. Quarter turn or multi-turn.
 4. Required turns for full travel on multi-turn applications.
 5. Direction of rotation for opening and closing.
 6. Maximum and normal torque requirements.
 7. Additional sizing requirements indicated in this Section.

- B. All motorized, intelligent actuators shall be the product of a single manufacturer for all valve and gate applications on this project, regardless of gate or valve type, manufacturer, or supplier.

1.06 SPARE PARTS

- A. Provide the following spare parts (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
 - 1. Stem nut.
 - 2. Worm shaft subassembly.
 - 3. Drive sleeve subassembly.
 - 4. Complete actuator seal kit.
 - 5. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
 - 6. Encoder.
 - 7. Control module.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or Engineer approved equal:
- B. Acceptable manufacturers for lines 4 inch and larger:
 - 1. One of following or equal:
 - a. Rotork Controls Inc.:
 - 1) IQ3 (Multi-turn).

2.02 CHARACTERISTICS FOR ACTUATORS ON LINES 4 INCHES AND LARGER

- A. Provide actuators complete and operable with all components and accessories required for operation.
- B. Power supply:
 - 1. Voltage and phases as indicated in the Schedule.
 - 2. Valve or gate motion independent of power supply phase rotation.
 - 3. Provide an internal backup power source to maintain settings and track valve position when main power is off.
 - 4. The actuators shall incorporate all major components such as the motor, starter, local controls, terminals etc. housed within a self-contained, sealed enclosure.
- C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Schedule:
 - 1. If an operating time is not indicated on the Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
 - 2. Size actuators so that gear boxes are not required where possible.

- D. Control interface:
1. Configuration:
 - a. Provide a non-intrusive, non-contacting interface for configuring all input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options:
 - 1) Configurable from a hand-held configuring tool or input devices on the actuator.
 2. Local interface, integral to actuator:
 - a. Non-intrusive, non-contacting selector switches:
 - 1) LOCAL-STOP-REMOTE:
 - a) Motor actuator operation is prevented with the switch in STOP.
 - 2) OPEN-CLOSE:
 - a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
 - b) Spring return to center.
 - c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
 - b. Local display:
 - 1) Valve fully open and fully closed indicators.
 - 2) Numerical display showing actual valve or gate position in percent of travel.
 3. Control inputs:
 - a. Capable of using 120 VAC or 24 VDC inputs.
 - b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
 - c. Isolated inputs capable of operating from external control voltage source or internal power supply:
 - 1) Furnish 120 VAC and 24 VDC control power supplies within the actuator.
 - d. Provide the following inputs:
 - 1) OPEN.
 - 2) CLOSE.
 - 3) STOP.
 - e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).
 4. Status outputs:
 - a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
 - b. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
 - 1) Fully closed.
 - 2) Fully open.
 - 3) LOCAL-STOP-REMOTE in REMOTE position.
 - c. Capable of being configured for the following additional functions:
 - 1) Communications failure.
 - 2) Valve opening or closing.
 - 3) Valve moving (continuous or pulsing).
 - 4) Motor tripped on torque in mid-travel.
 - 5) Open or close interlock active.
 - 6) ESD active.

- 7) Motor tripped on torque in mid-travel.
 - 8) Motor tripped on torque going open.
 - 9) Motor tripped on torque going closed.
 - 10) Pre-set torque exceeded.
 - 11) Valve jammed.
 - 12) Lost main power phase.
 - 13) Control supply lost.
 - 14) Internal failure detected.
 - d. All output contacts rated for 5 amps, 120 VAC and 24 VDC.
 5. Analog input when modulating duty:
 - a. Provide a 4-20 milliampere analog input for analog modulating valves when indicated on the Drawings.
 - b. Modulate valve to maintain position based on analog input value.
 - c. Maximum input impedance 250 ohms.
 6. Analog outputs when modulating duty:
 - a. Provide an isolated 4-20 milliampere analog outputs when indicated on the Drawings:
 - 1) Loop power sourced from the actuator power supply.
 - 2) Capable of driving into a load up to 500 ohms.
 - 3) Output proportional to process value(s) indicated on the Drawings.
 - 4) Valve or gate position.
 - 5) Operating torque.
- E. Features:
1. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.
 2. Data logging:
 - a. Store diagnostic data and reference data:
 - 1) Store reference data (recorded during commissioning) and data from last operation.
 3. Provide display of logged data on the actuator, or provisions to download to a personal computer.
- F. Materials:
1. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.
- G. Components:
1. Motors:
 2. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
 3. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety:
 - a. Design requirements for rubber-seated AWWA butterfly valves:
 - 1) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C540:
 - a) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.

- b) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
 - b. Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
 - 1) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540.
 - 2) Design for the maximum torque and thrust running load over the full cycle.
 - 3) Maximum torque or thrust rating: The actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.
 - 4. Capable of being removed and replaced without draining the actuator gear case.
 - 5. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
 - 6. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius:
 - a. Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
 - b. 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
 - 7. Provide the following motor protection features:
 - a. Jammed valve (no valve motion detected through a time delay).
 - b. High motor temperature (sensed by an embedded thermostats).
 - c. High torque.
 - d. Single phasing protection.
- H. Enclosures:
 - 1. Actuator housing ratings as indicated in the Schedule.
 - 2. Stainless steel external fasteners.
 - 3. Provide 'O' ring seals for each of the following areas:
 - a. Between the terminal compartment and the internal electrical elements.
 - b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.
 - 4. Provide the following minimum enclosure ratings:
 - a. NEMA Type 4X enclosure for general applications.
- I. Position sensing:
 - 1. Electronic and adjustable using a solid-state encoder wheel:
 - a. Mechanical limit switches and potentiometers are not acceptable.
 - 2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
 - 3. Valve range and position switch outputs field adjustable.
- J. Torque sensing:
 - 1. Torque shutdown setting: 40 percent to 100 percent rated torque:
 - a. Adjustable in 1 percent increments.
 - 2. Torque display: 0 to 100 percent-rated torque.

3. Capable of interrupting control circuit during both opening and closing and when valve torque overload occurs.
 4. Electrical or electronic torque sensing.
 5. Independent of variations in frequency, voltage, or temperature.
 6. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
 7. Provide visible verification of torque switch status without any housing disassembly.
- K. Manual actuators:
1. Hand wheel for manual operation:
 - a. Maximum 80-pound pull on rim when operating gate or valve under maximum load.
 - b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface:
 - 1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
 - 2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
 2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.
- L. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set:
1. Accurately cut to assure minimum backlash.
- M. Bearings:
1. Anti-friction bearing with caged balls or rollers throughout.
 2. Sealed-for-life type thrust bearings housed in a separate thrust base.
- N. Drive bushing:
1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
 2. Positioned in a detachable base of the actuator.
- O. Lubrication:
1. Provide totally enclosed actuator gearing with oil filled gear case suitable for operation at any angle.
 2. Suitable for standard SAE80EP gear oil.
 3. Actuators requiring special or exotic lubricants are not acceptable.

2.03 ACCESSORIES

- A. Software:
1. Provide software communications to the valve actuator and handheld setting tool using Bluetooth wireless communications:
 - a. Provide all accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.

- B. Setting tool:
 - 1. If required for setting or configuring the actuator, provide a hand-held setting tool.
 - a. Furnish 1 setting tool for every 10 actuators.
- C. Termination module cover:
 - 1. For actuators on a valve network provide a means to keep the valve network in service, in the event where the actuator must be removed.
 - 2. Provide sunshades for all outdoor installations of remote control stations that use a LCD or similar screen. Regular pushbutton, sector switches, and pilot light control stations will not require a sunshade.

2.04 SOURCE QUALITY CONTROL

- A. Factory test:
 - 1. Test each actuator in the factory, and submit an individual test certificate for each actuator.
 - 2. Perform a high potential test and record the following information:
 - a. Test voltage.
 - 3. Simulate a maximum and typical valve loads and record the following information:
 - a. Current and power factor at maximum and set torque values.
 - b. Torque as measured by the actuator.
 - c. Actuator output speed or operating time.
 - 4. Performance testing: Conduct performance test for each actuator simulating valve operating torque from full-open to full-close and from full-close to full-open. The following information shall be recorded during each performance test:
 - a. Torque at maximum torque setting.
 - b. Current at maximum torque setting.
 - c. Test voltage and frequency.
 - d. Actuator output speed and operating time for full-open to full-close.
 - e. Amperage draw on motors at breakaway and under normal operation.
- B. Field verify characteristics prior to sizing motor actuator.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install actuators in accordance with manufacturer's instructions.

3.02 MOTORIZED ACTUATOR SCHEDULE

- A. Provide all actuators indicated on the Drawings:
 - 1. Major process actuators are listed in the Intelligent Actuator Schedule in this section.
 - 2. The schedule does not include all number and types of actuators required for the Project.

- B. Abbreviations relating to type:
1. BFV = Butterfly Valve.
 2. BV = Ball Valve.
 3. PV = Plug Valve.
 4. SG = Slide Gate.
 5. KGV = Knife Gate Valve.
- C. Abbreviations relating to actuator type:
1. O/C = Open and Close Service.
 2. MOD = Modulating Service.
- D. Abbreviations relating to controls:
1. PA = Profibus PA.
 2. DP = Profibus DP.
 3. DN = DeviceNet.
 4. FF = Foundation Fieldbus H1.
 5. MB = Modbus RTU (RS-485).
 6. NET = Manufacturer's proprietary network.
 7. A = Analog (4-20 mA) control, modulating duty.
 8. D = Discrete control, modulating duty.
 9. D-O/C = Discrete Open/Close.

END OF SECTION

INTELLIGENT ACTUATOR SCHEDULE									
Item	Reference DWG	Type	Size	Actuator Type	NEMA Rating	Voltage/Phase/Hz	Notes	Open Time	Controls
Struvite Pump Suction Knife Gate Valves	N07, N08	KGV	6"	O/C	4	480/3/60		120 s	D-O/C
Struvite to Sludge Storage Knife Gate Valves	N07, N08	~~SKGV~~	6"	O/C	4	480/3/60		120 s	D-O/C

SECTION 40_05_65.01

GATE VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Gate valves.
- B. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 01_75_17 - Commissioning.
 - 3. Section 01_78_36 - Warranties and Bonds.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. B98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

1.03 SUBMITTALS

- A. Submit as specified in Section 01_33_00.

1.04 WARRANTY

- A. Provide warranty as specified in Section 01_78_36.
- B. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of valves comply in accordance with all provisions of AWWA C550.

PART 2 PRODUCTS

2.01 GATE VALVES

- A. Knife gate valves:
 - 1. Manufacturers: One of the following or equal:
 - a. DeZurick SPX, KGL.
 - b. ITT Fabri-Valve, C37.
 - 2. Design:
 - a. Size and configuration: Indicated on the Drawings.
 - b. Suitable for service under pressures equal to and less than 150 pounds per square inch gauge.
 - c. Full round port, metal seated, raised face design.
 - d. Flanged wafer design drilled and tapped to ASME Class 125/150 standard.
 - e. Rounded gate with beveled edge, finish-ground to 32 RMS, maximum, on both sides.
 - f. Body to incorporate guides and jams to assist in seating.

- g. Materials:
 - 1) Body: Cast or ductile iron or cast steel, with Type 316 stainless steel lining or cast Type 316 stainless steel.
 - 2) Wetted components (including gate): Type 316 stainless steel.
 - 3) Yoke sleeve: Acid resisting bronze or aluminum bronze.
 - 4) Packing: PTFE.
- h. Outside screw and yoke (OS&Y) with handwheel operator.

PART 3 EXECUTION

3.01 COMMISSIONING

- A. As specified in Section 01_75_17.

END OF SECTION

SECTION 40_61_00

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements applicable to all Process Control and Instrumentation Work.
 - 2. General requirements for process control and instrumentation submittals.
 - 3. As specified in this Section, some PLC programming and SCADA/HMI software configuration will be provided by the Owner, hereinafter referred to as the Owner or Programmer.
- B. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 01_60_00 - Product Requirements.
 - 3. Section 01_75_17 - Commissioning.
 - 4. Section 01_77_00 - Closeout Procedures.
 - 5. Section 01_78_23 - Operation and Maintenance Data.
 - 6. Section 01_81_01 - Project Design Criteria.
 - 7. Section 26_05_00 - Common Work Results for Electrical.
 - 8. Section 26_05_53 - Identification for Electrical Systems.
 - 9. Section 40_80_01 - Testing, Calibration, and Commissioning.
 - 10. Section 46_63_83.01 - Phosphorus Precipitation System.
- C. Interfaces to equipment, instruments, and other components:
 - 1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
 - 2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - 3. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
 - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.

- D. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
 - 1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
 - 2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
 - 3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Instrumentation and Control Specifications' requirements.
- E. Contract Documents:
 - 1. General:
 - a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
 - 2. Contract Drawings:
 - a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the Drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire Drawing set for construction purposes.
 - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
 - 1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
 - 2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
 - c. Installation details:
 - 1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
 - d. Loop Diagrams:
 - 1) Loop diagrams are provided by the Owner.

1.02 REFERENCES

A. Code compliance:

1. The following codes and standards are hereby incorporated into this Section:
 - a. American National Standards Institute (ANSI).
 - b. American Petroleum Institute (API):
 - 1) RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
 - 2) RP 551 - Process Measurement Instrumentation.
 - c. International Organization for Standardization (ISO):
 - 1) 9001 - Quality Management Systems - Requirements.
 - d. International Society of Automation (ISA):
 - 1) 5.1 - Instrumentation Symbols and Identification.
 - 2) 5.4 - Instrument Loop Diagrams.
 - 3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
 - e. National Electrical Manufacturers Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - f. National Fire Protection Association (NFPA).
 - g. National Institute of Standards and Technology (NIST).
 - h. Underwriters Laboratories, Inc. (UL):
 - 1) 508 - Standard of Safety for Industrial Control Equipment.
 - 2) 508A - Standard of Safety for Industrial Control Panels.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations in accordance with:

1. Factory Mutual (FM).
2. International Electrotechnical Commission (IEC).
3. Institute of Electrical and Electronics Engineers (IEEE).
4. International Society of Automation (ISA).
5. International Organization for Standardization (ISO).
6. National Electrical Code (NEC).
7. National Electrical Manufacturers Association (NEMA).
8. InterNational Electrical Testing Association (NETA).
9. National Fire Protection Association (NFPA).
10. National Institute of Standards and Technology (NIST).
11. Underwriters Laboratories (UL).

B. Specific definitions:

1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.

4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
 5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions and diagnostic information.
 6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
 - a. Fieldbus communications signal or both.
 7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24VDC signal, a digital bus communications signal or both.
 8. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.
- C. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
 2. Type 3R enclosure in accordance with NEMA 250.
 3. Type 4 enclosure in accordance with NEMA 250.
 4. Type 4X enclosure in accordance with NEMA 250.
 5. Type 7 enclosure in accordance with NEMA 250.
 6. Type 12 enclosure in accordance with NEMA 250.
- D. Acronym definitions:
1. DPDT: Double-pole, double-throw.
 2. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
 3. FAT: Factory acceptance test also known as Source Test.
 4. HART: Highway addressable remote transducer.
 5. HOA: Hand-Off-Auto control function. In the Hand mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
 6. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.
 7. I/O: Input/Output.
 8. IP: Internet protocol or ingress protection.
 9. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
 10. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.

11. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
12. P&ID: Process and instrumentation diagram.
13. PC: Personal computer.
14. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
15. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
16. PLC: Programmable logic controller.
17. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
18. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
19. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations etc.
20. SPDT: Single-pole, double-throw.
21. SPST: Single-pole, single-throw.
22. UPS: Uninterruptible power supply.
23. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the Owner or Contractor. These panels may contain PLCs, RIO, LOI, HMI, etc.
24. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
 - a. Preparing hardware submittals for field instrumentation.
 - b. Prepare the test plan, the training plan, and the spare parts submittals.
 - c. Procure all hardware.
 - d. Fabricate panels.
 - e. Perform bench calibration and verify calibration after installation.
 - f. Oversee, document, and certify loop testing.
 - g. Oversee, document, and certify system.
 - h. Installation Testing.
 - i. Oversee and document Functional Testing.

- j. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
 - k. Prepare operation and maintenance manuals.
 - l. Conduct training classes.
 - m. Provide Record Documents.
 - n. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
 - o. Perform all required corrective and preventative maintenance.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
- B. Operating facility:
- 1. Portions of this existing facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
 - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction to meet the requirements of the Owner.
 - b. As weather and facility demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
 - c. Where portions of the Work are in existing facilities and require interface to existing circuits, power systems, controls and equipment, perform comprehensive and detailed field investigations of existing conditions. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
 - 2. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
 - 3. Where shown or specified, replace existing field instruments with new.
 - 4. The Contractor is responsible for the integrity and measurement accuracy of all loops. However, any defect found in existing equipment is the responsibility of the Owner.
 - 5. The standards of documentation, instrument tagging, cable and conductor termination, terminal identification and labeling that apply to the new installation apply equally to the existing installation.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01_33_00 and this Section.
- B. General:
 - 1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
 - 2. Furnish the submittals required by each section in the Instrumentation Specifications.

3. Adhere to the wiring numbering scheme specified in Section 26_05_53 throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on all Equipment Drawings.
 4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
- C. Submittal preparation:
1. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
 - a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
 - b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.
- D. Specific submittal requirements:
1. Product data:
 - a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
 - b. Include:
 - 1) Catalog cuts.
 - 2) Bulletins.
 - 3) Brochures.
 - 4) Quality photocopies of applicable pages from these documents.
 - 5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
 - 6) Identify model number and options for the actual equipment being furnished.
 - 7) Neatly cross out options that do not apply or equipment not intended to be supplied.
 - c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
 - d. Adhere to wiring numbering scheme outlined in Section 26_05_53 throughout the Project:
 - 1) Uniquely number each wire per the Specifications.
 - e. Wire numbers must appear on all Equipment Drawings.
 2. Detailed sequence of operation for all equipment or systems.
 3. Operation and maintenance manuals:
 - a. As specified in Section 01_78_23.
 4. Project Record documents:
 - a. Furnish as specified in Section 01_77_00.
 5. Commissioning and Process Start-up Submittals:
 - a. Inform the Owner and or Engineer of the day, date, and time for a scheduled test at least 15 calendar days before the test takes place to allow the Owner and or Engineer sufficient time to plan travel to the test site.
 - b. General testing submittal requirements are specified in this Section.

- c. Test Procedure Submittals:
 - 1) Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
 - a) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
 - b) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
- d. Provide certified and witnessed test and calibration checklists for each of the following tests:
 - 1) Source Testing:
 - a) Also called Factory Acceptance Tests (FAT):
 - b) Submit completed Manufacturer's Certificate of Source Testing as specified in Section 01_75_17.
 - 2) Functional Testing:
 - a) Loop Validation Tests:
 - (1) Loop Validation Certifications:
 - (a) Complete field device loop tests have been successfully completed for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc.
 - b) Calibration, adjustment, and test details for all components and systems.
 - c) Programming.
 - d) Submit completed Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.
 - 3) Process Operational Period.
- 6. Test reports:
 - a. As specified in Section 01_33_00.

1.06 QUALITY ASSURANCE

- A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.
- B. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01_60_00.
- B. Special instructions:
 - 1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.
- C. Tagging:
 - 1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
 - 2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.

3. Tag instruments immediately upon receipt in the field.
4. Prominently display identification on the outside of the package.
5. Utilize the Tag and Loop Number identifications shown on the P&IDs.

D. Delivery and inspection:

1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

A. Site conditions:

1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
2. Seismic classification:
 - a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01_81_01.
3. Wind:
 - a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01_81_01.
4. Altitude, temperature and humidity:
 - a. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
 - b. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
 - 1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
5. Area classifications:
 - a. Furnish enclosures that match the area classifications as specified in Section 26_05_00.
6. Site security:
 - a. Abide by all security and safety rules concerning the Work on the Site.

1.09 SEQUENCING

A. General:

1. As specified in Section 01_75_17.

B. General Field Start-up and testing procedures:

1. As specified in Section 01_75_17.

C. Installation testing:

1. As specified in Section 01_75_17.
2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.

3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.
- D. Functional testing:
1. Representatives from each of the following groups shall be in attendance during the functional Testing: Programmer, strain press supplier, and centrifuge supplier. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
 2. Loop validation test.
 3. As specified in Section 40_80_01.
 - a. Coordinate the scheduling of tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
 - b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
 - c. Loop validation certifications:
 - 1) After the field device loop tests have been successfully completed as specified in Section 40_80_01 for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
 - a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.
- E. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped and identified.
- F. Process Operational Period:
1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM PROCESS START-UP

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

- A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by the Contract Documents.
- C. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.
- D. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.
- B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.

- B. Signal transmission:
1. Analog signals:
 - a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
 - b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
 - c. Analog signals within enclosures may be 1 to 5 VDC.
 - d. Electrically or optically isolate all analog signals from other signals.
 - e. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
 - f. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
 - g. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
 2. Discrete input Signals:
 - a. As indicated in the controller hardware specification.
 3. Discrete output signals:
 - a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
 - b. Provide external terminal block mounted fuse for all discrete outputs.
 - c. Provide interposing relays as needed for discrete outputs for voltage and/or current compatibilities.
 - d. Provide interposing relays as required for functionality of the control circuit.
 4. Signal Performance and Design Criteria:
 - a. Stability:
 - 1) After Control have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
 - b. Response:
 - 1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
 - c. Agreement:
 - 1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
 - d. Repeatability:
 - 1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
 - e. Sensitivity:
 - 1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
 - f. Performance:
 - 1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.
- C. Discrete circuit configuration:
1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.

2. Alarm contacts: Fail to the alarm condition.
3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

D. Grounding:

1. Provide control panels with a signal ground bus, isolated from the power ground bus:
 - a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.
2. Ground single point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

2.07 ACCESSORIES

A. Nameplates:

1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
2. All nameplates shall be of identical style, color, and material throughout the facility.
3. Device nameplates shall include:
 - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
 - 1) Device tag and loop number ID.
 - 2) PLC ID.
 - 3) Power information (e.g. MCP440, 120VAC).
 - b. White lettering on a blue background, laminated plastic.
4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 EXAMINATION

- A. Provide a complete instrumentation and control system:
 - 1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
 - 1. Verify all dimensions as indicated on the Drawings:
 - a. Actual field conditions govern all final installed locations, distances, and levels.
 - 2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
 - 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
- B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.
- C. The PCIS configurations are diagrammatic:
 - 1. The locations of equipment are approximate unless dimensioned.
 - 2. Where Project conditions require, make reasonable changes in locations and arrangements.
- D. Field instruments installation:
 - 1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
 - 2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
 - a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
 - b. Provide sun shields for all field electronic instruments exposed to direct sunlight.
 - 3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
 - a. Type of flexible conduit required for the area classification:
 - 1) Area classification as specified in Section 26_05_00.
 - b. Maximum length of 18 inches.
 - 4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
 - a. Special cable applications shall be in accordance with the NEC.

5. Verify the correctness of each installation:
 - a. Polarity of electric power and signal connections.
 - b. Ensure all process connections are free of leaks.
- E. Conduit, cables, and field wiring:
 1. Provide all PCS equipment cables, and process LAN communication networks under the Instrumentation and Control Specifications.
 2. Provide terminations and wire identification as specified in the Electrical Specifications.
 3. Protect all wiring from sharp edges and corners.
 4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of the Electrical Specifications.
- F. Equipment tie-downs:
 1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.
- G. Existing instrumentation:
 1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
 2. Provide certification of this Work before reinstallation of each instrument.
- H. Instrument tagging:
 1. As specified in Section 26_05_53.
 2. Provide all field-mounted instruments with nameplates:
 - a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
 - 1) Affix tags with stainless steel wire fasteners.
 3. Provide all back of panel instruments with nameplates:
 - a. Engraved with the instrument's full tag number as indicated on the Drawings:
 4. Provide all front of panel instruments with a nameplate:
 - a. Engraving to include the following:
 - 1) Instrument's full tag number
 - 2) Service description.
 - b. Nameplates:
 - 1) Secure nameplates to the panel with adhesive.
- I. Cable and conductor termination:
 1. Terminate all cables and conductors on terminal blocks.
 2. Terminal block enclosures:
 - a. Suitable for the area classification as specified in Section 26_05_00.
- J. Surge protection:
 1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments.
 2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.

3. Provide voltage surge protection for 4 wire transmitters and analyzers:
 - a. Protect both power source and signal loop.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01_75_17.
- B. Owner Training:
 1. Demonstration requirements are specified in Section 40_80_01.
 2. General:
 - a. Provide system maintenance and operator training courses for all the instrumentation and control equipment and systems furnished, as described below.
 - 1) All training described below shall be provided by the Contractor.
 - 2) Training for phosphorous recovery system in accordance with Section 46_63_83.01.
 - b. Tailor training classes to the specific needs of the class participants:
 - 1) Develop separate courses for operators, maintenance staff, and supervisors:
 - a) The specific categories and number of personnel in each category are identified below.
 - 2) Furnish training courses that are a combination of classroom and hands-on training:
 - 3) Present the minimum number of sessions, specified in Table 40_61_00-3.10-T1, for each course in order to satisfy class size restrictions and limitations scheduling Owner staff.
 - 4) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.
 - c. Instructor qualifications:
 - 1) Highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:
 - a) Instructor qualifications are subject to the approval of the Engineer.

Table 1

Course Title	Minimum Course Length (hours per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
Instrument Training	2	10	1

3. Training course requirements:
 - a. System overview training:
 - 1) Coordinate training courses that give the Owner's supervisory level personnel an overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
 - b. Instrumentation training:
 - 1) Furnish training covering all instruments and control panels.
 - 2) Furnish the specified quantity of training, allocated to cover new instruments and hardwired controls as specified in this Section and specifically determined in the accepted training plan.
 - 3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this Project.
 - 4) Furnish training on the operation of new hardwired controls.

3.08 FIELD QUALITY CONTROL

- A. Inspection:
 1. Allow for inspection of PCIS installation.
 2. Provide any assistance necessary to support inspection activities.
 3. Engineer inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect installation for compliance with Drawings and Specifications.
 - c. Inspect installation for obstructions and adequate clearances around equipment.
 - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - e. Inspect equipment nameplate data to verify compliance with design requirements.
 - f. Inspect cable terminations.
 - g. Inspect/witness instrument calibrations/verifications.
 4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 40_80_01.
- B. Instrument Installation Inspection:
 1. Provide any assistance necessary to support inspection activities.
 2. Inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
 - c. Inspect installation for compliance with Drawings and Specifications.
 - d. Inspect installation for obstructions and adequate clearances around equipment.
 - e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - f. Inspect equipment nameplate data to verify compliance with design requirements.
 - g. Inspect cable terminations.
 - h. Inspect/witness instrument calibrations/verifications.

3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 40_80_01.
 4. Field acceptance testing: (Functional Testing) is specified in Section 40_80_01.
- C. Installation supervision:
1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the Contractor shall provide the following services:
 - a. Installation resources:
 - 1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
 - b. Provide technical assistance to installation personnel by telephone:
 - 1) Furnish installation personnel with at least one copy of the accepted submittals, including all installation details.
 - c. Periodic inspections during the construction period.
 - d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
 - e. Field verify accuracy and calibration of all instruments.

3.09 ADJUSTING

- A. Control valves:
1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
 2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.
- B. Make all revisions necessary to the control system software, as directed by the Engineer.
1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-up, and during the Project Correction Period.

3.10 CLEANING

- A. As specified in Section 01_77_00.
- B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.
- C. Clean all panel surfaces.
- D. Return to new condition any scratches and/or defects.
- E. Wipe all instrument faces and enclosures clean.
- F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
1. Neatly coil and label all spare wiring lengths.

2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

G. As specified in other sections of the Contract Documents.

3.11 PROTECTION

- A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_61_05

PACKAGED CONTROL SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements for a Master Control Panel (MCP) designed to monitor and control all skids and ancillary equipment furnished for each skid, local control panels at each skid, local control panels for other furnished equipment, and field instruments required for a complete package control system.

1.02 REFERENCES

- A. Code compliance:
 - 1. As specified in Section 01_41_00 - Regulatory Requirements:
 - a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
 - 2. The following codes and standards are hereby incorporated into these Specifications:
 - a. Institute of Electrical and Electronics Engineers:
 - 1) C62.41.1 - IEEE Guide on the Surge Environment in Low-Voltage (1000V and less) AC Power Circuits.
 - b. International Society of Automation (ISA):
 - 1) 5.4 - Instrument Loop Diagrams.
 - 2) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
 - c. National Electrical Manufacturer's Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - d. National Fire Protection Association (NFPA).
 - e. Underwriters Laboratories Inc. (UL):
 - 1) 508C - Power Conversion Equipment.
 - 2) 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 - 3) 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
 - 4) 1283 - Standard for Electromagnetic Interference Filters.
 - 5) 1449 - Transient Voltage Surge Suppressors.

1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations as set forth in the:
 - 1. Factory Mutual or FM Global (FM).
 - 2. Institute of Electrical and Electronic Engineers (IEEE).
 - 3. InterNational Electrical Testing Association (NETA).
 - 4. International Electrotechnical Commission (IEC).

5. International Organization for Standardization (ISO).
 6. International Society of Automation (ISA).
 7. National Electrical Code (NEC).
 8. National Fire Protection Association (NFPA).
 9. National Institute of Standards and Technology (NIST).
 10. Underwriter Laboratories (UL).
- B. NEMA:
1. Type 1 enclosure in accordance with NEMA 250.
 2. Type 3R enclosure in accordance with NEMA 250.
 3. Type 4 enclosure in accordance with NEMA 250.
 4. Type 4X enclosure in accordance with NEMA 250.
 5. Type 6 enclosure in accordance with NEMA 250.
 6. Type 6P enclosure in accordance with NEMA 250.
 7. Type 12 enclosure in accordance with NEMA 250.
- C. Specific definitions:
1. Control circuit: Any circuit operating at 120 volts alternating current (AC) or direct current (DC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
 2. Panel: An instrument support system that may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term "panel" in these Contract Documents is interpreted as a general term, which includes flat surfaces, enclosures, cabinets, and consoles.
 3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
 4. Signal circuit: Any circuit operating at less than 50 volts AC or DC, which conveys analog information or digital communications information.
 5. Digital Bus: A communication network, such as Profibus, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
 6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides 4 to 20 mA current regulation of a signal in a series circuit with an external 24 VDC driving potential:
 - a. Field Bus Communications signal or both.
 7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may either be a 4 to 20 mA current signal, a Digital Bus communications signal or both.
 8. Hardwired control: Control circuitry that does not utilize software to initiate functionality.
 9. Hardwired interlocks: A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.
 10. Software interlocks: A safety or protective feature that will interrupt operation of the equipment when the RTU has control.
 11. The term "panel" in this Section is interchangeable with the term "enclosure".

D. Acronym definitions:

1. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
2. DPDT: Double-pole, double-throw.
3. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
4. FAT: Factory acceptance test also known as Source Test.
5. HART: Highway addressable remote transducer.
6. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
7. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.
8. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
9. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
10. I/O: Input/Output.
11. IP: Internet protocol or ingress protection.
12. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
13. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
14. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
15. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
16. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
17. P&ID: Process and instrumentation diagram.
18. PC: Personal computer.

19. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings.
20. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
21. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOS, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
22. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
23. PLC: Programmable logic controller.
24. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
25. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
26. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations etc.
27. SPD: Surge protection device.
28. SPDT: Single-pole, double-throw.
29. SPST: Single-pole, single-throw.
30. UPS: Uninterruptible power supply.
31. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
32. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

- A. Master control panel (MCP):
 1. PLC processor, power supply, I/O backplanes, I/O modules, and communications modules sized for connected I/O and required spares.
 2. LOI on the face of the MCP enclosure for monitoring and control of the package control system shall be 10" Panelview Plus 7 (with FactoryTalk software).
 3. Ethernet communication equipment to provide communications with plant PCS system.
 4. Uninterruptable power supply.
 5. The MCP shall exercise control over all aspects of the package control system.
 6. All PLC and LOI programming required for fully functional package control system.
- B. Other control panels:
 1. Provide each reactor system with a control panel.
 2. Provide other control panels at the supplier's discretion.

3. I/O modules and equipment necessary to interface with the MCP.
 4. Additional LOIs on individual unit skid local control panels at the supplier's discretion.
- C. Contractor shall be responsible for installation of loose Field instruments (provided by the vendor) that are not mounted on the process skid for process and equipment monitoring.

1.05 SUBMITTALS

- A. General:
1. Submit as specified in Section 01_33_00 - Submittal Procedures.
 2. Furnish submittals that are fully indexed with a tabbed divider for every component.
 3. Sequentially number pages within the tabbed sections. Submittals and Operations and Maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
 4. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
- B. Pre-bid information:
1. The Electrical and Instrumentation Drawings have been prepared based on information provided by potential equipment suppliers and existing installations of similar equipment. Suppliers of packaged systems shall provide sufficient information to the Contractor to allow an adequate estimate of the Electrical and Instrumentation Work associated with the installation of the packaged system.
 2. To the extent practical, packaged systems shall be factory assembled and wired. Information on packing splits and other anticipated field wiring requirements shall be provided to the Contractor prior to the bid.
 3. The Contractor shall be responsible to obtain the necessary information to accurately estimate the electrical connections to the packaged system equipment.
- C. Product data:
1. General:
 - a. Submitted for non-custom manufactured material specified in this and other sections and indicated on shop drawings.
 - b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
 - c. Include:
 - 1) Catalog cuts.
 - 2) Bulletins.
 - 3) Brochures.
 - 4) Quality photocopies of applicable pages from these documents.
 - 5) Identify on the data sheets the project name, applicable specification section, and paragraph.

- 6) Identify model number and options for the actual equipment being furnished.
 - d. Legibly cross out options that do not apply or equipment not intended to be supplied.
- 2. Material and equipment schedules:
 - a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and instruments that are proposed:
 - 1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- 3. Instrument data sheets:
 - a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA 20. Include the following information on the data sheet:
 - 1) Component functional description specified in this Section and indicated on the Drawings.
 - 2) Manufacturers model number or other product designation.
 - 3) Tag number specified in this Section and indicated on the Drawings.
 - 4) System or loop of which the component is a part.
 - 5) Location or assembly at which the component is to be installed.
 - 6) Input and output characteristics.
 - 7) Scale range with units and multiplier.
 - 8) Requirements for electric supply.
 - 9) Requirements for air supply.
 - 10) Power consumption.
 - 11) Response timing.
 - 12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
 - 13) Special requirements or features, such as specifications for ambient operating conditions.
 - 14) Features and options that are furnished.
- D. Shop drawings:
 - 1. General:
 - a. Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flowmeters, chemical feeders and other equipment related to the control work provided.
 - 2. Shop drawing requirements:
 - a. Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
 - b. Locations of conduit entrances and access plates.
 - c. Component layout and identification.
 - d. Schematic and wiring diagrams with wire numbers and terminal identification.
 - e. Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
 - f. Anchoring method and leveling criteria, including manufacturer's recommendations for the seismic specified in Section 01_81_02 - Seismic Design Criteria and wind conditions specified in Section 01_81_04 - Wind Design Criteria.
 - g. Weight.

- h. Finish.
 - i. Nameplates with legends:
 - 1) Temperature limitations, as applicable.
- 3. Loop drawings:
 - a. Submit loop drawings for every analog, discrete, signal and control circuit:
 - 1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop for supplier provided equipment.
 - b. Show every instrument and I/O point on at least one loop diagram.
 - c. Provide a complete index in the front of each bound volume:
 - 1) Index the loop drawings by systems or process areas.
 - d. Provide drawings showing definitive diagrams for every instrumentation loop system:
 - 1) Show and identify each component of each loop or system using requirements and symbols from ISA S5.4 as amended by the Contract Drawings, as defined by the most recent revision in ISA.
 - 2) Furnish a separate drawing sheet for each system or loop diagram.
 - e. In addition to the ISA S5.4 requirements, show the following details:
 - 1) Functional name of each loop.
 - 2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
 - 3) Show all terminal numbers, regardless of the entity providing the equipment.
 - 4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
 - 5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
 - 6) If a circuit is continued on another drawing show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings.
 - f. The Contractor shall be responsible for reviewing existing plant as-built information for the generation of drawings that include existing plant control equipment. Where as-built information is not available, accurate information shall be collected through site surveys.
- 4. Control panel drawings:
 - a. Layout drawings:
 - 1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
 - 2) As a minimum, include the following information:
 - a) To scale front, side, and plan views.
 - b) Dimensions.
 - c) Interior and exterior arrangements.
 - d) Mounting information, including conduit entrance location.
 - e) Finish data.
 - f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
 - g) Nameplate legend including text, letter size, and colors.
 - b. Wiring and piping diagrams:
 - 1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.

- 2) Include the following information:
 - a) Name of panel.
 - b) Wiring and piping sizes and types.
 - c) Terminal strip numbers.
 - d) Wire tags and labels.
 - e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
 - f) Electrical control schematics in accordance with ANSI standards.
- c. Calculations:
 - 1) Provide installation details based on calculated shear and tension forces:
 - a) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
 - 2) For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
 - a) Weight including panel internal components.
 - b) Seismic forces and overturning moments.
 - c) Shear and tension forces in connections.
 - 3) Cooling calculations, to include but not limited to:
 - a) Highest expected ambient temperature for the enclosure's location
 - b) Internal heat load.
 - c) Exposure to direct sunlight.
 - d) Dimensions of the enclosure in inches.
 - e) Maximum desired temperature inside the enclosure.
- d. Seismic panel construction:
 - 1) Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements as specified in Section 01_81_02 - Seismic Design Criteria:
 - a) Stamped by a Professional Engineer registered in the state where the Project is being constructed.
 - 2) For floor mounted free standing panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements at the project site. Calculations shall be signed and sealed by a Professional Engineer.
5. Schematic diagrams:
 - a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
 - b. Include device and field connection terminal numbers on all schematic diagrams.
- E. Process control and LOI software submittal:
 1. A complete listing of the PLC system point I/O database:
 - a. Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
 - b. Organize on a site-by-site basis, separate by point type.

- c. In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
2. Preliminary LOI screens, including pop-ups, trends, and alarm screens. Provide electronic and hard copy.
3. Final LOI screens for use by the ICSC in developing graphic screens for Meridian WWRF PCS system. Provide electronic and hard copy.
4. Provide a complete, documented listing of all PLC codes.

F. Testing:

1. For each test specified in this Section, prepare and submit complete test plans, test procedures, test forms, test binders, and test reports, and other submittals, as specified below.
2. Submit manufacturer's certifications and manufacturer's field reports where required.
3. Submit Test plans, procedures, forms, and binders for approval by the Engineer before scheduling or performing tests.
4. Additional test form and test procedure requirements are specified with individual test requirements.

1.06 QUALITY ASSURANCE

- A. Furnish all equipment listed by and bearing the label of the UL or of an independent testing laboratory acceptable to the Engineer and the authority having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Shipping precautions:

1. After completion of shop assembly and successful Source Testing, pack all equipment, cabinets, panels, and consoles in protective crates and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
2. Place dehumidifiers when required, inside the polyethylene coverings.
3. Skid-mount the equipment for final transport.
4. Provide lifting rings for moving without removing protective covering.
5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

B. Tagging:

1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment provided as part of this Section.
3. Tag instruments immediately upon receipt in the field.
4. Prominently display identification on the outside of the package.

1.08 PROJECT OR SITE CONDITIONS

- A. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

- A. The supplier shall schedule a coordination meeting with the Owner, ICSC, and Engineer.
 - 1. The meeting shall take place before installation of control systems equipment.
 - 2. The supplier shall bring sample LOI graphic screens, including pop-up, trends, and alarm screens.
 - 3. Sample LOI graphic screens shall be reviewed and discussed.
 - 4. Discuss Ethernet communications between the MCP and connected devices provided by others.
 - 5. Data transfer between the MCP and connected devices shall be discussed, including PLC data register addresses.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. If the PLC hardware provided for the MCP and local control panels is not the same type as the WWRF PLC system hardware, the supplier shall provide the following spare PLC hardware for the PLC equipment in the MCPs and LCPs.
 - 1. 1 spare CPU for every type of CPU in the system.
 - 2. 1 spare I/O modules for every type of I/O module in the system.
 - 3. 1 spare power supplies for every power supply in the system.
 - 4. 1 spare network and/or communications card for every network or communications card in the system.
 - 5. 1 spare remote adaptor for every remote adaptor in the system.
- B. Provide one spare fuse for every fuse furnished on the Project (100% spare fuses for each panel).

PART 2 PRODUCTS

2.01 GENERAL

- A. Signal transmission:
 - 1. Analog signals:
 - a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
 - b. Furnish electrical analog signals outside control panels that are 4 to 20 mA 24 VDC, except as indicated.
 - c. Analog signals within enclosures may be 1 to 5 VDC.
 - d. Electrically or optically isolate all analog signals from other signals.
 - e. All pneumatic signals: 3 to 15 psig.

- f. Discrete input signal: 24 VDC or 120 VAC according to the supplier's discretion.
 - g. Discrete output signals:
 - 1) Output type according to the supplier's discretion.
 - 2) Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
 - 3) Interposing relays:
 - a) Provide interposing relays as required.
 - h. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
 - i. Maintain the total 4 to 20 mA loop impedance to 10 percent below the published value at the loop operating voltage.
 - j. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
- B. Discrete circuit configuration:
- 1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
 - 2. Alarm contacts: Fail to the alarm condition.
 - 3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.
- C. Grounding:
- 1. Provide control panels with a signal ground bus, isolated from the power ground bus:
 - a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.
 - 2. Single-point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
 - 3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

2.02 CONTROL PANEL

- A. General:
- 1. PLC processor, power supply, I/O backplanes, and modules sized for connected I/O and required spares.
 - 2. An LOI shall be provided on the face of the MCP enclosure for monitoring and control of the system. Additional HMIs may be provided on individual units local control panels at the supplier's discretion.
 - 3. The MCP shall exercise control over all aspects of the system. Each unit shall be equipped with a control panel containing I/O modules and necessary interface with the MCP.
 - 4. Ethernet communication equipment to provide communications with plant PCS system.
 - 5. The MCP shall continuously monitor all operating parameters, and shall respond to alarms and emergency conditions by shutting down or activating system components. The MCP shall indicate alarm conditions locally at the LOI, and remotely for monitoring by the WWRF PCS system.
 - 6. The MCP shall be integrated into the overall WWRF PCS system via Ethernet.

7. The MCP shall be capable of sending and receiving equipment status signals, analog data and alarms, and receiving both discrete and analog control signals from the WWRF PCS system via Ethernet.
8. The WWRF PCS system (provided by the ICSC) will be configured to store data for the system for reports and alarm generation. System manufacturer shall provide information on register addresses on all data, which are to be transmitted. The data register shall be contiguous for each data type.
9. Uninterruptible power supply.
10. All PLC and LOI programming required for fully functional package control system.

2.03 PROGRAMMABLE LOGIC CONTROLLERS (PLC) HARDWARE

- A. PLC hardware shall be:
 1. Per specification Section 40_64_01 Control Systems: Programmable Logic Controllers.
- B. General:
 1. Install all communications modules in the PLC backplane.
- C. Installed spare requirements:
 1. I/O points:
 - a. 25 percent spare capacity for each type of I/O signal at the MCP.
 - b. 25 percent spare capacity for each type of I/O signal at the local control panels.
 - c. Wire all spare I/O points to field terminal blocks in the corresponding panel.
 - d. Space shall be available in the MCP to support the future addition of 50percent additional spare I/O.
 2. PLC backplane capacity:
 - a. At the MCP, 25 percent or 3 spare backplane slots, whichever is greater.
 - b. At the local control panels, 1 spare backplane slot.
 3. PLC memory:
 - a. 50 percent spare memory.

2.04 UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. General:
 1. Provide UPS at MCP.
 2. Provide UPS power at LCPs, either via UPS in the MCP, or via separate UPS mounted in each LCP.
 3. The minimum VA rating of the UPS shall be greater than or equal to 1.5 times the connected load or 700 VA, whichever is greater.
 4. The battery shall be sized to provide minimum 15 minutes runtime at full load.
 5. Provide calculations showing run time and VA loading of the UPS.
- B. Double-conversion true-online UPS: One of the following or equal:
 1. Free-standing UPS, 700-3,000 VA:
 - a. Vertiv, Liebert GXT 4.
 - b. Eaton Corp., Powerware 9130.
 2. Free-Standing UPS, above 3 kVA:
 - a. Vertiv, Liebert.

- C. Provide manual maintenance bypass switch:
 - 1. 700 to 3,000 VA units: One of the following or equal:
 - a. Vertiv, Liebert Micropod 2U.
 - b. Eaton Corp.: Powerware HotSwap.
 - 2. Above 3,000 VA units: By manufacturer of UPS, with connections matched for operation with UPS.

2.05 HUMAN MACHINE INTERFACE (LOI) HARDWARE

- A. General:
 - 1. NEMA Type 4X, or 12 rated, depending upon the environmental area the cabinet is located.
 - 2. LOI shall communicate directly with PLC processor via dedicated communication cable.
 - 3. Provide color touch-screen type display.
- B. LOI: One of the following or equal:
 - 1. Allen-Bradley, PanelView Plus 7 Standard (2711P-T10C22D8S, 10.4-inch version).

2.06 PLC AND LOI PROGRAMMING

- A. General:
 - 1. The PLC programming software system shall be manufactured by the PLC hardware manufacturer.
 - 2. Provide one licensed copy of PLC programming software to the Owner.
 - 3. The LOI programming software system shall be manufactured by LOI hardware manufacturer.
 - 4. Provide one licensed copy of LOI programming software to the Owner.
- B. PLC programming software: One of the following or equal:
 - 1. Rockwell Automation Software RSLogix 5000.
- C. LOI programming software: One of the following or equal:
 - 1. Rockwell Automation, Studio 5000.
- D. Coordination with plant control system:
 - 1. Coordinate with the ICSC to determine the requirements for data transfer between the packaged system controls and the plant process control system.
 - 2. Supplier shall program MCP to aggregate the data into contiguous registers for efficient transfer to the plant process control system.
 - 3. Minimum data transfer shall be as indicated in the control strategies. Supplier shall supplement the I/O requirements with setpoints and virtual I/O required to implement the control strategies as specified in this Section.
 - 4. Unless otherwise stated, the packaged control system shall provide data to the plant control system with data in engineering units.
 - 5. In addition to the supplier provided equipment, the following systems shall be monitored and controlled by supplier provided PLCs as indicated on the P&IDs and in the control strategies.

- E. General programming requirements:
1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
 2. Program slew rates for all setpoints to limit the effect of updated setpoints on the process:
 - a. Provide for control setpoints and manual speed and position selections.
 - b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
 - c. Provide operator access to change slew rates through the controls system.
 3. Saved setpoints:
 - a. Provide an operator selection to save all setpoint values.
 - b. Provide an operator selection to restore all setpoints to the last saved value.
 4. Calculated values:
 - a. Program calculations such that division by zero errors cannot occur.
 - b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
 - c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts and to rollover to zero at an even decimal interval (1 followed by 4 or more zeros).
 5. Timers:
 - a. Provide programmable settling and proving timers in all control sequences for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
 6. PLC status:
 - a. Furnish all information that depicts the status of all enclosures containing PLC or I/O in the control system, including but not limited to the following:
 - 1) PLC cabinet over-temperatures from high temperature switch.
 - 2) Intrusion status on all enclosures equipped with intrusion switches.
 - 3) AC power failure.
 - 4) DC power supply failure.
 - 5) UPS failure signal.
 7. PLC system communication status:
 - a. Furnish a minimum of 1 screen to display all communication errors and status within the control system network:
 - 1) Communication between PCS and PLC.
 - 2) PLC to RIO.
 - 3) Digital bus network status.
 - 4) Display status of each node, and summary of failures over the past 60 minutes.
 - b. Generate a communications alarm if any communication fault is detected.
 - c. In the event of communications loss:
 - 1) Continue normal operation at each PLC with last known shared values.
- F. Common control functions:
1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically specified in the specific control descriptions or elsewhere in the Contract Documents.
 2. Alarms:
 - a. Generate alarms within the PLC logic.

- b. Indicate alarms at PCS and the LOI. Enable acknowledgement from either the PCS or the LOI.
 - c. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
 - 1) Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
- 3. Where run time accumulation is required, integrate accumulated run time to the nearest 0.1 hours whenever the running status input indicates that the equipment is running:
 - a. Display total run time in hours.
- 4. For all monitored analog values:
 - a. Maintain trends in PCS.
 - b. Totalize flows:
 - 1) Display totals on the HMI and LOI.
- 5. Analog data processing:
 - a. Engineering units conversion:
 - 1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
 - b. Analog magnitude checking:
 - 1) Provide clamps to prevent operator-entered values (setpoints, etc.) that fall outside acceptable limits.
- 6. Tank and vessel levels:
 - a. Display all tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
 - 1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during the submittal phase.
 - b. Monitor rate of change of volume on all tanks and vessel:
 - 1) Establish the maximum rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.
- 7. I/O filtering and processing:
 - a. Analog input filtering:
 - 1) Provide RTU programming for each analog input to implement an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, shall configure analog inputs with no filtering affect.
 - 2) Monitor analog input signal quality:
 - a) Over range: The input value is above the normal range (typically over 21 mA).
 - b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
 - c) Generate alarms for over or under range inputs.
 - d) Do not use over- or under-range values for control or calculation purposes:
 - (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
 - (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.

- 3) Digital input filtering (proving timer):
 - a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing. By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
8. LOI/HMI HAND-OFF-AUTO:
 - a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections accessed from an LOI or HMI for operators with sufficient security, to provide the following operating modes:
 - 1) AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
 - 2) HAND: Enables Manual control where control decisions are made by an operator through the START-STOP, OPEN/CLOSE, or other selections as indicated.
 - 3) OFF: Automated control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.
9. Display the current status of all operator selections (HAND/AUTO, START/STOP, etc.) on the LOI and HMI.
10. Motor control:
 - a. Display current REMOTE status on the screens.
 - b. Monitor the device's running status:
 - 1) Display the current status (running or stopped) on the screens.

2.07 PANELS, ENCLOSURES, AND PANEL COMPONENTS

- A. General:
 1. Provide instruments and other components performing similar functions of the same type, model, or class, and from one manufacturer.
 2. It shall be the responsibility of the supplier to design and size all panels.
 3. Design panels to fit in the space as indicated on the Drawings.
- B. Requirements:
 1. Each panel will be fed by a 480-volt 3-phase AC power circuit or as otherwise indicated on the Drawings. Panel designs shall include control power transformers, power supplies and distribution components required to derive all necessary control voltages.
 2. Panel enclosure ratings shall conform to the area classifications as specified in Section 26_05_00 - Common Work Results for Electrical.
 3. Design cabinets for the environmental conditions described in Section 46_05_10 - Common Work Results for Mechanical Equipment.
 4. Unless otherwise indicated on the Drawings, instruments provided as part of the packaged system shall be powered from supplier provided control cabinets.
- C. Panels/enclosures:
 1. Manufacturers: One of the following or equal:
 - a. Rittal.
 - b. Hoffman Engineering.
 - c. Saginaw Control & Engineering.

2. Panel assembly:
 - a. General guidelines for panel fabrication include:
 - 1) Continuous welds ground smooth.
 - 2) Exposed surfaces free of burrs and sharp edges.
 - 3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
 - b. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
3. In addition to the requirements specified above, the following requirements for NEMA Type 4X stainless steel enclosures apply:
 - a. Minimum 14-gauge, Type 304 stainless steel.
 - b. Captive stainless steel cover screws threaded into sealed wells.
 - c. Finish: Unpainted, brushed finish.
 - d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
4. General wiring requirements:
 - a. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for general purpose (no open wiring) unless otherwise specified.
 - b. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
 - c. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a control power transformer and flange mounted disconnect.
 - 1) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected. Reactivate power once all doors are closed.
 - 2) Disconnect shall remove power from all power and control circuits, except for externally wetted signal and control signals. Externally powered circuits shall be grouped together, labeled, and provided with finger safe barriers.
 - d. Control panels supplied with 120 VAC:
 - 1) Provide an internal breaker with the line side terminals covered by a barrier.
 - 2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
 - e. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
 - f. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
 - g. Provide surge protection device on input supply power.
 - h. Provide nonmetallic ducts for routing and organization of conductors and cables:
 - 1) Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring.
 - i. Provide 1/2-A fuse for each 4-20 mA circuit.
 - j. Provide 5-A fuse for each discrete input loop.

- k. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
 - 1) Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
 - l. The control panel shall be the source of power for all 120 VAC devices interconnected with the control panel including, but not limited to:
 - 1) Solenoid valves.
 - 2) Instruments mounted both in the control panel and remotely connected to the control panel.
- D. Thermal management:
- 1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within an acceptable range.
 - 2. Provide enclosure temperature sensor:
 - a. Manufacturers: One of the following or equal:
 - 1) Omega, EWS Series.
 - 2) TCS Basys Controls, TS Series.
- E. Panel meters:
- 1. Digital:
 - a. Self-contained instruments that display process signals directly in engineering units.
 - b. Manufacturers: The following or equal:
 - 1) Red Lion.
 - 2) Action Instruments Visipak.
 - 2. Digital bar graph meter:
 - a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
 - b. Suitable for panel mounting.
 - c. Provisions for field adjustable scaling and/or offset.
 - d. Accuracy shall be within 1 least significant digit.
 - e. Manufacturers: One of the following or equal:
 - 1) Ametek Dixson.
 - 2) Yokogawa.
 - 3) Weschler Instruments.
- F. Pilot devices:
- 1. General:
 - a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
 - b. Size:
 - 1) 30.5 millimeters.
 - c. Heavy duty.
 - d. Pushbuttons:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - 2) Furnish 1 spare normally open and normally closed contact with each switch.
 - e. Selector switches:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - b) Knob type.

- 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
- 3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
- f. Pilot lights:
 - 1) Type:
 - a) LED for interior installations.
 - 2) Push to test.
 - 3) Lamp color:
 - a) On/Running/Start: Green.
 - b) Off/Stop: Red.
 - c) Power: White.
 - d) Alarm: Amber.
 - e) Status or normal condition: White.
 - f) Opened: Green.
 - g) Closed: Red.
 - h) Failure: Red.
2. Indoor and outdoor areas:
 - a. NEMA Type 4/13.
 - b. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 800T.
 - 2) Square D, Class 9001 Type K.
 - 3) General Electric, Type CR104P.
 - 4) IDEC TWTD Series.
3. Corrosive areas:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
 - d. Manufacturers: One of the following or equal:
 - 1) Cutler Hammer, Type E34.
 - 2) Square D, Class 9001 Type SK.
 - 3) Allen-Bradley, Type 800H.
 - 4) IDEC TWTD Series.
4. Hazardous (Classified) Areas/Class I Division 2:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy-coated zinc:
 - 1) All contacts contained within a hermetically sealed chamber:
 - a) Pushbuttons.
 - b) Selector switches.
 - c) Push-to-test contacts on pilot lights.
 - 2) UL listed and labeled for Class I Division 2 areas.
 - d. Manufacturers: One of the following or equal:
 - 1) Cutler Hammer, Type E34.
 - 2) Allen-Bradley, Type 800H.
- G. Signal isolators and converters:
 1. Furnish signal isolators that provide complete isolation of input, output, and power input:
 - a. Minimum isolation level: 1.5 kV AC/50 Hz for at least 1 minute.

- b. Adjustable span and zero.
 - c. Accuracy: Within 1.0 percent of span.
 - d. Ambient temperature range: -20 degrees Celsius to +65 degrees Celsius.
 - 2. Manufacturers: One of the following or equal:
 - a. Phoenix Contact, MCR Series.
 - b. Acromag, 1500, 600T, 800T, Flat Pack or ACR Series.
 - c. Action Instruments, Q500 Series or Ultra SlimPakII.
 - d. AGM Electronics, Model TA-4000.
- H. Relays:
- 1. General:
 - a. For all types of 120 VAC relays, provide transient surge protection across the coil of each relay.
 - b. For all types of 24 VDC relays, provide a free-wheeling diode across the coil of each relay.
 - 2. General purpose:
 - a. NEMA A300 rated for standard relays and NEMA B300 for latching.
 - b. Plug-in type.
 - c. LED indication for relay energized.
 - d. Touch safe design: All connection terminals to be protected against accidental touch.
 - e. Provide additional (slave/interposing) relays when the following occurs:
 - 1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
 - 2) Higher contact rating is required in order to interface with starter circuits or other equipment.
 - f. DIN rail mounting on 35-mm rail.
 - g. Ice Cube type relays shall be provided with retainer clips to secure relay in socket.
 - h. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact, PLC series.
 - 2) Potter and Brumfield, Type KRP or KUP.
 - 3) IDEC, R* series. (* = H, J, R, S, U).
 - 4) Allen-Bradley, Type 700 HC Series.
 - 5) Schneider Electric, Type K.
 - 3. Time delay:
 - a. Provide time delay relays to control contact transition time.
 - b. NEMA A300 rated.
 - c. Minimum timing range: 0.1 seconds to 10 minutes.
 - d. Manufacturers: One of the following or equal:
 - 1) IDEC RTE Series.
 - 2) Agastat, Type Series 7000 (pneumatic).
 - 3) Allen-Bradley, Type 700_HR.
- I. Terminal blocks:
- 1. Din rail mounting on 35-mm rail.
 - 2. Suitable for specified AWG wire.
 - 3. Rated for 30 amperes at 600 volts.
 - 4. Screw terminal type.
 - 5. Finger safe protection for all terminals for conductors.
 - 6. Construction: Polyamide insulation material capable of withstanding temperature extremes from - 40 degrees Celsius to 105 degrees Celsius.

7. Terminals: Plainly identified to correspond with markings on the diagrams:
 - a. Permanent machine printed terminal identification.
8. Identify terminals suitable for use with more than 1 conductor.
9. Provide minimum 10 percent spare terminals.
10. Manufacturers: One of the following or equal:
 - a. Phoenix Contact, UT4 Series.
 - b. Allen-Bradley Series 1492.
11. Fuses (holders) and circuit breakers:
 - a. Fuse holders:
 - 1) Modular type:
 - a) DIN rail mounting on 35-mm rail.
 - b) Touch safe design: All connection terminals to be protected against accidental touch.
 - c) Incorporates blown fuse indicator.
 - d) UL 489 rated, as applicable.
 - 2) Provide nameplate identifying each fuse:
 - a) As specified in Section 26_05_53 - Identification for Electrical Systems.
 - 3) Manufacturers: One of the following or equal:
 - a) Phoenix Contact.
 - b) Allen-Bradley, 1492-FB Series B.

J. Surge protection devices (SPD):

1. 120 VAC control panel power SPD:
 - a. Provide SPD for panel 120 VAC power entrances:
 - 1) Non-faulting and non-interrupting design.
 - 2) Provide line to neutral and neutral to ground surge protection.
 - b. Provide surge protection at secondary of main circuit breaker:
 - 1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
 - 2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
 - c. DIN rail mounting.
 - d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
 - 1) Gastight connections.
 - 2) Visual status indication of MOV status on the input and output circuits.
 - 3) Dry contact rated for remote status indication.
 - e. Approvals:
 - 1) Tested in accordance with IEC 61643-11.
 - 2) Tested in accordance with UL 1283.
 - 3) Tested in accordance with UL 1449.
 - 4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 μ s waveform in accordance with IEEE C62.41.1 Category C Area.
 - f. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact, Type SFP Filter.
 - 2) ASCO, Model 277.
2. 24 VDC control panel power SPD:
 - a. Provide SPD for 24VDC power circuits.
 - b. Provide surge protection at DC power supply output.

- c. DIN rail mounting.
 - d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
 - 1) Optical status indicator.
 - 2) Dry contact rated for remote status indication.
 - e. Approvals:
 - 1) Tested in accordance with IEC 61643-11.
 - f. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact, Plugtrab PLT-SEC-T3-24-FM-UT.
3. Panel mounted control, signal, and data line SPD:
- a. General:
 - 1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
 - 2) Approvals:
 - a) Tested in accordance with IEC 61643-21.
 - b) Tested in accordance with UL 497B.
 - 3) SPD shall consist of 2 parts:
 - a) Base module:
 - (1) DIN rail mounting.
 - (a) Grounded to DIN rail via mounting rail foot.
 - b) Plug protection module:
 - (1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
 - 4) Provide indirect shield ground style SPD unless otherwise noted.
 - 5) Provide ability to locally identify and indicate SPD health.
 - 6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
 - 7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
 - 8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.
 - b. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact, Plugtrab PT-IQ Series.
 - 2) Dehn, Blitzductor XTU Series.
4. Copper Ethernet SPD:
- a. Protects network equipment from lightning or other surge events.
 - b. Suitable for Gigabit networks.
 - c. Compatible with shielded Cat 6 cabling with shielded RJ-45 ports.
 - d. Compliant with PoE standards IEEE 802.3af and 802.3at.
 - e. Nominal discharge surge current: 10 kA.
 - f. Approvals:
 - 1) Tested in accordance with IEC 61643-21.
 - 2) Tested in accordance with UL 497B.
 - g. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact, DT-LAN-CAT6+.
 - 2) Weidmuller, VDATA CAT6.
 - 3) Eaton/MTL, ZoneBarrier.

5. Field device mounted SPD:
 - a. Conduit entry mounting.
 - 1) Provide parallel or through wiring configurations as required by the application.
 - a) Use parallel wiring configuration if there is an available cable gland at the device.
 - b) Use through wiring configuration if there is no available cable gland at the device.
 - 2) Provide Screw connections compatible with field device.
 - b. NEMA 4X stainless steel material housing.
 - c. Approvals:
 - 1) Tested in accordance with IEC 61643-21.
 - d. 4-wire field device:
 - 1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line.
 - a) Maximum continuous voltage:
 - (1) DC:
 - (a) Signal: 32 VDC.
 - (b) Power supply: 255 VDC.
 - (2) AC:
 - (a) Signal: 22.6 VAC.
 - (b) Power supply: 255 VAC.
 - 2) Manufacturers: The following, engineer knows of no equal:
 - a) Endress+Hauser, HAW569-CB2C.
 - e. 2-wire or 3-wire field device:
 - 1) Module shall provide protection for the signal cable, communication bus or data line.
 - 2) Manufacturers: One of the following or equal:
 - a) Endress+Hauser, HAW569 Series.
 - b) Phoenix Contact, Surgetrab S-PT Series.
 - c) Eaton/MTL, TP Series.

K. Power supplies:

1. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
2. Convert 120 VAC to 24 volt DC or other DC voltages required.
3. Provide power supplies configured as fully redundant units consisting of 2 power supplies connected with an automatic switchover unit with alarm contacts monitored by the PLC.
4. Sized to provide 40 percent excess rated capacity.
5. UL 508C listed to allow full rated output without de-rating.
6. Provide fuse or short-circuit protection.
7. Provide a minimum of 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.
8. Output regulation: Within 0.05 percent for a 10 percent line change or a 50 percent load change:
 - a. With remote voltage sensing.
9. Operating temperature range: 0 degrees Celsius to 50 degrees Celsius.
10. Touch safe design: All connection terminals to be protected against accidental touch.

11. Manufacturers: One of the following or equal:
 - a. Phoenix Contact Quint Power Supply with SFB technology.
 - 1) Phoenix Contact Quint - O-ring redundancy module.
 - b. IDEC PS5R Series:
 - 1) With redundancy Diode.
 - c. Sola.
 - d. PULS.

- L. Intrinsic safety barriers:
 1. Transformer isolated barrier:
 - a. Containing a transformer to provide complete:
 - 1) Isolation between the safe and hazardous areas for loop powered devices.
 - 2) 3-way isolation between the safe area, hazardous area and power supply powered devices.
 - b. Resistor for current limitation.
 - c. Fuses for short circuit protection.
 - d. Provide barriers with pluggable connectors that are coded for easy replacement.
 - e. Transmission error shall be less than or equal to 0.1 percent of full scale.
 - f. DIN rail mounted on 35-mm DIN rail.
 - g. Approvals:
 - 1) FM.
 - 2) UL 913.
 2. Manufacturers: One of the following or equal:
 - a. Phoenix Contact, ME Series.
 - b. Pepperl + Fuchs.

- M. Limit switches:
 1. NEMA 4X.
 2. AC contact rating 120 V, 10 A.
 3. DC contact rating 125 V, 0.4 A.
 4. DeviceNet compatible as indicated on the Drawings.
 5. Provide robust actuation mechanism not prone to degradation.
 6. Provide complete actuator mechanism with all required hardware.
 7. Allows for contact opening even during contact weld condition.
 8. UL approved.
 9. Operating temperature range: -18 degrees to +110 degrees Celsius (0 degrees to 230 degrees Fahrenheit).
 10. Manufacturers: One of the following or equal:
 - a. Allen-Bradley, 802 Series.
 - b. Honeywell HDLS Series.
 - c. Omron D4 Series.
 - d. Eaton, E47, E49, E50.
 - e. ABB.

- N. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

O. Protection:

1. Provide disconnecting, short-circuit, and overcurrent protection for all control panels.
2. Provide a separate protective device for each 120 VAC powered electrical device.
 - a. Each 120 VAC control loop and instrument shall have an individual circuit breaker within its respective control panel and clearly identified for function.
 - b. Each 120 VAC and 24 VDC PLC output shall have its own individual fuse external of the I/O card with blown fuse indication:
 - 1) Size external fuse to open before any I/O card mounted fuses.
3. Provide dedicated single-pole circuit breakers, one for the panel luminaire(s), and one for the panel receptacle(s):
 - a. 15 amperes, 120 VAC.

P. Conductors and cables:

1. Power and control wiring:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 volts Type MTW.
 - c. Minimum sizes:
 - 1) Primary power distribution: 12 AWG.
 - 2) Secondary power distribution: 14 AWG.
 - 3) Control: 16 AWG.
 - d. Color:
 - 1) AC power (line and load): BLACK.
 - 2) AC power (neutral): WHITE.
 - 3) AC control: RED.
 - 4) AC control: ORANGE for foreign voltages.
 - 5) DC power and control (ungrounded): BLUE.
 - 6) DC power and control (grounded): WHITE with BLUE stripe.
 - 7) Ground: GREEN.
2. Signal cables:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 V, PVC outer jacket, 16 AWG paired triad overall aluminum shield (tape), with copper drain wire.
 - c. Color:
 - 1) 2 conductor:
 - a) Positive (+): BLACK.
 - b) Negative (-): WHITE and RED.
 - 2) 3 Conductor:
 - a) Positive (+): BLACK.
 - b) Negative (-): RED.
 - c) Signal: WHITE.
 - d. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

Q. Receptacles:

1. Provide one duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
2. GFCI, 125-volt, single-phase, 15-ampere style plug.
3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.

R. Grounding:

1. Provide the following:
 - a. Grounding strap between enclosure doors and the enclosure.
 - b. Equipment grounding conductor terminals.
 - c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
 - d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND," the letter "G," or the color green.
3. Signal (24 VDC) grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members
5. Design so that removing a device does not interrupt the continuity of the equipment grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, in the vicinity of the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
10. Bond together all remote and local control panels, processor racks, and conductive enclosures of power supplies and connect to the equipment-grounding circuit to provide a common ground reference.

2.08 FIELD INSTRUMENTS

A. General:

1. Instrument housing shall be rated NEMA Type 4X.
2. Wetted materials shall be compatible with process fluid and manufacturer's recommendations for the intended service.
3. For analog field instruments, provide local LCD display.
4. Provide sunshades for all transmitters located outdoors.
5. Provide all hardware for instrument mounting.
6. Factory calibrate each instrument at a facility that is traceable to the NIST.
7. Analog instrument outputs:
 - a. Isolated 4-20 mA DC with HART communication protocol.

2.09 ACCESSORIES (NOT USED)

2.10 CONTROL SYSTEM SOURCE TEST

A. Source Test - General:

1. Right of observation: The Owner retains the right to observe all Source test activities including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.
2. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittal.

3. Costs for repeating testing: The supplier shall pay for Engineer's and other Owner's representatives' travel, subsistence for witnessing the repetition of failed tests.
 4. Correction of deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
 5. Any changes and/or corrections shall be noted on the test forms. Engineer shall witness the revisions and/or corrections prior to leaving the test site.
 6. If the corrections and/or revisions are too extensive to be made while the Engineer is scheduled to be at the Source test site, the Source Test shall be, at the Engineer's sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the supplier.
- B. Testing simulation:
1. The Source shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points of the PLCs and controllers provided. All inputs and outputs shall be simulated and proper control and system operation shall be validated.
- C. Panel inspections:
1. The Engineer to inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the approved shop drawings.
 2. Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
- D. I/O test:
1. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and operator displays.
 2. Test forms to include, but not be limited to:
 - a. PLC and panel number.
 - b. I/O type.
 - c. I/O tag name.
 - d. Panel terminal block numbers.
 - e. Rack/slot/number of I/O point.
 - f. Check-off for correct response for each I/O point.
 - g. Space for comments.
 - h. Initials of individual performing test.
 - i. Date test was performed.
 - j. Witness' signature lines.
- E. Control logic test:
1. The purpose of this test is to verify that all software functions and logic work as specified, along with any hardwired logic or functions in the tested control panels.

2. Testing requirements:
 - a. Demonstrate each function described in the general and specific control description. Demonstrate in detail how each function operates under a variety of operating scenarios. Test to verify the application of each general control strategy function to each specific control strategy or loop description.
 - b. Demonstrate the proper operation of the programming and configuration for each control strategy or loop description. Test each strategy or loop description on a sentence-by-sentence and function-by-function basis. Loops with similar or identical logic must each be tested individually.
3. Test forms:
 - a. Include the fully revised and approved for the loop being tested.
 - b. Identify the cause and effect as each I/O point is toggled through the simulator. Check boxes shall be provided to track proper and/or improper operation of the loop.
 - c. Any deficiencies or operational changes shall be noted on the forms for correction and documentation:
 - d. Include signature and date lines.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Field instruments installation:
 1. Install field instruments as specified in the Contract Documents and in accordance with API 550 and 551 and the manufacturer's instructions.
 2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
 - a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted.
 3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
 - a. Type of flexible conduit required for the area classification.
 - b. Maximum length of 18 inches.
 4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
 - a. Special cable applications shall be in accordance with the NEC.
 5. Verify the correctness of each installation:
 - a. Polarity of electric power and signal connections.
 - b. Ensure all process connections are free of leaks.
- B. Process sensing lines and air tubing:
 1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
 2. Provide supports for rigid tubing at intervals of not more than 3 feet.

3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
 4. Bends:
 - a. Use proper tool.
 - b. Make bends for parallel lines symmetrical.
 - c. Make bends without deforming or thinning the walls of the tubing.
 5. Square-cut and clean all ends of tubing before being inserted in the fittings.
 6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
 7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
 - a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.
- C. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the site.
 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.
- D. Instrument tagging:
1. Provide all field-mounted instruments with nameplates:
 - a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
 - 1) Affix tags with stainless steel wire fasteners.
 2. Provide all back of panel instruments with nameplates:
 - a. Engraved with the instrument's full tag number.
 3. Provide all front of panel instruments with a nameplate:
 - a. Engraving to include the following:
 - 1) Instrument's full tag number.
 - 2) Service description.
 - b. Nameplates:
 - 1) Secure nameplates to the panel with stainless steel screws.
 - 2) Use an approved adhesive if screws would violate the NEMA or other ratings of the enclosure.
- E. Cable and conductor termination:
1. Terminate all cables and conductors on terminal blocks.
 2. Terminal block enclosures:
 - a. Suitable for the area classification.
- F. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments.
 2. Individually fuse each 4-20 mA DC loop with a 1/16-ampere fuse between power supplies and receiver surge protectors.
 3. Provide voltage surge protection for 4-wire transmitters and analyzers:
 - a. Protect both power source and signal loop.

- G. Control panel installation:
 - 1. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.
 - 2. Provide floor stand kits for wall-mount enclosures larger than 48 inches high.
 - 3. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. General:
 - 1. Failure testing:
 - a. In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
 - 1) Equipment failure.
 - 2) Operator error.
 - 3) Communications sub-system error.
 - 4) Power failure.
 - 5) Process equipment failure.
 - 6) High system loading conditions.
- B. Loop check/validation:
 - 1. Check all control loops under simulated operating conditions.
 - 2. Provide "end-to-end" tests:
 - a. Test PLC/controller inputs and outputs from field device to all operator displays and pilot devices.
- C. Pre-commissioning (functional) test:
 - 1. General:
 - a. Commence pre-commissioning tests after completion of all loop check/validation tests:
 - 1) Pre-commissioning to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
 - 2. Control logic operational validation:
 - a. The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.

3. Loop tuning:
 - a. Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
 4. Pre-commissioning validation sheets:
 - a. Document each pre-commissioning test on an approved test form.
 - b. Document loop tuning with a report for each loop, including 2-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by supplier and Engineer.
 5. Pre-commissioning certification:
 - a. Document via a certified report the completion of all pre-commissioning and test activities:
 - 1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all pre-commissioning test requirements have been satisfied.
- D. Performance/reliability/operational tests:
1. After successful completion of the pre-commissioning test as accepted by the Engineer and Owner, the performance test can proceed.
- E. The performance test may be performed concurrently with the 7-day operational test specified in Section 01_75_17 - Commissioning.

3.08 ADJUSTING

- A. Control valves:
1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
 2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

3.09 CLEANING

- A. Vacuum clean all control panels and enclosures before start-up and again after final completion of the project.
- B. Clean all panel surfaces.
- C. Return to new condition any scratches and/or defects.
- D. Wipe all instrument faces and enclosures clean.
- E. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
1. Neatly coil and label all spare wiring lengths.
 2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

3.10 DEMONSTRATION AND TRAINING

- A. Training:
 - 1. Provide system maintenance and operator training courses for all the instrumentation, control systems furnished.
 - 2. Training course requirements:
 - a. Operator training:
 - 1) Operator's training shall include:
 - a) Control system overview: Architecture, equipment functions, software components, etc.
 - b) Display navigation, overview, and types of displays.
 - c) Process and equipment monitoring and control: Basic principles and operation.
 - d) Logging ON and OFF the system and description of the security and access system.
 - e) Alarm subsystem.
 - f) Trending: Provide a thorough session on how to use all trending functions.
 - b. PLC hardware training:
 - 1) Furnish training on PLC hardware and on related components, including battery backup equipment, UPSs, LOI hardware, control circuits, and analog circuits.
 - 2) Furnish training on PLC hardware principles, product features, proper installation, operation, troubleshooting, and maintenance.
 - 3) PLC training may be provided by manufacturer's certified trainers.
 - c. PLC software training:
 - 1) Furnish training on PLC software:
 - a) Training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the work performed under this Contract.
 - d. LOI hardware and software training:
 - 1) Provide the following:
 - a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
 - b) Configuration of tag database.
 - c) Creating, editing, and saving display screens.
 - d) Troubleshooting.
 - e. Instrumentation training:
 - 1) Furnish training covering all instruments and control panels.
 - 2) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this project.
 - 3) Furnish training on the operation of new hardwired controls.

3.11 PROTECTION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

- B. Fully protect all instruments after installation and before commissioning. The Contractor shall replace any instruments damaged before commissioning:
 - 1. The sole party responsible for determining the corrective measures is the Engineer.

3.12 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Furnish all instruments identified on the Contract Drawings or in the Contract Specifications. If an instrument is shown on one of these documents, it shall be considered to be shown on all.
- B. Produce completed Instrument data sheets for all instruments required under this Contract:
 - 1. Submit all instrument data sheets for review.
 - 2. Furnish instrument data sheets in both hard copy and electronic format.
- C. The instrument data sheets are included as a guideline for the supply of instruments. The data sheets are not complete; some information needed to order and specify the required instruments is not included.
- D. The P&IDs are intended as a guideline for the supply of instruments. Some information needed to order and specify the required instruments is not included.

END OF SECTION

SECTION 40_64_01

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Programmable logic controller (PLC) based control systems hardware.
 - 2. Development software to be used with the specified PLC hardware.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE).

1.03 DEFINITIONS

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. CPU: Central processing unit.
 - 2. I/O: Input/Output.
- C. Specific definitions:
 - 1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
 - 2. Application software: The software that is programmed specifically for the Project.

1.04 SYSTEM DESCRIPTION

- A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures and 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. CPU:
 - a. Processor type.
 - b. Processor speed.
 - c. Memory.
 - d. Internal processor battery backup time.

2. I/O modules:
 - a. Type.
 - b. Standard wiring diagram.
- C. Calculations:
 1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
 2. Submit calculations to verify that spare I/O requirements of this Section are met.
 3. Submit calculations to verify that PLC power supply requirements of this Section are met.
- D. Product data:
 1. Programming languages.
 2. Operating system requirements.
- E. Control logic:
 1. Fully annotated copy of programmed PLC logic.
 2. Cross-referenced index of all PLC registers or points.
- F. Provide application software for the specific Project process requirements:
 1. Fully annotated copy of programmed PLC logic in its native format.
 2. Cross-referenced index of all PLC registers or points.

1.06 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.
- C. Additional requirements:
 1. Provide PLC system components by a single manufacturer:
 - a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
 2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
 3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. In addition to the spare parts requirements specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems, furnish the following:
 - 1. CPU: 1 spare for each type of CPU in the system.
 - 2. I/O cards: 3 spares for each type of I/O card in the system.
 - 3. Power supplies: 2 spares for every power supply in the system.
 - 4. Network/communications cards: 1 spare for every network or communications card in the system.
 - 5. Remote adapter: 1 spare for every remote adaptor in the system.
 - 6. Chassis: 1 spare for each chassis size in the system.
 - 7. Communication cable: 1 spare for each type of cable used in the system.
- C. Installed spare requirements:
 - 1. I/O points:
 - a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC and remote inputs and outputs (RIO).
 - b. Wire all spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
 - 2. PLC backplane capacity:
 - a. Provide 25-percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
 - 3. PLC memory:
 - a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Rockwell Automation, ControlLogix:
 - a. CPU; 1756-L82E
 - b. Ethernet Communications module; 1756-EN2TR.

- c. Discrete Input Module; 1756-IA16I
 - d. Discrete Output Module; 1756-OA16I
 - e. Analog Input Module; 1756-IF16H
 - f. Analog Output Module; 1756-OF8I
 - g.
- B. The PLC programming software system shall be manufactured by PLC hardware manufacturer:
- 1. Rockwell Software:
 - a. RSLogix 5000.
 - b. Studio 5000.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Programmable logic controller:
- 1. Construction:
 - a. Furnish plug-in modular system.
 - b. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
 - 1) Temperature: 0 to 60 degrees Celsius.
 - 2) RFI: 80 to 1,000 MHz.
 - 3) Vibration: 10 to 500 hertz.
 - 4) Humidity: 0 to 95 percent.
 - c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
 - d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
 - 1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
 - 2. CPU:
 - a. Configure each CPU so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
 - b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
 - c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
 - 3. Memory:
 - a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM), PCMCIA, compact flash card, or SD card.

- b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
 - 1) Reserve capacity:
 - a) Totally free from any system use.
 - 2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
- 4. Programming:
 - a. Provide a system where processors are programmed by:
 - 1) Portable laptop computer both locally and via the PLC control network.
- 5. PLC power supply:
 - a. Input: 120 VAC.
 - b. Mounted in the PLC housing or as indicated on the Drawings.
 - c. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
- 6. PLC input/output, I/O modules:
 - a. General:
 - 1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
 - 2) Provide I/O modules that:
 - a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
 - b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
 - c) Accept dual-ended inputs.
 - 3) The use of common grounds between I/O points is not acceptable.
 - 4) Provide modules that are removable without having to disconnect wiring terminals:
 - a) Utilize a swing-arm or plug-in wiring connector.
 - 5) Provide at each PLC the I/O modules for the following:
 - a) Designated future I/O points contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
 - b) Installed spare capacity in accordance with the requirements of this Section.
 - c) Wire all spares provided to the field terminal strip.
 - 6) Condition, filter, and check input signals for instrument limit conditions.
 - 7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
 - 8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
 - 9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.
 - 10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.

- b. Discrete input modules:
 - 1) Defined as contact closure inputs from devices external to the input module.
 - 2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
 - 3) Individually isolated inputs.
 - 4) With LEDs to indicate status of each discrete input.
 - 1) Input voltage: 120VAC.
 - 2) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
 - a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.
- c. Discrete output modules:
 - 1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
 - a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
 - 2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
 - 3) LEDs to indicate status of each output point.
 - 4) Output voltage: 120VAC.
 - 5) Individually isolated outputs.
- d. Analog input modules:
 - 1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
 - 3) The analog-to-digital conversion updated with each scan of the processor.
 - 4) Individually isolated each input.
 - 5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
- e. Analog output modules:
 - 1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 2) Individual isolated output points each rated for loads of up to 1,000 ohms.
- 7. Communications modules:
 - a. Remote I/O adapter module:
 - 1) For any PLC location requiring more than 1 housing (backplane) to mount all of the I/O modules or that is identified as a RIO, provide an appropriate communications modules for communication with the secondary housing(s).
 - 2) Install the communications modules in the PLC backplane and the RIO backplane.

- 3) Provide communications modules that support all available types of I/O modules required.
 - 4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 - 5) Complete diagnostic LEDs.
 - b. Network communications modules:
 - 1) General:
 - a) Install communications modules in the PLC backplane and install external ethernet switch to handle building traffic.
 - 2) Ethernet:
 - a) Ports: 2-RJ-45.
 - b) Communication rate: 100 Mbit/s.
 - c) Allen-Bradley ControlLogix - 1756-EN2TR.
 - 3) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 8. PLC backplane housing:
 - a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
 - b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
 - c. Provide a blank slot filler module for each spare slot.
- B. PLC programming software:
1. Furnish operating software capable of monitoring and/or controlling the PLCs via the PLC data network:
 - a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
 - b. Monitor devices at each drop on the PLC data network for proper communications.
 - c. Provide the ability to program all PLCs on the PLC data network from the Engineer's console.
 2. PLC programming laptop/desktop operating system:
 - a. Microsoft Windows 10.
 3. The PLC programming software shall be suitable for the PLCs specified above.
 4. PLC programming software for all programming, monitoring, searching, and editing:
 - a. Usable both on-line, while connected to the PLC, and off-line.
 - b. The operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
 - c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.
 - d. Include a search capability to locate any address or element and its program location.
 - e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
 5. The PLC programming software shall support the following programming languages:
 - a. Ladder Diagram.
 - b. Function Block Diagram.
 - c. Structured Text.

- d. Instruction List.
- 6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
 - a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.
 - b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
 - c. Use a mnemonic associated with each contact, coil, etc. that describes its function.
 - d. Utilize the tag and loop identification as contained in the P&IDs:
 - 1) If additional internal coils, timers, etc. are used for a loop, they shall contain the loop number.
 - e. Provide a cross-reference report of program addresses.
- 7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
 - a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
 - 1) Respond to demands from a program request.
 - 2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
 - 3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
 - 4) Queuing of requests in order of priority if one or more requested resources are unavailable.
 - 5) Resolution of contending requests for the same resource in accordance with priority.
 - 6) Service requests for execution of one program by another.
 - 7) Transfer data between programs as requested.
 - 8) Management of all information transfers to and from peripheral devices.
 - 9) Control and recovery from all program fault conditions.
 - 10) Diagnose and report real-time hardware device errors.
- 8. Program execution:
 - a. Application software - program execution scheduled on a priority basis:
 - 1) A multilevel priority interrupt structure is required.
 - 2) Enter into a list of pending programs a program interrupted by a higher priority program:
 - a) Resume its execution once it becomes the currently highest priority program.
 - 3) Schedule periodic programs.
 - 4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.

9. Start-up and restart:
 - a. Provide software that initializes and brings a PLC or any microprocessor-based hardware unit from an inactive condition to a state of operational readiness.
 - b. Initialization:
 - 1) Determination of system status before start-up of initializing operating system software and initializing application software.
 - 2) Loading of all memory-resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.
10. Shutdown:
 - a. Where possible, provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
 - b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
 - c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
 - d. Alarm PLC failure at the operator interface level.
11. Diagnostics:
 - a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
 - b. Use the manufacturer's standard diagnostic routines as much as possible.
 - c. Furnish diagnostic software and test programs for each significant component in the control system.
 - d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
12. Calendar/time program:
 - a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system-level and application software.
 - b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
 - c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
13. Algorithms:
 - a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
 - b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
 - c. Algorithms must include alarm checks where appropriate.
 - d. Provide, as a minimum, the following types of algorithms:
 - 1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
 - 2) A switch algorithm, which reads the current and value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated: 2 outputs with 1 input and 1 output with 2 inputs.
 - 3) A 3-mode proportional-integral-derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supports both direct and reverse-acting modes.
 - 4) Lead, lag, dead time, and ratio compensators.

- 5) Integration and totalization of analog process variables.
- 14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
 - a. In addition, provide spare database points for future expansion.
- 15. One integrated database can be utilized for all types of analog points or separate databases for each type; in either case, the database for each point must include all specified aspects.
- 16. All portions of the database must be available for use by the display, report, and other specified software modules.
- 17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:
 - a. Analog input signal types:
 - 1) Provide software at the remote terminal units (RTUs) and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
 - b. Input accuracy:
 - 1) Inputs must be read with an accuracy of within 0.05-percent full-scale or better.
 - 2) Data conversion errors must be less than 0.05-percent full-scale.
 - 3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once per minute.
 - 4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
 - c. Blocking:
 - 1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
 - 2) For any input so blocked, the operator may manually enter a value to be used as the input value.
 - d. Filtering:
 - 1) For each analog input, provide a first order lag digital filter with an adjustable filter factor.
 - e. Linearizing:
 - 1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
 - f. Calculated values:
 - 1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated values, constants, etc.
 - 2) These values must be handled the same as real inputs in terms of record-keeping, alarming, etc.
 - g. Scaling and zero suppression:
 - 1) Provide a conversion program to convert input values into engineering units in a floating-point format.
 - h. Alarms:
 - 1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.

- 2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
 - 3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
 - 4) Must be possible to inhibit alarms based on external events, e.g., lock-out low pump flow alarm when the pump is off.
- i. Averages:
- 1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
 - 2) Continuously compute averages, e.g., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
 - 3) Update hourly averages each minute or at the polling interval for the selected variable.
 - 4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
 - 5) Update monthly averages at least once each day and calculate using the results of the daily averages.
 - 6) At the end of each averaging period, store the average values for the period on the hard disk for historical record-keeping and reset the present period average register to the present value of the variable.
 - 7) The active database must include the present period average and previous period average for each variable and averaging period.
- j. Totals:
- 1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
 - 2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
 - 3) Assign a separate factor for each totalizing interval.
 - 4) Variables for which totalization is inappropriate must have scaling factors of zero.
 - 5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record-keeping and reset the present period totalization register to zero.
 - 6) The active database must include the present period total and previous period total for each variable and totalizing period.
- k. Engineering units:
- 1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
 - 2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in gpm, mgd, cfs, and acre-feet per day.
 - 3) Pre-program the conversion of the engineering units, and, if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, e.g., multiplication of the database attributes by a constant.
 - 4) The programming method must be at a level and compatible with the specified training of the operator and the Owner's personnel.
 - 5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.

- I. Control modules:
 - 1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
 - 2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
 - 3) Provide control algorithms for manual control with output values adjustable by the operator.
 - m. Analog outputs:
 - 1) Analog outputs must be maintained as part of the database.
 - 2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.
 - 18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.
- C. General control functions:
- 1. Analog control functions:
 - a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
 - b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
 - c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
 - d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
 - 2. Discrete control functions:
 - a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
 - 3. Software support:
 - a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
 - b. Call each function as required by the configured controls to perform the intended function.
 - 4. Control and status discrepancies:
 - a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
 - 1) For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
 - b. Involuntary change in the device's status must also generate an alarm:
 - 1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
 - c. Each command, status, and alarm must cause the color of the symbol to change.

- d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
 - 1) Delay periods for each final control element must be adjustable at the operator interface.
 - 2) List all time delays in the final documentation.
5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

D. Control configuration:

1. Provide software to allow control strategies to be developed, and their operation initiated through the operator interface.
2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, setpoints, tuning constants, etc.
3. Provide a mechanism to link separate control functions together into an integrated control strategy.
4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU, and to upload them to the operator interface for operational record-keeping.
6. Perform control configurations on-line at the operator interface; the PLC or RTU may be taken off-line when being configured or downloaded.

E. Remote inputs and outputs (RIOs):

1. Compatible with all of the PLCs being furnished under this Contract, shall be by the same manufacturer as the PLCs, and, as a minimum, include:
 - a. Power supply.
 - b. Rack.
 - c. Backplane.
 - d. Communications module.
 - e. I/O modules.
 - f. Enclosure.
2. Provide all cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
3. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
4. The control system must continue operation should a fault occur on a single RIO drop:
 - a. Upon clearing the fault, restart communications to that drop automatically.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
 - 1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.
- C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.
- D. General:
 - 1. The control system logic program shall reside at the PLC level.
- E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.
- F. Program the PLC logic using the following language(s):
 - 1. Ladder Diagram.
 - 2. Function Block Diagram.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

- A. Provide a minimum of 4 CD/DVD copies of the following:
 - 1. Application software:
 - a. Finalized fully annotated copy of programmed PLC logic in its native format.
 - b. Cross-referenced index of all PLC registers or points.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.
- C. Perform training by pre-approved and qualified representatives of the ICSC and/or manufacturer of the PLC hardware and programming software:
 - 1. A representative of the ICSC may perform the PLC hardware training only if the representative has completed the manufacturer's training course for the PLC hardware.
 - 2. A representative of the ICSC may perform the PLC programming software training only if the representative has completed the manufacturer's training course for the PLC programming software.

3.11 PROTECTION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_71_15

FLOW MEASUREMENT: MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Full-body magnetic flowmeters.
- B. Provide all instruments identified in the Contract Drawings.
- C. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures
 - 2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

- A. As specified in Section 40_61_00.
- B. International Organization for Standardization (ISO):
 - 1. 9000 - Quality management systems -- Fundamentals and vocabulary.
 - 2. 17025 - General requirements for the competence of testing and calibration laboratories.
- C. National Institute of Standards and Technology (NIST).
- D. NSF International (NSF).

1.03 DEFINITIONS

- A. As specified in Section 40_61_00.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.
- B. A template for the data sheet is included in the specification. System Supplier shall complete data sheet based on system design.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.

- 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 40_61_00.

1.08 WARRANTY

- A. As specified in Section 40_61_00.

1.09 MAINTENANCE

- A. As specified in Section 40_61_00.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Endress+Hauser:
 - a. W 400 for most locations, Promag H100 fine chemical lines less than 1-inch diameter.
 - b. Badger ModMAG M-Series

2.02 MANUFACTURED UNITS

- A. Magnetic flowmeter:
 - 1. General:
 - a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
 - b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
 - c. Include for each magnetic flow metering system:
 - 1) A metering tube with electrodes (sensor).
 - 2) Signal cable.
 - 3) Transmitter integral or remote as indicated on the instrument data sheets.
 - 4) Flowmeter grounding rings.

2. Performance requirements:
 - a. Accuracy:
 - 1) 0.25 percent of flow rate from 10 to 100 percent of full-scale for velocities ranging between 1.9 to 10 feet per second.
 - b. Repeatability:
 - 1) 0.25 percent of rate.
3. Element:
 - a. Metering tube:
 - 1) Constructed of carbon steel or Type 304 stainless steel (unless specifically noted otherwise in the instrument data sheets) with flanged connections to match with piping material.
 - 2) Liner material in conformance with:
 - a) Manufacturer's recommendations for the intended service.
 - 3) Electrodes type and material in conformance with:
 - a) Manufacturer's recommendations for the intended service.
 - b) Utilize a minimum of 2, self-cleaning electrodes.
 - 4) Meter terminal housing NEMA Type 4X unless specifically noted otherwise in the instrument data sheets.
 - 5) Meter coating consisting of epoxy painted finish.
 - 6) Components:
 - a) 2 grounding rings:
 - (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.
 - (2) Designed to protect and shield from abrasion of the liner's edge interface at the meter's end.
4. Transmitter:
 - a. Power supply:
 - 1) As indicated in the data sheets. Universal 100-240 VAC.
 - 2) Power consumption: 60 VA maximum.
 - b. Outputs:
 - 1) As noted in the instrument data sheets.
 - 2) For all instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
 - c. Microprocessor-based signal converter/transmitter.
 - d. Utilize DC pulse technique to drive flux-producing coils.
 - e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
 - f. Operator keypad interface.
 - g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
 - h. Integral low flow cut-off zero return.
 - i. Programmable parameters including:
 - 1) Meter size.
 - 2) Full-scale flow rate.
 - 3) Magnetic field frequency.
 - 4) Time constant.
 - j. Data retention for a minimum of 5 years without auxiliary main or battery power.
 - k. Self-diagnostics and automatic data checking.
 - l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
 - m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).

- n. The transmitter should retain all setup parameters and accumulated measurements internally in non-volatile memory in the event of power failure.
- o. Device failure modes, self-monitoring characteristics and remedy diagnosis shall follow NAMUR standards NE 43 and NE 107.

2.03 ACCESSORIES

- A. Stainless steel tag labeled as specified in the Contract Documents.
- B. Provide sunshades for all transmitters located outdoors.
- C. Provide galvanic isolation gaskets, nylon/Teflon™ flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.
- D. Furnish 1 spool piece for every size of magnetic flow tube being provided.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00.
- B. Factory calibrate each flow metering system at a facility that is traceable to the NIST. ISO-17025 accredited test facility with certified accuracy traceable to NIST.
- C. Evidence of accreditation shall originate from a national verification agency such as A2LA.
- D. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values of the flow tube:
 - 1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
 - 2. Minimum calibration shall be a 3-point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
 - 3. Manufacturer shall archive all calibration reports for future reference.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.
- B. For instruments located outdoors or where instrument elements and transmitters are separated by conduit located outside the building envelope, provide surge protection devices at the transmitters.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00.
- B. Provide manufacturer's services to perform installation inspection.

3.05 ADJUSTING

- A. Field verification:
 - 1. Verify factory calibration of all instruments in accordance with the manufacturer's instructions.
 - 2. The transmitter and sensor to include a method to verify flow meter performance to the original manufacturer specifications.
 - 3. Verification should be traceable to factory calibration using a third party, attested onboard system pursuant to ISO standards.
 - 4. The verification report should be compliant to common quality systems such as ISO 9000 to prove reliability of the meter specified accuracy.
 - 5. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

- A. As specified in Section 40_61_00.

3.09 SCHEDULES

- A. Instrument Data Sheets included in this Section.
- B. The provided information does not necessarily include all required instruments.
- C. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E:		Carollo Engineers		MAGNETIC FLOWMETERS				INSTRUMENT DATA SHEETS		
Contractor:				No	By	Date	Revision	Spec. No.		Rev.
Project:		Sidestream Treatment Project						40_71_15		
Customer:		City of Meridian						Contract		Date
Plant:		WRRF						Req.		P.O.
Location:		Meridian, ID								
BOM No.:								By	Chk	App
File:										
1	Instrument Tag No.		F680							
2	Service									
3	P&ID		PI-SSD-06							
4	C	Line Size / Schedule								
5	O	Line Material								
6	N	Connection Type/ Pressure Rating								
7	N	Connection Materials								
8		Tube Size								
9		Tube Material								
10		Liner Material								
11	M	Electrode Type		Mfg Standard						
12	E	Electrode Material								
13	T	Meter Casing								
14	E	Power Sply	Phase	120 VAC	1P					
15	R	Grounding Type & Matl.		Grounding Rings						
16		Enclosure Class		NEMA 4X						
17		Other								
18		Fluid								
19	F	Max Flow								
20	L	Min Velocity								
21	U	Min Flow	Norm Flow							
22	I	Min Temp	Max Temp							
23	D	Min Press	Max Press							
24		Vacuum Possibility								
25		Conductivity								
26	T	Function								
27	R	Mounting		Remote		Remote				
28	A	Enclosure Class		NEMA 4X		NEMA 4X				
29	N	Length Signal Cable								
30	S	Type Span Adjustment								
31	M	Power Supply								
32	I	Transmitter Output		4-20 mA HART		4-20 mA HART				
33	T	Relay Outputs		Form C		Form C				
34	T	Accuracy		0.25%		0.25%				
35	E	Calibrated Range								
36	R	Empty Pipe Detection								
37		Display Scale Size	Range							
38		Alarm Contact No.	Form							
39		Manufacturer								
40		Element (Meter) Model No.								
41		Transmitter (Inst.) Model No.								
Notes:										

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A/E: Carollo Engineers		MAGNETIC FLOWMETERS				INSTRUMENT DATA SHEETS		
		No	By	Date	Revision	Spec. No.	Rev.	
Contractor:						40_71_15		
Project: Sidestream Treatment Project						Contract	Date	
Customer: City of Meridian						Req.	P.O.	
Plant: WRRF						By	Chk	App
Location: Meridian, ID								
BOM No.:								
File:								
1	Instrument Tag No.	SSPR1FIT0003		SSPR1FIT0502				
2	Service	SSPR1FIT0501		SSPR1FIT0502				
3	P&ID	N12 N07		N12 N08				
4	C Line Size / Schedule							
5	O Line Material							
6	N Connection Type/ Pressure Rating					SSPR1FIT0004		
7	N Connection Materials							
8	Tube Size							
9	Tube Material							
10	Liner Material							
11	M Electrode Type	Mfg Standard		Mfg Standard				
12	E Electrode Material							
13	T Meter Casing							
14	E Power Sply Phase	120 VAC	1P	120 VAC	1P			
15	R Grounding Type & Matl.							
16	Enclosure Class	NEMA 4X		NEMA 4X				
17	Other							
18	Fluid							
19	F Max Flow					Grounding Rings		
20	L Min Velocity							
21	U Min Flow Norm Flow							
22	I Min Temp Max Temp							
23	D Min Press Max Press							
24	Vacuum Possibility							
25	Conductivity							
26	T Function							
27	R Mounting	Integral		Integral				
28	A Enclosure Class	NEMA 4X		NEMA 4X				
29	N Length Signal Cable							
30	S Type Span Adjustment							
31	M Power Supply							
32	I Transmitter Output	4-20 mA HART		4-20 mA HART				
33	T Relay Outputs	Form C		Form C				
34	T Accuracy	0.25%		0.25%				
35	E Calibrated Range							
36	R Empty Pipe Detection							
37	Display Scale Size Range							
38	Alarm Contact No. Form							
39	Manufacturer							
40	Element (Meter) Model No.							
41	Transmitter (Inst.) Model No.							
Notes:								

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A/E: Carollo Engineers		MAGNETIC FLOWMETERS				INSTRUMENT DATA SHEETS		
Contractor:		No	By	Date	Revision	Spec. No.		Rev.
Project: Sidestream Treatment Project						40_71_15		
Customer: City of Meridian						Contract		Date
Plant: WRRF						Req.		P.O.
Location: Meridian, ID								
BOM No.:						By	Chk	App
File:								
1	Instrument Tag No.	~~F331~~		SSPR1FIT0502				
2	Service	SSPR1FIT0501						
3	P&ID	N12 - PL NFD-06		N12				
4	C Line Size / Schedule							
5	O Line Material							
6	N Connection Type/ Pressure Rating							
7	N Connection Materials							
8	Tube Size							
9	Tube Material							
10	Liner Material							
11	M Electrode Type	Mfg Standard		Mfg Standard				
12	E Electrode Material							
13	T Meter Casing							
14	E Power Sply Phase	120 VAC	1P	120 VAC	1P			
15	R Grounding Type & Matl.			Grounding Rings				
16	Enclosure Class	NEMA 4X		NEMA 4X				
17	Other							
18	Fluid							
19	F Max Flow							
20	L Min Velocity							
21	U Min Flow Norm Flow							
22	I Min Temp Max Temp							
23	D Min Press Max Press							
24	Vacuum Possibility							
25	Conductivity							
26	T Function							
27	R Mounting	Integral		INTEGRAL				
28	A Enclosure Class	NEMA 4X		NEMA 4X				
29	N Length Signal Cable							
30	S Type Span Adjustment							
31	M Power Supply							
32	I Transmitter Output	4-20 mA HART		4-20 mA HART				
	Relay Outputs	Form C		Form C				
33	T Accuracy	0.25%		0.25%				
34	T Calibrated Range							
35	E Empty Pipe Detection							
36	R Bi-Directional Flow							
37	Display Scale Size Range							
38	Alarm Contact No. Form							
39	Manufacturer							
40	Element (Meter) Model No.							
41	Transmitter (Inst.) Model No.							
Notes:								

March 2021

January 2021 - DRAFT

pw://Carollo/Documents/Client/ID/Meridian/11700A10/Specifications/Pre-Purchase/40_71_15 (IDS50)

40_71_15-7

11700A10

SECTION 40_71_76

FLOW MEASUREMENT: THERMAL MASS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Thermal mass flow measurement.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. Surface mount technology: The practice and method of attaching leaded and non-leaded electrical components to the surface of a conductive pattern that does not utilize leads in feed-through holes. This technology reduces power requirements for the thermal flow instruments.
 - 2. Retract mechanism: A device that holds the sensor probe in place for the flow measurement. This device also includes a mechanism that enables the plant maintenance staff to remove the probe easily for cleaning and other maintenance needed. This device also enables the plant maintenance staff to re-insert the sensor probe back into its original position without leakage for measurement service again.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures and 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Design calculations:
 - 1. Flow modeling.
- C. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems:
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Thermal mass flowmeters:
 - 1. Dry gas measurement:
 - a. Insertion mounting:
 - 1) One of the following or equal:
 - a) Fluid Components International (FCI®), Model No. ST100.
 - b) Kurz Instruments, Inc., Model No. 454FTB series.
 - c) Sierra Instruments, Inc., Model No. 640S.

- b. Inline mounting with integral flow conditioning:
 - 1) One of the following or equal:
 - a) Kurz instrument, Inc., Model 534FTB.
 - b) Fluid Components International (FCI®), Model ST100L.
 - 2. Wet gas measurement (insertion mounting):
 - a. One of the following or equal:
 - 1) Kurz Instruments, Inc.:
 - a) Single point: Model No. 454FTB-WGF series.
 - b) Multipoint: K-Bar 2000B series and Mass Flow Computer.
 - b. Fluid Components International LLC (FCI®), Model No. ST50 with thermal dispersion flow element, remote transmitter, and a balance retract mechanism for the probe sensor.

2.02 MANUFACTURED UNITS

- A. Thermal mass flowmeter for dry gas measurement:
 - 1. General:
 - a. Thermal mass flowmeters measure airflow, industrial, and process gas mass flows by detecting the heat transfer from a heated RTD sensor referenced to the temperature of the ambient gas stream sensor.
 - b. The electronic circuitry shall either maintain a constant differential temperature between the gas temperature and the heated element or a constant power.
 - c. The electronic circuitry shall deliver a linear signal 4 to 20 mA DC output proportional to the process fluid flow.
 - 2. Performance requirements:
 - a. Accuracy:
 - 1) 1.5 percent of full scale for velocities over 2 feet per second.
 - b. Repeatability:
 - 1) 0.5 percent of full scale.
 - 3. Element:
 - a. Sensor with terminal enclosure.
 - b. Mounting:
 - 1) For insertion mounting:
 - a) Utilize a sensor with 3/4-inch male NPT process connection.
 - 2) For inline mounting:
 - a) Utilize a sensor with Class 150 ANSI flanged connection.
 - c. No overheat at zero flow.
 - 4. Transmitter:
 - a. Microprocessor-based.
 - b. Enclosure: NEMA Type 4X.
 - c. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 50 VA maximum.
 - d. Outputs:
 - 1) Isolated 4 to 20 mA DC with HART communication protocol.
 - e. Alphanumeric display for flow rate.
 - f. Ambient operating temperature limits: 0 to 150 degrees Fahrenheit.
 - 5. Components:
 - a. Signal cable between insertion probe and transmitter:
 - 1) Abrasive-resistant, polyurethane jacket.

- 2) Sensor cable permanently bonded to sensor.
 - 3) Provide enough length of cable to allow removal and inspection of insertion element.
- B. Thermal mass flowmeter for wet gas measurement:
1. General:
 - a. Thermal mass flowmeters measure airflow, industrial, and process gas mass flows by detecting the heat transfer from a heated RTD sensor referenced to the temperature of the ambient gas stream sensor.
 - b. The electronic circuitry shall either maintain a constant differential temperature between the gas temperature and the heated element or a constant power.
 - c. The electronic circuitry shall deliver a linear signal proportional to the process fluid flow.
 2. Performance requirements:
 - a. Accuracy:
 - 1) 1.5 percent of full scale for velocities over 2 feet per second.
 - b. Repeatability:
 - 1) 0.5 percent of full scale.
 3. Element:
 - a. Sensor with terminal enclosure.
 - b. Utilize a sensor with 3/4-inch male NPT process connection.
 - c. No overheat at zero flow.
 4. Transmitter:
 - a. Microprocessor-based.
 - b. Enclosure: NEMA Type 4X.
 - c. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 50 VA maximum.
 - d. Outputs:
 - 1) Isolated 4 to 20 mA DC with HART communication protocol.
 - e. Alphanumeric display for flow rate.
 - f. Ambient operating temperature limits: 0 to 150 degrees Fahrenheit.
 5. Components:
 - a. Signal cable between insertion probe and transmitter:
 - 1) Abrasive-resistant, polyurethane jacket.
 - 2) Sensor cable permanently bonded to sensor.
 - 3) Provide enough length of cable to allow removal and inspection of insertion element.

2.03 ACCESSORIES

- A. Software (if available as either a standard or an option) for fully validation on instrument performances.
- B. Provide sunshade for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST:
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed:
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Install digester gas flowmeters 45 degrees below the horizontal to prevent condensation from building up on the tip.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection services.

3.05 ADJUSTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: Sidestream Treatment Project Customer: City of Meridian Plant: WRRF Location: Meridian, ID BOM No.: File:		THERMAL MASS FLOWMETERS				Spec. No. 40_71_76		Rev.	
		N	By	Date	Revision				
						Contract		Date	
						Req.		P.O.	
				By	Chk	App			

1	Instrument Tag No.		SSPR1FIT0010-		SSPR1FIT0020			
	Service							
2	P&ID		N07		N08			
3	E L E M E N T	C	Line Size / Schedule		8 INCH		8 INCH	
4		O	Line Material					
5		N	Connection Type					
6		N	Connection Materials					
7		P R O B E O	Type		Spool Piece: Insertion: X			
8			Probe Material					
9			Probe Insertion Length					
10			Enclosure Class					
11			Balance Retract Mech.					
12		E N T	Other					
13	Other							
14	Other							
15	F L U I D	Fluid		AIR		AIR		
16		Max Flow Units		SCFM		SCFM		
17		Max Velocity Units						
18		Norm Flow	Min Flow					
19		Max Temp	Min Temp					
20		Max Press	Min Press					
21		Other						
22		Other						
23	T R A N S	Function						
24		Mounting		REMOTE		REMOTE		
25		Enclosure Class		NEMA 4X		NEMA 4X		
26		Length Signal Cable						
27		Type Span Adjustment		Mfr. Std.				

SECTION 40_72_24

LEVEL MEASUREMENT: RADAR PULSE TIME OF FLIGHT (PTOF)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Non-contact radar (PTOF) level instruments.
- B. Provide all instruments identified in the Contract Documents.
- C. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

- A. As specified in Section 40_61_00.

1.03 DEFINITIONS

- A. As specified in Section 40_61_00.
- B. Specific definitions:
 - 1. PTOF: Pulse Time of Flight.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.
- B. A template for the data sheet is included in the specification. System Supplier shall complete the data sheet based on system design.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 40_61_00.

1.08 WARRANTY

- A. As specified in Section 40_61_00.

1.09 MAINTENANCE

- A. As specified in Section 40_61_00.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following:
 - 1. Endress+Hauser, Micropilot FMR20.

2.02 MANUFACTURED UNITS

- A. Pulse Time of Flight:
 - 1. General:
 - a. Instrument emits radar pulses via a transmitter, with a frequency range of 6.3 GHz to 26 GHz.
 - b. The pulses reflect from the surface being measured and are received back at the instrument via a sensor.
 - c. The instrument measures the pulse travel time between the transmitter, surface, and receiver to calculate the level.
 - d. Safety:
 - 1) Shall not generate frequency waves with power levels hazardous to humans.
 - 2. Performance requirements:
 - a. Accuracy:
 - 1) 0.1-inch.
 - 3. Element:
 - a. Level element must conform to the process material compatibility as indicated on the Instrument Data Sheets or the Instrument Index.
 - b. Connections:
 - 1) Process: Tank mounted.
 - 2) The design shall be such that product condensation on the antenna shall not affect the performance of the gauge. It shall be possible to choose between either parabolic-, cone-, rod-shaped antennas.
 - 4. Display:
 - a. E&H RIA15.
 - b. Power supply:
 - 1) 24 VDC - 2-wire loop powered.
 - 2) Power consumption: 15 VA maximum.

- c. Backlit digital display for level or volume.
- d. Protected terminals and fuses in a separate compartment, which isolates field connection from electronics.
 - 1) Indication: Local - 5-digit display.
- e. Enclosure rating: NEMA Type 4X.
- f. Electrical connection: 1/2-inch male NPT.

2.03 ACCESSORIES

- A. Software: Provide Windows based PC software for configuration and echo mapping.
- B. Provide sun shield for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00.
- B. Factory calibrate each level transmitter at a facility that is traceable to NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.
- C. Furnish 2 hours of Owner training.

3.08 PROTECTION

- A. As specified in Section 40_61_00.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: Sidestream Treatment Project Customer: City of Meridian Plant: WRRF Location: Meridian, ID BOM No.: File:		RADAR PTOF LEVEL INSTRUMENTS							
						Spec. No.		Rev.	
		N	B	Date	Revision	40_72_24			
		o	y			Contract		Date	
						Req.		P.O.	
					By	Chk	App		

G E N	1	Instrument Tag Number		SSPR1LIT0501	
	2	Service		MGCL Tank	
	3	P&ID		N11	
	4	Other			
P R O B E	5	Type		Pulse Time of Flight (PTOF)	
	6	Housing Material		PVDF	
	7	Measurement Range		By Vendor	
	8	Op. Temp. Range			
	9	Manufacturer		E+H	
	10	Model		FMR20	
	11	Model Number			
	12	Antenna Style		Probe	
	13	Other			
	14	Other			
	15	Other			
	16	Other			
T R A N S M I T T E R	17	Type		Pulse Time of Flight (PTOF)	
	18	Operating Mode			
	19	Enclosure		NEMA 4X	
	20	Mounting		Remote – Near Fill	
	21	Temperature Range		Connection	
	22	Voltage Requirements			
	23	Power		Loop Powered (24 VDC)	
	24	Accuracy		± 0.25 inches	
	25	Calibrated Range			
	26	Display		Multi Character LCD	
	27	Output		4-20 mA HART	
	28	Calibration			
	29	Status Relay			
	30	Manufacturer		E+H	
	31	Model No.			
	32	Damping			
	33	Elect. Entry			
	34	Other			
O P T S	35				
	36				
	37				
	38				

Notes:					

SECTION 40_72_36

LEVEL MEASUREMENT: CAPACITANCE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Level measurement devices using the principle of admittance/capacitance for level measurement.
 - 2. For discrete measurement of liquid, slurry and granular levels.
 - 3. For analog measurement of liquid, slurry and granular levels.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 - Submittal Procedures and 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Manufacture instrument facilities certified to the quality standards of ISO Standard 9001 – Quality Systems – Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems:
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc., necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Continuous RF admittance/capacitance level:
 - 1. One of the following or equal:
 - a. Drexelbrook, Universal Lite 509-15 Series.
 - b. Delta Controls, Model TS173.
 - c. Endress + Hauser, Liquicap Level Transmitter, Models FMI51/52.
 - d. Magnetrol Kotron 805.

2.02 MANUFACTURED UNITS

- A. RF admittance/capacitance level measurement:
 - 1. General:
 - a. RF signal enables a very small current flow from the sensor to reference ground. A change in RF admittance indicates presence or absence of the measured material. Transmitter circuitry enables the instrument to ignore the effect of buildup of material coating on the sensing element.

- b. Single-point level switch sensing level of liquid, slurries, or granular materials.
 - c. Sensing interface between 2 liquids with significantly different dielectric constants (1 liquid must be non-conductive).
- 2. Performance requirements:
 - a. Accuracy:
 - 1) Within 0.25-inch.
 - b. Repeatability:
 - 1) Within 0.1-inch.
- 3. Element:
 - a. Rigid probe or flexible cable with weight for large container liquid applications.
 - b. Probe and insulation material must conform to measured material chemical compatibility as indicated on the instrument data sheet or the instrument index.
- 4. Transmitter:
 - a. Power supply:
 - 1) 24 VDC.
 - 2) Power consumption: 15 VA maximum.
 - b. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
 - c. Enclosure: NEMA Type 4X.
 - d. Operating temperature range from -28 to 155 degrees Fahrenheit.

2.03 ACCESSORIES

- A. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST:
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed:
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. As specified in Section 40_80_01 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 40_72_76

LEVEL MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Displacement float level switch.
 - 2. Tuning fork level switch.
- B. Provide all instruments identified in the Contract Documents.
- C. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
 - 3. Section 40_72_76 - Level Measurement: Switches.
 - 4. Section 40_80_01 - Testing, Calibration, and Commissioning.

1.02 REFERENCES

- A. As specified in Section 40_61_00.

1.03 DEFINITIONS

- A. As specified in Section 40_61_00.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.
- B. Provide complete documentation covering the traceability of all calibration instruments.
- C. A template for the data sheet is included in the specification. System Supplier shall complete data sheet based on system design.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 40_61_00:
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 40_61_00.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Tuning fork level switch:
 - a. E+H, Liquiphant.
 - b. Drexelbrook, TF-100 Series.
 - 2. Displacement float level switch:
 - a. Gems Sensors and Controls, Series LS-3.
 - b. B/W, Unifloat.
 - 3. Ball float level switch:
 - a. E+H, Liquifloat T FTS20.
 - b. Evoqua Water Technologies, 9G-EF.
 - c. ITT Flygt, Model ENM-10.
 - d. Anchor Scientific Inc., Ecofloat/Solofloat.

2.02 MANUFACTURED UNITS

- A. A. Ball float level switch:
 - 1. General:
 - a. Free hanging, encapsulated body with a switch to determine position of float.
 - 2. Element:
 - a. Mechanical switch encapsulated in waterproof floating ball of nominal diameter, supported by flexible PVC cable and jacket or heavy neoprene.
 - b. The length of the PVC cable shall be, at a minimum, equal to sump depth plus 5 feet.

- c. Float: Provide Type 316 stainless steel or polypropylene, maximum 3 inches in diameter.
 - d. An operating temperature rating: -30 degrees Fahrenheit to +150 degrees Fahrenheit.
 - e. Mercury switches are not acceptable.
 - f. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
 - 3. Switch:
 - a. Single pole double throw contacts rated 10 amps resistive at 120 VAC.
 - b. Provide the number of floats per level system as indicated on the Drawings.
 - c. Suspend ball float and adjust for level setpoint as required.
 - 4. Components:
 - a. Floats shall include Type 316 stainless steel clamp and brackets and 1/4-inch cable to allow testing of the float without entering the basin or wet well.
 - b. Provide strain relief at both ends of the float cable.
- B. Tuning fork level switch:
- 1. General: Tuning fork level switches comprised of a control relay, mechanically rigid fork, and transmitter housing.
 - 2. Switch: The control relay senses the liquid level by frequency attenuation at the probe fork when immersed.
 - a. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 10 VA maximum.
 - b. Outputs:
 - 1) Relay outputs:
 - a) 1 Form C contact.
 - b) 5 amperes at 120 VAC.
 - c) Programmable.
 - c. Electrical connection: One 1/2-inch NPT conduit entry.
 - d. Enclosure: NEMA Type 4X.
 - e. Approvals: Class I, Div 1 - if wired intrinsically safe.
- C. Displacement float level switch:
- 1. General: Float with a permanent magnet encircles a stationary stem. A hermetically sealed magnetically operated latching reed switch(es) mounted in the stem:
 - a. Mercury switches are not acceptable.
 - 2. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
 - 3. Switch:
 - a. Single pole single throw (SPST).
 - 4. The number of floats per level system shall be as indicated on the Drawings.

2.03 ACCESSORIES (NOT USED)

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed:
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00.

3.05 ADJUSTING

- A. As specified in Section 40_80_01.

3.06 CLEANING

- A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00.

3.08 PROTECTION

- A. As specified in Section 40_61_00.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be as indicated on the Drawings, as specified in the Specifications or both.

END OF SECTION

SECTION 40_73_13

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure/vacuum gauges.
- B. Provide all instruments specified in the Contract Documents.
- C. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

- A. As specified in Section 40_61_00.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

- A. As specified in Section 40_61_00.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.
- B. Additional requirements:
 - 1. Product data:
 - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 40_61_00.

1.08 WARRANTY

- A. As specified in Section 40_61_00.

1.09 MAINTENANCE

- A. As specified in Section 40_61_00.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Ashcroft:
 - a. Maximum pressure less than 10 pounds per square inch: Model 1188.
 - b. Maximum pressure less than 200 pounds per square inch:
 - 1) Model 1279.

2.02 MANUFACTURED UNITS

- A. General:
 - 1. Pressure gauge assembly shall include pressure-sensing element, gauge case, and dial mechanism.
- B. Performance requirements:
 - 1. Pressure range:
 - a. As specified in the Contract Documents.
 - 2. Accuracy:
 - a. Grade 2A, as defined by ASME B40.100.
 - b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
 - c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
 - 3. Element:
 - a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
 - b. Socket tips for bellows and Bourdon® tube:
 - 1) Materials: Type 316 stainless steel.
 - c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
 - d. Wetted materials: Type 316 stainless steel.

4. Dial gauge:
 - a. Dial size: 4-1/2 inches.
 - b. Dial case material:
 - 1) Maximum pressure less than 10 pounds per square inch:
 - a) Stainless steel.
 - 2) Maximum pressure greater than or equal to 10 pounds per square inch:
 - a) Stainless steel.
 - c. Provide safety gauge with safety blow out through the back or top of the unit.
 - d. Dial face: Gasketed shatterproof glass or polycarbonate.
 - e. Provide gauge locks on all pressure gauges directly connected to sanitary seals.
 - f. Provide gauge locks where possible.
 - g. Connection and mounting:
 - 1) Direct mounted and suitable for outdoor installation.
 - 2) 1/2-inch NPT.
 - 3) Connection material: Stainless steel.
 - h. Pointer: Externally adjustable.

2.03 ACCESSORIES

- A. Pulsation dampeners and snubbers:
 1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
 2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
 3. Materials: Type 316 stainless steel.
 4. Mount pulsation dampener or snubber integrally to the pressure gauge.
 5. Connection: 1/2-inch NPT.
 6. Provide sanitary seals as specified in the Contract Documents.
 7. Provide means for gauge isolation as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00.
- B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00.

3.08 PROTECTION

- A. As specified in Section 40_61_00.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 40_73_23

PRESSURE/VACUUM MEASUREMENT: DIRECT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure transmitters and indicators.
- B. Provide all instruments identified in the Contract Documents.
- C. Related sections:
 - 1. Sections 01_33_00 - Submittal Procedures.
 - 2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
 - 3. Section 40_73_64 - Pressure/Vacuum Measurement: Instrument Valves.
 - 4. Section 40_80_01 - Commissioning for Instrumentation and Controls.

1.02 REFERENCES

- A. As specified in Section 40_61_00.

1.03 DEFINITIONS

- A. As specified in Section 40_61_00.
- B. Specific definitions:
 - 1. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
 - 2. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.
 - 3. Calibrated range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than or equal to the URV. The calibrated range corresponds to the flow signal sent from the transmitter.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.
- B. Provide complete documentation covering the traceability of all calibration instruments.
- C. A template for the data sheet is included in the specification. System Supplier shall complete data sheet based on system design.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 40_61_00.
- B. Project environmental conditions as specified in Section 40_61_00:
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 40_61_00.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following:
 - 1. Endress & Hauser, Cerabar S Series.
 - 2. Emerson, Rosemount 3051S Series.

2.02 MANUFACTURED UNITS

A. Pressure transmitters - direct:

1. General:
 - a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.
2. Performance requirements:
 - a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
 - b. Accuracy:
 - 1) Reference accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
 - 2) Total performance accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
 - 3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
3. Element:
 - a. Diaphragm type transducer integral to pressure transmitter.
 - b. Diaphragm material: Stainless steel or ceramic.
 - c. Process material compatibility:
 - 1) Verify all material compatibilities with the instrument manufacturer.
 - d. Process connection: As specified in the Instrument Data Sheets.
4. Transmitter:
 - a. Power supply:
 - 1) 24 VDC - 2 wire loop powered.
 - 2) Power consumption: 3 VA maximum.
 - b. Outputs:
 - 1) Isolated 4-20mA DC with HART communication protocol.
 - c. Provided with electronic microprocessor.
 - d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
 - e. Local display:
 - 1) 5-digit LCD.
 - 2) Scaled in engineering units.
 - f. Remote or Integral as specified in data sheet. Remote mount transmitters only as shown on the plan drawings to provide maintenance staff access.
 - g. Enclosure:
 - 1) NEMA Type 4X or NEMA 7 based on the defined classified space.
 - h. Over range protection: To maximum process line pressure.
 - i. Conduit: 1/2-inch male NPT.
5. Components:
 - a. Transmitter mounting:
 - 1) As specified in the Instrument Data Sheets.
 - 2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

- A. Provide valve manifolds as specified in Section 40_73_64:
 - 1. Mount valve manifold integrally to the transmitter.
 - 2. Valve manifold and transmitter shall be assembled by Manufacturer and shipped as an assembly.
 - 3. Provide remote or integral diaphragm seals as shown in the Typical Details.
- B. Provide sunshades for outdoor installations if in direct sunlight.
- C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST:
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed:
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00.

3.05 ADJUSTING

- A. As specified in Section 40_80_01.

3.06 CLEANING

- A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00.

3.08 PROTECTION

- A. As specified in Section 40_61_00.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: Side Stream Treatment Project Customer: City of Meridian Plant: WRRF Location: Meridian, ID BOM No.: File:			PRESSURE TRANSMITTERS				Spec. No.		Rev.	
			No	By	Date	Revision	40_73_23			
							Contract		Date	
							Req.		P.O.	
							By	Chk	App	
GENERAL	1	Instrument Tag No.	SSPR1LIT0104				SSPR1LIT0204			
	2	Service	Water				Water			
	3	P&ID	N07				N08			
SERVICE	4	Pressure								
	5	Process Temperature	35-70 deg F				35-70 deg F			
	6	Ambient Temperature								
TRANSMITTER	7	Manufacture								
	8	Model No.								
	9	Pressure Transmitter Type	Remote Mount				Remote Mount			
	10	Calibrated Span								
	11	Accuracy								
	12	Adjustable Range								
	13	Output Signal	4-20 mA				4-20 mA			
BODY	14	Body Rating								
	15	Process Flange Type	Threaded				Threaded			
	16	Drain/Vent	None				None			
	17	Process Flange	MNPT				MNPT			
	18	Adapters								
	19	Wetted O-Ring								
	20	Housing								
	21	Bolts								
	22	Mounting Brackets								
	23	Conduit Entry Size								
ELEMENT	24	Isolating Diaphragm	Flanged				Flanged			
	25	Fill Fluid	Silicone				Silicone			
OPTIONS	26	Certification / Approval Type								
	27	Meter								
	28	Zero Span & Adjustment								
	29	Surge Protection								
MANIFOLD	30	Custom Configuration								
	31	Manufacturer								
	32	Model Number								
	33	Manifold Style	Reference Details							
	34	Manifold Type	Block and Bleed							
Notes: Provide tank level measurement instrument including direct mount flanged diaphragm seal with pressure element, remote mount transmitter, interconnecting cable between diaphragm seal assembly and transmitter.										

SECTION 40_73_64

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Valve manifolds and instrument valves.
- B. Provide all valves identified in the Contract Documents.
- C. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
 - 3. Section 40_80_01 - Commissioning for Instrumentation and Controls.

1.02 REFERENCES

- A. As specified in Section 40_61_00.

1.03 DEFINITIONS

- A. As specified in Section 40_61_00.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.
- B. Additional requirements:
 - 1. Product data:
 - a. Valve type.
 - b. Body material.
 - c. Size.
 - d. Options.
 - 2. Shop drawings:
 - a. Mounting details for all manifold valves.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00.
- B. Examine the complete set of Contract Documents and verify that the valves are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.

- c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the valve manufacturer's recommendations or specifications.
- D. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00.
- B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 40_61_00:
 - 1. Provide valves suitable for the installed site conditions including, but not limited to, material compatibility, process, and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 40_61_00.

1.09 MAINTENANCE

- A. As specified in Section 40_61_00.
- B. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Valve manifold:
 - 1. One of the following or equal:
 - a. Anderson Greenwood.
 - b. Hex Valve.
 - c. Noshok.
 - d. Emerson, Rosemount.
 - e. Endress & Hauser
- B. Block and bleed valve:
 - 1. One of the following or equal:
 - a. Anderson Greenwood.
 - b. Hex Valve.

- C. Gauge valve:
 - 1. One of the following or equal:
 - a. Anderson Greenwood.
 - b. Hex Valve.
- D. Level sensor isolation valve:
 - 1. One of the following or equal:
 - a. Indu-Tech, Level Sensor Isolation Valve.
 - b. DeZURIK, Level Sensor Isolation Valve.
 - c. Tyco, Rovalve Isolation Knife Gate Valve.

2.02 MANUFACTURED UNITS

- A. Valve manifolds:
 - 1. General:
 - a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds as indicated on the Drawings.
 - b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
 - 2. Requirements:
 - a. Bonnet lock pin to prevent accidental loosening.
 - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
 - e. Manifold valves shall allow for direct or remote instrument mounting.
 - f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
 - g. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.
 - h. 2-Valve manifolds:
 - 1) 1 isolation valve and 1 drain/vent and calibration valve.
 - i. 3-Valve manifolds:
 - 1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
 - 2) Plugged vent connections used for vent/drain or calibration.
 - j. Blowdown 5-valve manifold:
 - 1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
 - k. Metering 5-valve manifold:
 - 1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.
- B. Block and bleed valves:
 - 1. General:
 - a. Valve shall provide process isolation and venting/draining capabilities.
 - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.

- 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.
- C. Gauge valves:
 - 1. General:
 - a. Valve shall provide process isolation from pressure instrument.
 - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.
- D. Level sensor isolation valves:
 - 1. General:
 - a. Valve shall provide process isolation from level diaphragm.
 - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) Flange diameter size: 3 inches.

2.03 ACCESSORIES

- A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.
- B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location and verify it will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of all valves.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00.

3.05 ADJUSTING

- A. As specified in Section 40_80_01.

3.06 CLEANING

- A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00.
- B. Demonstrate performance of all valves to the Engineer before commissioning.

3.08 PROTECTION

- A. As specified in Section 40_61_00.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 40_74_66

TEMPERATURE MEASUREMENT: TEMPERATURE SWITCH

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Temperature switch instruments.
- B. Provide all instruments identified in the Contract Documents.
- C. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
 - 3. Section 40_80_01 - Commissioning for Instrumentation and Controls.

1.02 REFERENCES

- A. As specified in Section 40_61_00.

1.03 DEFINITIONS

- A. As specified in Section 40_61_00.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.
- B. Provide complete documentation covering the traceability of all calibration instruments.
- C. A template for the data sheet is included in the specification. System Supplier shall complete data sheet based on system design.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 40_61_00:
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 40_61_00.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Ashcroft, B Series.

2.02 MANUFACTURED UNITS

- A. Temperature switches:
 - 1. General:
 - a. Temperature switch shall be bulb type with snap-action switch element.
 - 2. Performance requirements:
 - a. Temperature range: As indicated in the data sheets or the P&IDs.
 - b. Accuracy:
 - 1) Within 2.0 percent of range.
 - c. Repeatability:
 - 1) Within 2.0 percent of range.
 - 3. Element:
 - a. Sensing element material: Stainless steel.
 - b. Sensing element shall not require ambient temperature compensation.
 - c. Switch elements:
 - 1) Snap acting.

4. Transmitter:
 - a. Setpoint:
 - 1) Dual.
 - 2) Activate switch at setpoint on increasing temperature for high temperature alarm applications and on decreasing temperature for low temperature alarm applications.
 - b. Fixed deadband.
 - c. Manual reset type.
 - d. Enclosure: Epoxy coated NEMA Type 4X.
 - e. Switch mounting:
 - 1) Local mount directly to process.
 - 2) Process connection: 1/2-inch NPT.
 - 3) Provide all necessary hardware for temperature switch mounting.
 - f. Outputs:
 - 1) Relay outputs:
 - a) Form C contact: 1.
 - b) Rated at 10A, 125/250VAC.

2.03 ACCESSORIES

- A. Thermowell:
 1. Unless otherwise noted, provide thermowell with each temperature switch.
 2. Process connection: As indicated in the Data sheets.
 3. Thermowell material: As Indicated in the Datasheets.
 4. Stem style: As indicated in the Data sheets.
 5. Immersion depth:
 - a. Minimum 3 inches or 10 times the diameter of thermowell, whichever is larger.
 - b. Where pipe diameter is inadequate for appropriate immersion depth, install thermowell in an elbow on the axis of the pipe.
- B. Provide sunshades for outdoor installations.

2.04 SOURCE-QUALITY-CONTROL

- A. As specified in Section 40_61_00.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST:
 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00.

3.05 ADJUSTING

- A. As specified in Section 40_80_01.

3.06 CLEANING

- A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00.

3.08 PROTECTION

- A. As specified in Section 40_61_00.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 40_75_13

ANALYZERS: PH

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. pH instruments.
- B. Provide all instruments identified in the Contract Documents.
- C. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
 - 3. Section 40_80_01 - Commissioning for Instrumentation and Controls.

1.02 REFERENCES

- A. As specified in Section 40_61_00.
- B. CSA International (CSA).

1.03 DEFINITIONS

- A. As specified in Section 40_61_00.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01_33_00 and 40_61_00.
- B. Provide complete documentation covering the traceability of all calibration instruments.
- C. A template for the data sheet is included in the specification. System Supplier shall complete data sheet based on system design.

1.05 QUALITY ASSURANCE

- A. As specified in Section 40_61_00.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 40_61_00.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 40_61_00.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 40_61_00.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. HACH:
 - a. Sensor model DPD1P1.
 - b. Transmitter model SC200.

2.02 MANUFACTURED UNITS

- A. pH analyzers:
 - 1. General:
 - a. pH measurement shall use the potentiometric measurement method utilizing a glass electrode. The pH sensitive glass membrane surface reacts to the acid content of the solution with a specific voltage, which is measured relative to a reference electrode.
 - 2. Performance requirements:
 - a. Accuracy: Within 0.01 pH.
 - b. Stability: Within 0.01 pH/month.
 - c. Repeatability: Within 0.01 pH.
 - 3. Element:
 - a. Sensor material:
 - 1) Glass pH sensor housed in a molded reinforced polypropylene body threaded as recommended by manufacturer.

- 2) Built in temperature sensor.
- 3) The reference electrode junction shall be capable of maintaining steady reference signal by resisting plugging in dirty applications.
- b. pH measuring range: 2 to 12 pH.
- c. Temperature measuring range: 0 to 70 degrees Celsius.
- d. Operating temperature range: 0 to 80 degrees Celsius.
- e. Operating pressure range: 0 to 87 pounds per square inch.
- 4. Transmitter:
 - a. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 73 VA maximum.
 - b. Outputs:
 - 1) Two isolated 4 to 20 milliamperes DC with HART communication protocol.
 - a) Proportional to pH and temperature.
 - c. Display:
 - 1) Backlit LCD digital display.
 - d. Measurement ranges: 0 to 14 pH.
 - e. Temperature: 0 to 50 degrees Celsius.
 - f. Displayed resolution: Within 0.01 pH.
 - g. Ambient conditions:
 - 1) Operable from 0 to 50 degrees Celsius.
 - 2) Relative humidity 0 to 95 percent.
 - h. Mechanical:
 - 1) Enclosure rating:
 - a) NEMA Type 4X (IP65).
 - 2) Mounting:
 - a) Panel mount suitable for mounting in an enclosure that includes gasket to maintain weather rating of the panel.
 - b) Surface mount enclosures, include self-tapping screws.
 - c) Pipe mounting accessories shall be included for mounting enclosures to a 2-inch pipe.
 - 3) Provide all mounting hardware for proper installation and servicing of the sensor assembly.
 - i. Electrical certification: NRTL certified to UL and CSA standards, and CE approved.
- 5. Components:
 - a. Sensor cable:
 - 1) Shall be provided with watertight sensor-to-cable connector that prevents cable twisting and eliminates rewiring when replacing the sensor.
 - 2) Cable length: As required to connect sensor to transmitter plus 10 percent.

2.03 ACCESSORIES

- A. Sensor:
 - 1. Process assemblies:
 - a. Provide threaded DN flange.
 - b. Provide 1-inch FNPT CVPC Pipe for probe connection.
 - c. Coordinate detailed connection with between tank and instrument manufacturer.

- B. Transmitter:
 - 1. DAT module.
 - 2. Flat gasket.
 - 3. Stainless steel tag:
 - a. Marking specified on Instrument Data Sheets.
- C. Preamplifier:
 - 1. Use Manufacturer recommended preamplifier on coaxial cable runs longer than 15 feet. Review the contractor drawings and verify the need for a preamplifier.
- D. NEMA 4X enclosure with viewing window as defined on the Drawings.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 40_61_00.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST:
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 40_61_00.
- B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

- A. As specified in Section 40_80_01.

3.06 CLEANING

- A. As specified in Section 40_61_00.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 40_61_00.

3.08 PROTECTION

- A. As specified in Section 40_61_00.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 40_80_01

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing requirements that apply to process control and instrumentation systems for the entire Project.
- B. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 01_75_17 - Commissioning.
 - 3. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

- A. As specified in Section 40_61_00.
- B. Electronics Industries Alliance (EIA).
- C. Telecommunications Industry Association (TIA).

1.03 DEFINITIONS

- A. As specified in Sections 01_75_17 and 40_61_00.
- B. Specific definitions:
 - 1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
 - 2. Loop Validation Tests - Signals are tested from the field device to the PLC.
 - 3. Platform Testing: Testing of the PLC and SCADA/HMI at the manufacturer's shop to demonstrate the program's functionality based upon specified and designed control requirements.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01_33_00.
- B. General:
 - 1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 40_61_00.

- C. Overall test plan:
1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
 2. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
 3. Describe the test phases as they apply specifically to this Project and each process system.
 4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
 5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
 6. Provide examples of proposed forms and checklists.
- D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and to the satisfaction of the Owner.
 2. Provide a statement of test objectives for each test.
 3. Prepare specific procedures for each process system.
 4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
 5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
 6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
 7. Provide the forms and checklists to be used.
- E. Test forms:
1. Submit completed calibration forms, test forms, and checklists.
 - a. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
 - b. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
 - c. Sample test forms at the end of this Section show the minimum required content:
 - 1) The sample test forms have not been customized for this Project.
 - 2) Contractor shall develop and submit test forms customized for the Project and meeting the specified test and submittal requirements.
- F. FAT procedure additional minimal requirements:
1. Prepare and submit a FAT procedure which includes:
 - a. Control system testing block diagram.
 - b. Estimated test duration.

- G. Details on the simulator construction, components, and operation. Testing binders:
 - 1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
 - 2. Fill out in advance headings and all other information known before the test.
 - 3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
 - 4. Include or list reference material and provide separately at the time of the test.
 - 5. Record test results and verify that all test requirements and conditions have been met.
- H. Test reports:
 - 1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
 - 2. Include all completed test binders, forms, and checklists.
 - 3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

1.06 QUALITY ASSURANCE

- A. Test personnel:
 - 1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

- A. As specified in Section 40_61_00.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 40_61_00.
- B. Installation supervision:
 - 1. Provide as specified in Section 40_61_00.

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

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. Commissioning as specified in Section 01_75_17.
- B. Testing and training phase:
 - 1. Source testing:
 - a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
40_67_01	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
40_80_01	Commissioning for Instrumentation and Controls	Witnessed

- b. Prerequisite requirements:
 - 1) Engineer approval of the hardware and equipment source testing submittal, Manufacturer Certificate of Source Testing, is required before proceeding to Preliminary FAT.
- c. Preliminary FAT (Pre-FAT):
 - 1) The purpose of the Pre-FAT is to provide assurance that the HMI/SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality:
 - a) Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT.
 - b) Contractor shall fully test the HMI/SCADA system and fix all deficiencies found before the FAT.
 - 2) Conduct utilizing test procedures approved by Engineer.
 - 3) Owner shall have the right to witness any or all of the Pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
 - 4) Submit a letter, signed by the Contractor's project manager or company officer, certifying that integrated system hardware and software has been tested and confirmed to be fully operational and in compliance with the requirements specified in the Contract Documents and is fully ready for the full, witnessed FAT:
 - a) Attach the completed pre-FAT test forms, signed by the Contractor's staff.

- 5) Engineer approval of the pre-FAT submittal is required before proceeding to FAT.
- d. FAT hardware and communications testing:
 - 1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
 - 2) The complete PCIS system including operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.
 - 3) Testing simulation:
 - a) Inputs and outputs shall be simulated and proper control and system operation shall be validated.
 - b) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system:
 - (1) The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
 - (2) The simulator may consist of a PLC, operating under a HMI/SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points.
 - (3) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
 - 4) Additional source tests are specified in other sections of the Instrumentation and Control Specifications.
 - 5) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
 - 6) Verify communications between the hardware and the programmer's software comply with specified requirements:
 - a) For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio based telemetry systems.
 - 7) Panel inspections:
 - a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings:
 - (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
 - b) Inspection forms:
 - (1) Provide panel inspection forms as part of the FAT procedures submittal.
 - (2) A sample FAT control panel form has been provided at the end of this Section.

- 8) I/O test:
 - a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
 - b) Test methodology:
 - (1) Discrete inputs:
 - (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
 - (2) Discrete outputs:
 - (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
 - (3) Analog inputs:
 - (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
 - (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
 - (4) Analog outputs:
 - (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
 - c) Test forms to include, but not be limited to the following data:
 - (1) PLC and panel number.
 - (2) I/O type.
 - (3) I/O tag name.
 - (4) Rack/slot/number of I/O point.
 - (5) Check-off for correct response for each I/O point.
 - (6) Comments field.
 - (7) Initials of individual performing test.
 - (8) Date test was performed.
 - (9) Witness signature lines.
- 9) System configuration test:
 - a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.
 - b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
 - c) Demonstrate the proper operation of peripheral hardware.
 - d) Demonstrate general HMI/SCADA functions.
 - e) Demonstrate proper operation of log-on and other security access functions.
 - f) Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
 - g) Test automatic fail over of redundant equipment.
 - h) Demonstrate the proper operation of the alarm display and acknowledgement functions.

- i) Test forms:
 - (1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
 - (2) List the specific tests and steps to be conducted.
 - (3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
 - (a) Include signature and date lines.
 - 10) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.
- e. FAT Platform Testing - Control logic test:
 - 1) Verify the PLC, HMI, and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
 - 2) Testing requirements:
 - a) Demonstrate each function described in the Control Strategies.
 - b) Demonstrate in detail how each function operates under a variety of operating scenarios:
 - (1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
 - c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description.
 - (1) Test each strategy or loop description on a sentence-by-sentence and function-by-function basis.
 - (2) Loops with similar or identical logic must each be tested individually.
 - (3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
 - d) Demonstrate the proper operation of all digital communication links and networks.
 - (1) Verify each digital communication I/O point.
 - e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.
 - 3) Test forms:
 - a) Submit completed test forms for each loop including but not limited to the fully revised and approved control strategy.
 - b) Identify the cause and effect as each I/O point is toggled through the simulator:
 - (1) Identify and track proper and/or improper operation of the loop.
 - c) Note any deficiencies or operational changes on the forms for correction and documentation:
 - (1) Include signature and date lines.
 - 4) Engineer approval of the FAT submittal is required prior to shipment of system components.

2. Owner training:
 - a. Demonstration requirements are specified in this Section.

Table 1			
Course Title	Minimum Course Length (hours per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	1	10	1
Operator Training - Basic	2	10	2
Operator Training - Advanced	4	5	2

3. Training course requirements:
 - a. System overview training:
 - 1) Furnish training courses that give the Owner's supervisory level personnel and overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
 - 2) Furnish a training course that gives the Owner's supervisory level personnel and overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.
 - b. Operator training:
 - 1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
 - 2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
 - 3) Operator's training shall include the following for each vendor package and programmable device:
 - a) Control system overview: Architecture, equipment functions, software components, etc.
 - b) Display navigation, overview, and types of displays.
 - c) Process and equipment monitoring and control: Basic principles and operation.
 - d) Logging ON and OFF the system and description of the security and access system.
 - e) Alarm subsystem.
 - f) Trending: Provide a thorough session on how to use all trending functions.
 - g) Reports: How to access, print, and review content.
 - h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.

- i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.
- 4. Installation testing:
 - a. Calibration:
 - 1) Performed by Contractor and Vendor.
 - 2) Calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
 - 3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy:
 - a) Calibration for discrete devices:
 - (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.
 - b) Calibration for ultrasonic and radar level devices:
 - (1) Provide Echo Transmission and signal quality on level transmitters including guided and unguided units:
 - (a) Submit printout of the actual transmission and parameters.
 - (2) Adjust mounting, as required, to obtain accurate readings.
 - (3) Post mounting: Provide any additional calibration required by manufacturer.
 - c) Calibrating analog transmitters:
 - (1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.
 - (2) Test and verify that components and/or systems are within the specified limits of accuracy.
 - (3) Calibration points:
 - (a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
 - (4) Field verify calibration of instruments including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
 - d) Analyzer calibration:
 - (1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
 - (2) Submit completed instrument calibration sheets for every field instrument and analyzer.
 - (3) Calibration tags:
 - (a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
 - (b) Sign the tag when calibration is complete.
 - e) Calibration for industrial networking test equipment:
 - f) Submit calibration documentation.
 - b. Loop check:
 - 1) Performed by the Contractor.
 - 2) Cabling installed, terminated, and labeled.

- 3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
- 4) Complete loop check form for each device.
- 5) Submit loop check test results before proceeding to the next step.
- c. Loop validation tests:
 - 1) Performed by the Contractor and manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
 - 2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
 - a) The PLC may or may not be connected to the network.
 - 3) Engineer approval of the loop validation test submittal is required before proceeding to CEET.
- d. LAN cable post-testing:
 - 1) Performed by Contractor.
 - 2) After installing the cable and connectors, test all cables using the LAN certification to confirm the installation meets the requirements of the specification.
 - 3) Provide test documentation that includes the cable number, total length of cable, a permanent hard copy, as well as a USB or CD copy of all traces:
 - a) After installing connectors:
 - b) Perform cable end-to-end testing on all installed cables from both ends of the cable. Test shall include cable system performance tests and confirm the absence of wiring errors.
 - c) Submit a signed test report presenting the results of the cable testing.
 - d) Repair or replace any portions of the system not meeting TIA/EIA standards for installed cabling. Repaired sections shall be retested.
 - 4) Submit final documentation (including traces), using the approved test form, to the Engineer upon successful completion of the testing.
 - 5) Engineer approval of the LAN cable post-testing submittal is required before proceeding to CEET.
- e. Complete End-to-End Testing (CEET):
 - 1) Performed by Contractor, manufacturer's representative working together, with assistance from the OWNER or the inspection staff, as needed:
 - a) The participants need to be dedicated full-time to CEET.
 - b) Contractor will be responsible for creating field signals and verifying proper operation of final control elements.
 - 2) Prerequisites:
 - a) CEET cannot begin until the successful completion of the preceding tests:
 - (1) Calibration.
 - (2) Loop check.
 - (3) Loop validation tests.
 - (4) LAN cable post-testing.
 - (5) Industrial network testing.

- 3) Testing description:
 - a) This testing is to ensure all I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
 - b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. The outputs will be energized for a duration long enough to verify proper operation of the final control element.
 - c) SCADA screens:
 - (1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
 - (2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
 - (3) Retest any loop following any necessary corrections.
- 4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system:
 - a) Use actual process inputs wherever available.
 - b) Issue commands from the HMI/SCADA system and verify proper responses of field devices:
 - (1) Test SCADA system inputs from field device to SCADA system operator workstations:
 - (a) Track responses through trend charts in the HMI/SCADA system.
 - (2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
- 5) Discrete device testing:
 - a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
 - (1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
 - (2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
 - (3) Calibrate and test instruments supplying discrete inputs, and observe proper operation.
 - b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
 - (1) Stroke valves through outputs from the HMI/SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
 - (2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.

- (3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.
- 6) Analog device testing:
 - a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
 - b) Apply provisional settings on controllers and alarm setpoints.
- 7) Analog input:
 - a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system:
 - (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
- 8) Analog output:
 - a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system:
 - (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal.
 - (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
- 9) Submit completed test forms:
 - a) Discrete instrument input devices:
 - (1) Switch setting, contact action, and dead band.
 - (2) Valve position switches:
 - (a) Response in the PLC as the valve is stroked from the PLC.
 - (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
 - (3) Operator interface switches (control stations and other pilot devices) and associated response.
 - (4) Starter and drive auxiliary device contact response.
 - (5) Response of all other discrete inputs to the PLC.
 - (6) Test equipment used and associated serial numbers.
 - b) Discrete output devices:
 - (1) Observed response of field device to the discrete output from the PLC.
 - (2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
 - (3) Test equipment used and associated serial numbers.
 - c) Analog input devices:
 - (1) Calibration range.
 - (2) Calibration data: Input, output, and error at each test value.
 - (3) Analog input associated PLC register address.
 - (4) Value in PLC register at each test point.

- (5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
 - (6) Test equipment used and associated serial numbers.
 - d) Analog output devices:
 - (1) Calibration range.
 - (2) Test value at each test point.
 - (3) Analog output associated PLC register address.
 - (4) Control variable value at field device at each test point.
 - (5) Physical device response at each test point:
 - (a) Response to be actual valve position, or motor speed, etc.
 - (6) Test equipment used and associated serial numbers.
 - 10) Failure testing:
 - a) Demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
 - (1) Equipment failure.
 - (2) Communications sub-system error.
 - (3) Power failure.
 - (4) Process equipment failure.
 - (5) High system loading conditions.
 - 11) Engineer approval of the CEET submittals is required before proceeding to Functional Testing.
5. Functional testing:
- a. General:
 - 1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
 - 2) Performed by Contractor and manufacturer's representative working together, with assistance from the Owner or the inspection staff, as needed.
 - 3) Additional tests are specified in other Instrumentation and Control Sections.
 - 4) Follow approved detailed test procedures and check lists for Functional Test activities.
 - b. Control logic operational validation:
 - 1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
 - 2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
 - 3) Test in detail on a function-by-function and sentence-by-sentence basis.
 - 4) Thoroughly test hardware and software functions:
 - 5) Including all hardwired and software control circuit interlocks and alarms.
 - 6) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.

- 7) Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.
- c. Loop tuning:
 - 1) Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
 - 2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
 - 3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
 - 4) Functional validation sheets:
 - a) Document each Functional test on an approved test form.
 - b) Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
 - c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
 - (1) Loop number and P&ID number.
 - (2) Control strategy, or reference to specification tested.
 - (3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
 - d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
 - (1) Specification page and paragraph of function demonstrated.
 - (2) Description of function and/or text from specification.
 - (3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
 - 5) Functional certification:
 - a) Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17.
 - (1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.

- C. Process Start-up Phase:
1. Process Start-up:
 - a. Manufacturer shall be onsite to support Process Start-up activities and provide functional changes as required.
 2. Process Operation Period:
 - a. Manufacturer shall be available to support Process Operational Period and provide functional changes as required.
 3. Instrumentation and Controls Fine-Tuning:
 - a. General:
 - 1) After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
 - 2) The performance test is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
 - 3) The complete PLC control and HMI/SCADA system must run continuously for the duration of the performance test.
 - 4) Test and use the entire process control system under standard operating conditions.
 - 5) Exercise all system functions.
 - 6) Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause:
 - a) Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system:
 - (1) Response time to the Project Site: 24 hours or less, for a major failure.
 - b. SCADA system testing:
 - 1) Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
 - 2) Failure of the HMI/SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications:
 - a) Corrective action is required before restarting the performance test.
 - 3) Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
 - 4) Failures:
 - a) Classify failures as either major or minor:
 - (1) Minor failure:
 - (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
 - (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.

- (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
 - (d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
 - (2) Major failure:
 - (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
 - (b) Cause termination of the performance test.
 - (c) Start a new acceptance test when the causes of a major failure have been corrected.
 - (d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
- 5) Technician report:
 - a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
 - b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
 - c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
 - d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES

- A. Example test forms:
 - 1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
 - 2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	
1. GENERAL INSPECTION A. Structural Inspection ☐ Verify Lifting Lugs Installed ☐ Verify enclosure has lock and lock is functional ☐ Confirm that seismic bracing components are provided per manufacturer's installation instructions B. Exterior Inspection ☐ Cabinet exterior is clean, scratch, and dent free ☐ Inspect externally for corrosion and damage ☐ Verify enclosure door opens and closes easily ☐ Verify enclosure has a 3-point latch ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet) ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.) ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant) Nameplates ☐ Cabinet has identification nameplate ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract ☐ Cabinet has a nameplate that includes the following: ☐ Power source(s) ☐ Circuit ID(s) ☐ Integrator's Logo ☐ Short Circuit KAIC ratings ☐ If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.) Door Devices ☐ All devices penetrating the outside of panel have gaskets, silicone or both ☐ All door devices are installed (HMIs, Pilot Devices, etc.) ☐ Door mounted equipment is mounted straight and square ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened ☐ NEMA classification has not been violated due to penetrations ☐ Door mounted equipment has the same NEMA rating as the panel ☐ All door mounted equipment installed at the correct height ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner) ☐ Doors with multiple penetrations have adequate bracing (if needed) ☐ Visually check condition of indicators , controllers and annunciators ☐ Check that pilot lights illuminate correctly ☐ Check the Push-To-Test function ☐ Ensure correct pilot light color Peripheral Devices ☐ Horn / Beacon is installed (where required) ☐ Silence and Reset pushbutton		
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____		TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS			
1. GENERAL INSPECTION (continued) C. Interior Inspection ☐ Cabinet is cleaned of marks and dirt. ☐ Inspect internally for corrosion and damage. ☐ Back panel is clean of marks and dirt. ☐ Interior of panel vacuumed and shall be free of all debris. ☐ Check that the panel roof is clean and clear of foreign materials. ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed. ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open. ☐ Check that a document pocket has been provided. ☐ Intrusion alarms (where required). Interior Labeling ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags. ☐ Verify that door mounted components are mounted square and symmetrical. ☐ Verify that nameplates are straight, legible, and spelled correctly. ☐ All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps. ☐ All wiring shrink labeled and or phased correctly to the specifications. ☐ All wire labels shrunk completely rotated and aligned alike for easy identification. ☐ All fuses and circuit breakers are labeled with ID and current rating. ☐ System Integrator's label or labels installed on door. ☐ Panel manufacturer model/serial number tag is present. ☐ All required safety/warning tags installed and straight. ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.). Wireways ☐ Plastic wire way covers installed properly. ☐ Plastic wireways have no sharp edges. ☐ No wire Ties inside the wireways. ☐ No sharp edges on wire ties. ☐ Separation: White duct is used for DC voltages, Gray duct is used for AC voltages. ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____ </td> <td style="width: 50%; vertical-align: top;"> TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____ </td> </tr> </table>			PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____			

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
1. GENERAL INSPECTION (continued) C. Interior Inspection (continued) Wiring ☐ Visually check terminals and condition of internal wirings ☐ Verify that the control panel has been assembled and wired as designed ☐ Verify that all components are operational and perform the functions intended ☐ Verify that all components are sized appropriately for the application ☐ Verify that equipment control circuits function as intended ☐ Back of door wiring is labeled and neatly formed ☐ Back panel to door wiring has sufficient bending radius with spiral wrap ☐ Wire connection has been verified wired to correct points within the panel ☐ Individual wires have been given a pull test to verify a good terminal connection ☐ Wire and cable minimum bending radius have not been violated ☐ All equipment installed straight and square to back panel ☐ Wire colors are correct: ☐ Black and White > AC hot and neutral, respectively ☐ Red > AC control signals ☐ Blue > DC power and control (Blue w/White stripe for DC ground) ☐ Yellow > Foreign voltages (those still present when panel power is disconnected) ☐ Green > AC equipment ground ☐ Black > TSP (+) ☐ White > TSP(-) ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields) ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself ☐ Discrete inputs are separately fused or protected by a circuit breaker on a "per loop" basis ☐ Intrinsic Safety Wiring ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring ☐ Verify all spare terminals are installed according to the percentage listed in the specifications Grounding ☐ Equipped with "Blackburn" or other grounding type lug ☐ Lug is securely fastened to the panel structure ☐ Verify Grounding bar is installed ☐ Verify Isolated ground bar is installed												
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
2. POWER TEST A. AC Power ☐ AC Power is routed correctly within the panel, and is isolated from DC and network wiring. ☐ All fuses are installed and sized properly. ☐ All breakers are installed and sized properly. ☐ 24 VDC Power Supplies are functional. ☐ 24 VDC Power fail contacts are functional. ☐ 24 VDC power supplies are redundant, and have diode modules enabling the hot swap-over between supplies. ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional. ☐ Dedicated receptacle is wired to receive a dedicated AC supply. ☐ Verify continuity for all DC commons, ground and AC neutrals. ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage. ☐ Close the CP main circuit breaker(s). ☐ Verify that voltages at subsequent circuit breakers are correct. ☐ Close circuit breakers. ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct. ☐ Turn on power supplies if they are not already on. ☐ Verify that voltages at distribution terminals are correct. ☐ Energize any remaining hardware such as the PLC. B. Uninterruptible Power Supply (UPS) ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel. ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit). ☐ Test all UPS alarms (on inverter, failure, battery failure etc.) ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.												
3. CONTROLS & AUXILIARY DEVICES TEST ☐ Verify all interposing and auxiliary relays are functioning. ☐ Verify panel lights are functioning. Ventilation and Heating ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked. ☐ Verify components are installed in the correct orientation for proper air flow.												
4. HARDWIRED INTERLOCK AND SAFETY TEST ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump. ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.												
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
5. PLC TEST A. Components ☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional. ☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used. ☐ TVSS is installed across the main incoming 120 VAC. PLC and PLC Rack ☐ Verify all cards are securely seated. ☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the "no encroachment" area. Confirm with manufacturer clearance recommendations. B. PLC I/O Test ☐ Furnish I/O test forms and test all the listed input and output points as follows: ☐ Discrete Inputs: Simulate a field contact closure by "shorting" across the appropriate terminal blocks. Observe the transition between a logical "0" and "1" in the PLC software. ☐ Discrete Outputs: Force the output bit to toggle between logical "0" and logical "1" using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the "ohms" setting. ☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred. ☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter. C. Redundant Controllers (where required) Test ☐ Remove Communication cable from primary PLC to verify switching to backup PLC ☐ Remove Communication cable from backup PLC to verify switching back to primary PLC ☐ Remove Power cable from primary PLC to verify switching to backup PLC ☐ Remove Power cable from backup PLC to verify switching back to primary PLC D. PLC Control Logic Verification ☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below. ☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal. ☐ For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.												
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
5. PLC TEST (continued) D. PLC Control Logic Verification (continued) Typical Fault Logic ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears. ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear. Typical Fail to Start Logic ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm. 6. HMI OR OIT TEST HMI / OIT Functionality ☐ Communication with PLC ☐ Screen Layouts ☐ Screen Navigation ☐ Set Point Entry ☐ Animation ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention) ☐ Alarms ☐ Acknowledge and Reset ☐ Security / Access Levels / Passwords 7. NETWORK COMMUNICATION TEST A. Network Components ☐ Fiber optic cabling terminates in a patch panel ☐ Media converters are installed and functional ☐ Terminating resistors have been installed for trunk/tap topologies or where required ☐ Wire and cable bending limitations have not been violated B. Networking Functions ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams ☐ Verify network traffic rate and error margin is acceptable												
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS			
8. FAT DOCUMENTATION AND RECORD Panel Documentation ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material. ☐ Panel schematic and interconnection drawings. ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested. ☐ I/O list test forms of the process area to be tested. ☐ FAT procedure of the process area to be tested. ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel. ☐ Hard copy of the PLC application program of the process area to be tested. ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested. 9. FAT TOOLS AND SOFTWARE ☐ Simulation software if required ☐ Digital volt meter Fluke 87 ☐ Process meter Fluke 787 ☐ Laptop computer with PLC application program ☐ Temporary SCADA computer with HMI software and applicable graphic screens ☐ Jumper wires				
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	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

REMARKS: _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

<u>FIELD CALIBRATION CHECK</u>						
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐
 INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? No Yes

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐
 INDICATOR ☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

<u>BENCH CALIBRATION CHECK</u>				
INPUT RANGE = _____			OUTPUT RANGE = _____	
HEAD CORRECTION = _____			☐ LINEAR	
CALIBRATED SPAN = _____			☐ SQUARE ROOT	
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

<u>FIELD CALIBRATION CHECK</u>				
INPUT RANGE = _____			OUTPUT RANGE = _____	
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

- ☐ DIRECT ☐ REVERSE
☐ ACTION VERIFIED AT 50% SPAN
☐ ACTION VERIFIED AT _____ SPAN

CONTROLLER SETTINGS								
SETTING	GAIN	PB	RESET (INTEGRAL)	DERIV. (RATE)	HIGH LIMIT	LOW LIMIT	ELEV. ZERO	ZERO SUPP
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	PB	RESET (REPEAT/MIN)	RESET (MIN/REPEAT)	DERIVATION (MINUTES)
FLOW	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐
 INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? No Yes

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

- ☐ VALVE TAG NO. _____ SERIAL NO. _____
- ☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____
- ☐ SOLENOID TAG NO. _____ SERIAL NO. _____
- ☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____
- ☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

TRANSDUCER CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

- ☐ BENCH CALIBRATED PER ABOVE _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____
- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE	ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

SECTION 43_11_33

ROTARY-LOBE BLOWERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Rotary-lobe blowers.
- B. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 01_75_17 - Commissioning
 - 3. Section 01_78_23 - Operation and Maintenance Data.
 - 4. Section 01_78_36 - Warranties and Bonds.
 - 5. Section 01_81_01 - Project Design Criteria.
 - 6. Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - 7. Section 40_73_13 - Pressure/Vacuum Measurement: Gauges.
 - 8. Section 40_73_23 - Pressure/Vacuum Measurement: Direct.
 - 9. Section 40_80_01 - Commissioning for Instrumentation and Controls.
 - 10. Section 46_05_10 - Common Work Results for Mechanical Equipment.
 - 11. Section 46_05_94 - Mechanical Equipment Testing.
- C. Tag numbers:
 - 1. Rotary-lobe Blower 1 SBU681.
 - 2. Rotary-lobe Blower 2 SBU682.

1.02 REFERENCES

- A. American Bearing Manufacturers Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
 - 1. 52.1 - Testing for HVAC Air Filtration.
- C. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- D. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 SYSTEM DESCRIPTION

- A. System components: Aeration blowers, blower panel, and appurtenances.
- B. General: Aeration blowers and appurtenances shall include the following items and supplied by blower manufacturer:
 - 1. Rotary positive displacement blower and motor.

2. Air intake filters.
3. Silencers, inlet, and discharge.
4. Check valves.
5. Relief valves.
6. Flexible pipe connectors.
7. Pressure gauges.
8. Acoustic enclosure.
9. Discharge temperature gauge.
10. Appurtenances as required.

C. Design requirements:

Type of Blower	Rotary lobe, positive displacement
Number of blowers	2 (1 per reactor train)
Rated speed	3,514 rpm @ 99% of maximum
Rated inlet air flow at rated speed SCFM	255 scfm per machine
Inlet filter/Silencer pressure loss	0.35 pounds per square inch
Rated discharge pressure	8.0 psig
Rated inlet pressure	13.1 psia
Inlet temperature	93 degree Fahrenheit
Design Relative Humidity	10 %
Minimum Turndown (VFD ONLY)	69 scfm per machine
Brake Horsepower (max)	15 bHp

1. Motor: As specified in Section 26_05_09, except as otherwise specified or supplemented below:

Power supply	480-volt, 3-phase, 60-hertz
Horsepower	20 HP
Speed, maximum	3,535
Enclosure	TEFC
Service factor	1.15

2. Drive: Belt.
3. Noise control:
 - a. Sound pressure levels radiated from equipment furnished shall not exceed 73 dBA (mean, A-weighted) at 3 feet ($RE\ 2 \times 10^{-5}\ N/m^2$) for free field condition when unit is in operation at rated flow.
4. Vibration:
 - a. Maximum acceptable peak vibration velocity (unfiltered) for blower equipment is 0.45 inches per second.
5. Package flow, pressure, and BHP performance to include pressure loss through a clean inlet filter / silencer, pressure loss of the exhaust silencer and check valve.

6. Package Performance shall be guaranteed to ISO 1217 with a tolerance is +/- 5% on volume flow and +/- 5% on package horsepower. Manufacturer of blower must provide data for purchased machine.
7. Sound data shall be from an ISO 2151 method of measurement, in an ISO 3745 qualified test facility. Sound data shall be compliant with a Declaration of Conformity assessment standard.

1.04 SUBMITTALS

- A. Submit as specified in Section 01_33_00.
- B. Product data:
 1. As specified in Section 46_05_10.
 2. Blower information:
 - a. Manufacturer.
 - b. Model.
 - c. Blower speed in revolutions per minute.
 - d. Blower site capacity, actual cubic feet per minute (scfm and icfm at site conditions).
 - e. Discharge pressure, pounds per square inch absolute.
 - f. Rated maximum pressure rise of blowers.
 - g. Horsepower required including loss in V-belt drive.
 - h. Weight of blower.
 - i. Weight of motor.
 - j. Free-field noise level at 3 feet from blower acoustic enclosure.
 3. Motor performance and construction data.
 4. Construction details of acoustic enclosure.
 5. Descriptive brochures and applicable performance and construction data for each item of auxiliary equipment along with their weights.
 6. Test data on equipment performance, vibration, and noise.
 7. Certified general arrangement drawings showing materials, details of construction, dimensions, and connections.
 8. List of recommended spare parts broken down into on hand parts and long term for 2 years operation and 3 to 5 years operation.
 9. ISO-1217 Performance Test Results Slip test results are unacceptable as an alternate. Manufacturer must provide documented results for the purchased machines. Typical or average data is not acceptable.
- C. Shop drawings: As specified in Section 46_05_10:
 1. Blower panel device layout and material list.
- D. Calculations: As specified in Section 46_05_10.
- E. Vendor operation and maintenance manuals: As specified in Section 01_78_23.
- F. Commissioning submittals:
 1. Provide Manufacturer's Certificate of Source Testing.
 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

1.05 ENVIRONMENTAL CONDITIONS

- A. Blower shall be suitable for continuous service and outdoor installation.
- B. Blower shall be suitable for continuous service at the elevation and other conditions associated with the facility location: Meridian, ID.

1.06 WARRANTY

- A. Provide warranty as specified in Section 01_78_36. All blower equipment supplied shall be covered by a warranty of 24 months from date of commissioning.

PART 2 PRODUCTS

2.01 AERATION BLOWERS

- A. Manufacturers: One of the following or equal:
 - 1. Aerzen Generation 5 Delta Hybrid Rotary Lobe Compressor D10S, or equal.
- B. Regardless of manufacturer, the package will be produced by the manufacturer of the blower stage, to ensure single source responsibility for blower performance and compatibility of associated accessories. Packagers not permitted to bid.
- C. The equipment shall be designed, constructed and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings.

2.02 MATERIALS

- A. General:
 - 1. Aeration blower assembly: Complete with blower, drive, inlet and discharge silencers, valves, and appurtenances.
 - 2. Blower rating: As specified above.
 - 3. Rotation direction of blower shall match requirements of piping.
- B. Blower and drive:
 - 1. General:
 - a. Blower shall deliver oil-free air.
 - b. Blower and motor mounting: On common base.
 - c. Lifting provisions: Lifting eyes on blowers, motors, and base so each major component or entire unit can be lifted.
 - d. Piping connections: 125 pound class flanges in accordance with ASME B16.1.
 - 2. Type: Positive displacement rotary blowers using 2 impellers to pressurize a trapped volume of air at a controlled rate prior to exposing it to a discharge pressure.
 - 3. Casing and head plates:
 - a. Blower casing: 1 piece with separate head plates and end covers.
 - b. Casing and head plates: Made of close-grained, machined cast iron.
 - c. End covers and head plates: Reinforced with bosses at penetrations with cast, machined support feet.

4. Impellers:
 - a. Material: Ductile iron or cast iron.
 - b. Design: Straight, 3-lobe, involute type.
 - c. Balance: Dynamically, by removing metal from impeller body.
 - d. Operation: Free of rubbing without need for liquid seals or lubrication.
 - e. Timing: positively by a pair of accurately machined, heat-treated, alloy steel timing gears.
 - f. Shafts: Alloy steel forgings, pressed into each end of each impeller and pinned.
 - g. Impeller assembly support: Anti-friction type bearings, sized for a minimum ABMA 9 and 11 L10 life for bearings of 85,000 hours.
5. Lubrication:
 - a. Positive oil seal: Provided at each bearing.
 - b. Seal design: Capable of preventing lubricant from leaking into air stream.
 - c. Vent provisions: Capable of venting impeller side of oil seal to atmosphere while eliminating possible carryover of lubricant into air stream.
 - d. Drive-end bearings: Grease or oil lubricated.
 - e. Timing gears and gear-end bearings: Splash oil lubricated.
 - f. Blower's shipment: With openings sealed after injection of rust inhibitor.

2.03 APPURTENANCES

- A. Inlet filter shall have front access for filter element access. Filter shall provide 99 percent removed efficiency of 5-micron particle size and larger.
- B. Inlet Filter / Silencer:
 1. Each package shall be supplied with one combination inlet filter silencer.
 2. The inlet filter silencer shall be mounted directly to the inlet flange of the blower.
 3. The filter media efficiency must meet the requirements of ASHRAE 52.2 MERV7 50-70 percent @3-10 microns corresponding to EN779 G4.
 4. The silencer portion shall be located upstream of the inlet filter.
 5. Filter and silencer performance losses shall be included in the blower performance calculation.
 6. The filter element shall be designed to trap dirt on the inside so that upon changing, dirt does not fall into the machinery. Filters where dirt accumulates on the external surface of the filter will not be permitted.
- C. Base Frame / Discharge Silencer:
 1. Each package shall be supplied with one combination base frame / discharge silencer.
 2. The silencer shall be a chamber type design for maximum sound attenuation and shall not use fibrous or absorption materials of any kind. Internal absorption material has been shown to degrade and internally foul diffusers and will not be permitted.
 3. The silencer shall be fabricated of a single shell of pressure vessel quality steel with continuous welds.
 4. The silencer shall be subject to a pressure test for tightness and strength at a minimum of 1.65 times the maximum blower operating pressure.
 5. The silencer shall have a machined inlet connection where the discharge flange of the blower stage bolts directly to, with no intermediary pieces.

- Threaded connection between the compressor stage and the discharge silencer is subject to leakage and misalignment and will not be permitted.
6. Discharge silencer performance losses shall be included by the blower vendor in the blower performance calculation.
 7. The base frame shall be constructed from welded carbon steel or cast iron that shall be designed to maintain alignment of the blower internal components and the drive during operation.
 8. The base frame shall be designed to resist distortion while being installed on vibration isolating mounts.
 9. The blower manufacturer shall supply a stainless steel grounding lug fully welded to the base.
- D. Acoustic enclosure:
1. Galvanized sheet-metal sandwich construction.
 2. With noise attenuating walls and with ventilation openings ported, ducted, shielded, and lined with acoustic absorptive material as required to achieve specified noise levels.
 3. Design criteria:
 - a. As specified in Section 01_81_01.
 4. Raintight and dusttight, suitable for outdoor unprotected installation (due to potential for spray water caused by washdown of other equipment within facility).
 5. With ventilation system designed for not more than 15 degrees Fahrenheit air temperature rise with aeration blower operating at maximum load.
 6. With fan interlocked with blower motor to start when blower starts and to stop with an adjustable time delay after the blower motor stops.
 7. With a weather-protected ventilation air intake filter:
 - a. Of disposable, dry type, pleated lofted cotton and polyester fiber media construction, securely bonded to a welded galvanized wire backing, with a frame of heavy-duty paperboard.
 - b. Sized for not more than 400 feet per minute face velocity.
 - c. With ASHRAE Standard 52.1 cleaning efficiency of not less than 25 percent.
 - d. With thickness not less than 1 inches.
 - e. With an easily visible and resettable "replace filter" indicator with retained indication independent of blower on/off status.
 8. With removable access panels located for maintenance and inspection access to the housed equipment, each weighing not more than 40 pounds, or hinged if weight exceeds 40 pounds.
- E. Relief valve: High-capacity, full-nozzle type; 2 inch minimum valve inlet:
1. Manufacturers: The following or equal:
 - a. Kunkle Valve Co.
- F. Check valves:
1. Each package shall be supplied with one check valve that shall be installed on the discharge line.
 2. The check valve shall be of the full-bore low pressure-drop, flapper type design with a steel body, and steel flap embedded in Silicone with full-contact seal.

3. The valve shall be removable without disturbing the piping. Pressure losses produced by the check valve shall be included in the blower performance calculation.
 4. Consisting of following components:
 - a. Valve body: ASTM A126 cast iron.
 - b. Disc: ASTM B148-9A, aluminum bronze.
 - c. Spring: ASTM A276, Type 316 stainless steel.
 - d. Pins and thrust bearings: ASTM A276 Type 316, stainless steel.
 - e. Seals, rated for minimum 350 degrees Fahrenheit.
- G. Pressure gauges:
1. As specified in Section 40_73_13.
- H. Switches:
1. High discharge air temperature switch:
 - a. With thermowell, suitable for mounting in discharge piping.
 - b. Adjustable over range of 80 to 300 degrees Fahrenheit or as recommended by blower manufacturer. Initial setting as recommended by blower manufacturer.
 - c. With local indication of temperature.
 - d. Activation shuts down unit and activates an alarm condition.
 - 2.
- I. Other safety devices and controls: As recommended by blower manufacturer.
- J. Rubber expansion joints:
1. Provided at discharge flanges of blowers.
 2. Suitable for pressures up to 25 pounds per square inch gauge and temperature up to 392 degrees Fahrenheit.
 3. At discharge joints, provided with control rods to restrict axial pipe movement.
 4. Manufacturers: The following or equal:
 - a. General Rubber.
- K. Discharge piping and silencer insulation: Insulation inside acoustic enclosure by blower manufacturer.
- L. Supports and bracing: As required to support blower, associated equipment, and piping, and to prevent excessive or harmful vibration or movement of equipment or piping.

2.04 CONTROLS

- A. Manufacturer shall provide local control panel:
1. Panel shall include emergency stop switch and applicable relays/switches for high discharge and motor temperature.
- B. Mounting position of emergency stop and temperature switches: As recommended by manufacturer of sensing equipment to provide maximum protection.

2.05 SPARE PARTS AND SPECIAL TOOLS

- A. Spare parts: Provide the following:
1. 4 complete sets of ventilation and air intake filters.

2. 2 sets of drive belts:
 - a. Spare parts shall be properly bound and labeled for easy identification without opening the packaging.
- B. Special tools: Provide the following:
 1. 1 set of special tools with equipment when required for normal operation and maintenance.

PART 3 EXECUTION

3.01 DELIVERY, STORAGE AND HANDLING

- A. All equipment shall be completely factory assembled, skid mounted, crated and delivered to protect against damage during shipment.
- B. All exposed flanges shall be covered and sealed with shrink-wrap to prevent the entrance of moisture. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.
- C. All equipment delivered to the site shall be stored as specified in accordance with the manufacturer's instructions.

3.02 INSTALLATION

- A. Install adequate supports and bracing to support blower, associated equipment, and piping, and to prevent excessive or harmful vibration or movement of equipment or piping resulting from operation of the system.
- B. Mount blower on base plate: Properly align and grout base plate as required for blower and base for electric motor with sliding rails.
- C. Secure silencers with hold-down bolts.

3.03 COMMISSIONING

- A. As specified in Sections 01_75_17, 46_05_94, and this Section.
- B. Manufacturer services:
 1. Provide certificates:
 - a. Manufacturer's Certificate of Source Testing.
 - b. Manufacturer's Certificate of Installation and Functionality Compliance.
 2. Manufacturer's Representative onsite requirements:
 - a. Installation and Functional Testing: 1 trip, 1-day minimum.
 - b. The functional test shall consist of 4 hours of operation of each blower with vibration, temperature, noise, and pressure readings as well as motor amp readings taken and recorded at 60-minute intervals.
 - c. Electrical and Controls: Conduct testing as specified in Section 40_80_01.
 3. Training:
 - a. The Manufacturer shall provide operations and maintenance training to the plant personnel. The training shall consist of 1 hour of classroom training using the Operation and Maintenance Manual for reference and 2 hours of hands on training at the blower package.

4. Process operational period:
 - a. As required by Owner or Contractor.
- C. Source testing:
 1. Each blower stage shall be factory tested in accordance with ISO 1217 performance test to verify flow and brake horsepower at blower maximum conditions. A slip test shall not be acceptable, nor is average data for the manufactured size.
 2. The acceptance criteria are +5% tolerance on power and -5% tolerance on flow regardless of the size of the machine.
 3. Blower:
 - a. Test witnessing: Not witnessed.
 - b. Conduct Level 1 General Equipment Performance Test.
 - c. Conduct Level 1 Vibration Test.
 - d. Conduct Level 1 Noise Test.
 4. Electrical and Controls:
 - a. Conduct testing as specified in Section 40_80_01.

END OF SECTION

SECTION 43_23_57.10

PROGRESSING CAVITY PUMPS

1.01 GENERAL

1.02 SUMMARY

- A. Section includes: Rotary, positive displacement, Moineau principal, single screw, progressing cavity type pumps with drivers, and specified components.
- B. Tag numbers: As specified in Pump Schedule.

1.03 REFERENCES

- A. American Bearing Manufacturers' Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- B. American Gear Manufacturers Association (AGMA).
- C. American Society of Mechanical Engineers (ASME):
 - 1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
- D. ASTM International (ASTM):
 - 1. A48 - Standard Specification for Gray Iron Castings.
 - 2. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 3. A283 - Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
 - 4. A681 - Standard Specification for Tool Steels Alloy.
 - 5. D2240 - Standard Test Method for Rubber Property—Durometer Hardness.
- E. Hydraulic Institute (HI):
 - 1. 3.1-3.5 - Rotary Pumps for Nomenclature, Definitions, Application and Operation.
 - 2. 3.6 - Rotary Pump Tests.
 - 3. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application, Sound Measurement and Decontamination.
- F. National Electrical Manufacturers Association (NEMA).

1.04 DEFINITIONS

- A. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 3.1-3.5, 3.6, and 9.1-9.5 and as modified in the Specifications.
- B. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.05 SYSTEM DESCRIPTION

- A. Pump type and components:
 - 1. Rotary, positive displacement, Moineau principle, single screw, progressing cavity type pumps with components.
 - 2. System includes pump, motor or other driver, drive arrangements, seals or packing, couplings, base plates, guards, supports, anchor bolts, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.
- B. Design requirements:
 - 1. Pump performance characteristics:
 - a. As specified in the Pump Schedule.
 - b. Performance tolerances shall be the same as the test tolerances specified in Section 46_05_94 - Mechanical Equipment Testing.
 - 2. Motor characteristics: As specified in the Pump Schedule.
- C. Product requirements as specified in Section 01_60_00 - Product Requirements and Section 46_05_10 - Common Work Results for Mechanical Equipment.

1.06 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment:
 - 1. Submit seal water pressure and flow requirements.
- C. Shop drawings: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- D. Calculations: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment:
 - 1. Torsional analysis: When scheduled submit as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- E. Vendor operation and maintenance manuals: As specified in Section 01_78_23 - Operation and Maintenance Data.
- F. Commissioning submittals:
 - 1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 - 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.07 WARRANTY

- A. As specified in Section 01_78_36 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Pumps: The following, no equal:
 - 1. Netzsch, Inc., Model Series NM.
- B. Pumps: One of the following or equal (alternate quotation):
 - 1. Seepex, BN Series.
 - 2. Moyno Industrial Products Division of Robbins & Meyers, Inc., Model Series EZ Strip.

2.02 MATERIALS

- A. General: Materials in the Pump Schedule shall be the type and grade as specified in this Section.
- B. Cast iron: ASTM A48, Class 30 minimum.
- C. Buna-N: Synthetic rubber with a minimum Durometer hardness of 70 in accordance with ASTM D2240 test methods.
- D. Tool steel: ASTM A681, with 0.020 inch minimum chrome plating thickness oversized and finish to Rockwell hardness of not less than C60.
- E. Stainless steel: ASTM A276, Type as scheduled.
- F. Structural steel: ASTM A283, Grade D.

2.03 PUMP CASINGS

- A. Construction: Material as scheduled of sufficient strength, weight, and thickness to provide accurate alignment, and prevent excessive deflection.
- B. Housing cover plates: 2-piece split case housing over stator for access to rotor and shaft ends without otherwise dismantling the pump.
- C. Design Working Pressure: Not less than the maximum of 1.25 the Rated Design Point head or 1.1 times the maximum discharge pressure at the maximum revolutions per minute in vendor published information for the specified model.
- D. Hydrostatic test: 5-minute hydrostatic test minimum 1.5 times Design Working Pressure.
- E. Suction and discharge piping connections: Flanged in accordance with ASME B16.1, Class 125, or ASME B16.5, Class 150; provide higher pressure class as required to meet Design Working Pressure.
- F. Vent and taps: Provide casings with both 3/4 inch National Pipe Thread high point vent and low point drain taps.

2.04 STATOR AND ROTOR

- A. Stages: As scheduled.
- B. Materials: As scheduled.
- C. Stator removal: Removable for maintenance replacement.
- D. Rotation: Clockwise looking from driver, unless otherwise indicated on the Drawings.
- E. Balance: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment to meet the vibration criteria as specified in Section 46_05_94 - Mechanical Equipment Testing.

2.05 DRIVE SHAFTS

- A. Type: Solid shaft, rigidly connected to the rotor through a connecting rod and grease lubricated, gear type U-joint:
 - 1. Pin shaft joints or flexible shafts are not acceptable for other pumps.
 - 2. Shaft turned and polished.
- B. Material: As scheduled.
- C. Strength: Able to withstand minimum 1.5 times maximum operating torque and other loads, and of ample strength and stiffness to operate without distortion or vibration which may reduce pump life at normal speeds as shown in the manufacturer's literature.
- D. Resonant frequency: As specified in Sections 46_05_10 - Common Work Results for Mechanical Equipment and 46_05_94 - Mechanical Equipment Testing.
- E. Shaft connecting rod: Design to limit operating angle to within 1-degree angular deflection.
- F. Shaft connecting rod: Design to limit operating angle to within 1-degree angular deflection.

2.06 BEARINGS AND BEARING FRAME

- A. Materials:
 - 1. Pump bearing frame: As scheduled.
- B. Bearing type: Mount shaft in 2 sets of antifriction tapered roller bearings or radial ball bearings meeting ABMA standards and adequate to withstand radial or axial thrust forces and complying with following:
 - 1. Inboard set: Single.
 - 2. Outboard set: Dual.
 - 3. Shaft expansion: Make provisions in shaft and bearing mounting to prevent distortion of shaft due to temperature expansion.

- C. Bearing lubrication: Grease with external grease fittings or sealed for life:
 - 1. Size sufficiently to safely absorb heat energy normally generated in bearing under maximum ambient temperature of 60 degrees Celsius.
 - 2. Equip with grease relief pipe, if externally greased.
- D. Bearing life: Minimum L10 life of 100,000 hours at rated design point but not less than 24,000 hours in accordance with ABMA 9 or 11 at bearing design load imposed by pump shutoff with maximum sized impeller at rated speed.

2.07 SHAFT STUFFING BOX

- A. Size: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Materials: Same as pump casing.
- C. Shaft seal type: As scheduled and as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- D. Drain size: Minimum 3/4 inch, with drain line routed to nearest equipment floor drain.

2.08 COUPLINGS

- A. Types: When driver or gear coupled to pump, provide flexible coupling as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Flexible coupling life: Infinite at up to 0.30-degree misalignment angle total or per disk for disk type at maximum operating loads.
- C. Design coupling to withstand a minimum of 1.5 times the maximum operating torque and other imposed loads.

2.09 SUPPORTS, PEDESTALS, AND BASEPLATES

- A. Type: Single piece base plate with drive arrangement as scheduled and as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. Materials: Structural steel, hot-dip galvanized after fabrication and coated per manufacturer recommendation.
- C. Pump and driver support strength: Able to withstand minimum 1.5 times maximum imposed operating loads or imposed seismic loads, whichever is greater.
- D. Configuration: Allow easy access to stuffing boxes, bearing frames, suction housing and couplings; suction flange at least 2 inches above pump foundation; factory mount pump and driver to baseplate.
- E. Motor arrangement:
 - 1. For overhead, piggyback or side motor arrangements: Provide motor base with slide rails to allow for adequate belt and alignment adjustment of pump and motor.

2. When in-line motor arrangement scheduled:
 - a. Motor centerline to coincide with pump centerline.
 - b. Provide gearbox as needed to provide specified pump speed.
 3. When piggyback or overhead motor arrangement scheduled:
 - a. Support motor directly above pump centerline.
 - b. Mount motor minimum of 6 inches above top of pump on structural frame.
 4. When side-mounted motor arrangement scheduled:
 - a. Mount side-mounted motors adjacent to pump, secured directly to baseplates.
 - b. Provide side-mounted motors “left-handed” or right-handed” as indicated on the Drawings.
- F. Anchor bolts: Provide post-installed anchors, per manufacturer’s sizing and recommendation.

2.10 SPEED REDUCERS

- A. Gear reducers (when scheduled or required for a pump in this Section):
1. Provide with NEMA C face connection between motor and gearbox.
 2. Provide helical reduction gears, rated for AGMA Class II service with a 1.5 service factor.
 3. Provide oil bath lubricated.
 4. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- B. V-belt drives (when scheduled or required for a pump in this Section):
1. Design to transfer torque of installed driver.
 2. Limit speed reduction ratio to 5 to 1.
 3. As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

2.11 EQUIPMENT GUARDS

- A. Provide equipment safety guards as specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.

2.12 DRIVERS

- A. Horsepower:
1. As scheduled.
 2. Listed driver horsepower is the minimum to be supplied.
 - a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
 - b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
 - c. Make all structural, mechanical, and electrical changes required to accommodate increased horsepower.
- B. Motors: Provide motors as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower and as specified in this Section:
1. Revolutions per minute: As scheduled:
 2. Enclosure: As scheduled.

3. Electrical characteristics: As scheduled.
4. Efficiency, service factor, insulation, and other motor characteristics: As specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
5. Motor accessories: As specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower and in this Section.
6. Coordinate motors with the variable frequency drive manufacturer to ensure compatibility between the motor and variable frequency drive:
 - a. Coordinate pump starting torque requirements to ensure supplied variable frequency drive provides sufficient starting torque capacity for all operational conditions, including after extended shutdown periods while in service pumping process fluids and sludge.

C. Other drivers: As scheduled and as specified in sections listed in the Schedule.

2.13 PUMP ACCESSORIES

- A. Provide stator run dry protection for all supplied pumps:
 1. Run dry protection shall be provided for the pump stator through the measurement of temperature at the stator/rotor interface. The temperature run dry protection shall shut down the pump upon high temperature before stator damage occurs.
 2. As part of the run dry protection package, provide thermistor, thermowell drilled and tapped into pump stator, explosion proof connection head, and in relay controller type that can be housed in pump controller.
 - a. Connection head shall be aluminum.
 - b. Controller shall display indicating stator temperature and alarm setpoint.
 - c. Controller shall include fault output for remote monitoring.
 - d. Controller shall be mounted within NEMA 4X LCP located near pump.
 - 1) LCP shall be provided by Contractor.
 3. Provide relay to allow annunciation of a high stator temperature (fail) alarm if the temperature reaches an adjustable preset temperature. Setpoint for alarm condition shall be set in the field per Manufacturer's recommendations.
 4. Electrical characteristic: 120 volts, single-phase, 60 hertz.

2.14 SPARE PARTS AND SPECIAL TOOLS

- A. Spare parts:
 1. Pump thrust bearing set.
 2. Pump radial bearing set.
 3. Stators: 1 every type.
 4. Shaft coupling or U-joint: 1 every size and type.
 5. Pump rotor: 1 every type.
- B. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

PART 3 EXECUTION

3.01 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning and this Section.

- B. Manufacturer services:
1. Provide certificates:
 - a. Manufacturer's Certificate of Source Testing.
 - b. Manufacturer's Certificate of Installation and Functionality Compliance.
 2. Manufacturer's Representative onsite requirements:
 - a. Installation: 1 trip, 1-day minimum.
 - b. Functional Testing: 1 trips, 1-day minimum each.
 3. Training:
 - a. Maintenance: 4 hours per session, 2 sessions.
 - b. Operation: 2 hours per session, 2 sessions.
 4. Process operational period:
 - a. As required by Owner or Contractor.
- C. Source testing: As specified in Pump Schedule.
- D. Functional testing: As specified in Pump Schedule.

3.02 PUMP SCHEDULE

Tag Numbers	PMP-001, PMP-002
<u>General Characteristics</u>	
Service	Struvite and Anaerobic Digested Sludge
Quantity	2
Minimum Pumped Fluid Temperature, degrees Fahrenheit	40
Normal Pumped Fluid Temperature, degrees Fahrenheit	80
Maximum Pumped Fluid Temperature, degrees Fahrenheit	95
Fluid Viscosity, Maximum Centipoise	-
Fluid Viscosity, Minimum Centipoise	-
<u>Pump Characteristics</u>	
Number of Rotor Sealing Stages	1
Bearing Lubrication	Grease or Sealed
Shaft Seal Type	Gland Packing
Coupling Type	Spacer
Speed Control	Fixed
Maximum Pump revolutions per minute	175
Minimum Pump revolutions per minute	35
<u>Rated Design Point (At Maximum Revolutions per Minute):</u>	
Flow, gallons per minute	100
Head, feet	40

Tag Numbers	PMP-001, PMP-002
<u>Other Conditions:</u>	
Maximum NPSHr at Every Specified Flow, feet	13
Minimum NPSHa at Every Specified Flow, feet	23
Minimum Suction Static Head, feet	2
Maximum Suction Static Head, feet	40
<u>Pump Materials</u>	
Pump Casing	Cast Iron
Stator	Buna-N
Rotor	316 SST
Shaft	316 SST
Pump Bearing Frame	Cast Iron
<u>Driver Characteristics</u>	
Driver Type	Motor
Drive Arrangement	Close Coupled
Non-reverse Ratchets	None Required
Minimum Driver Horsepower	
Maximum Driver Speed, revolutions per minute	1,800
<u>Motor Characteristics (when motor is driver type)</u>	
Inverter Duty Rated	No
Motor Voltage/Phases/Hertz	460/3/60
Enclosure Type	TEFC
<u>Source Testing</u>	
Test Witnessing	Not Witnessed
Performance Test Level	1
Vibration Test Level	1
Noise Test Level	1
<u>Functional Testing</u>	
Performance Test Level	1
Vibration Test Level	None
Noise Test Level	None

END OF SECTION

SECTION 43_33_20.01

LIQUID CHEMICAL DIAPHRAGM-TYPE METERING PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Positive displacement, diaphragm metering pumps; accessories, drives, and control panel requirements for pumping chemical solutions.
- B. Tag numbers:
 - 1. As specified in Pump Schedule.

1.02 REFERENCES

- A. International Society of Automation (ISA):
 - 1. ISA5.4 - Instrument Loop Diagrams.
- B. National Electrical Code (NEC).
- C. National Electrical Manufacturer's Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. NSF International (NSF):
 - 1. 61 - Drinking Water System Components - Health Effects.

1.03 DEFINITIONS

- A. NEMA: Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

- A. General: Provide mechanically actuated, positive displacement, diaphragm type chemical metering pumps, accessories, and other items required for a complete and operational system. Each chemical metering pump system shall include, but not be limited to, the following items, which shall be supplied by the chemical metering pump manufacturer:
 - 1. Pumps.
 - 2. Motors.
 - 3. Electronic speed and manual stroke controllers.
 - 4. Control panels.
 - 5. Calibration columns.
 - 6. Pulsation dampeners.
 - 7. External pressure relief valves.
 - 8. Diaphragm back pressure valves.
- B. Fluid characteristics:
 - 1. Magnesium Chloride:
 - a. Dry chemical formula: $MgCl_2$.
 - b. Solution concentration: 25 to 35 percent by weight.

- c. Solution pH: 4 to 9.
 - d. Solution specific gravity: 1.24 to 1.34.
- 2. FLOFOAM™ DM:
 - a. Dry chemical formula: Polydimethylsiloxane (C₂H₆OSi)_n.
 - b. Solution pH: 6 to 8 at 1% aqueous solution.
 - c. Solution specific gravity: 0.9 to 1.2.
- C. Design requirements:
 - 1. Pump:
 - a. Dry self-priming, capable of being run dry without damaging effects to pump.
 - 2. Motor characteristics:
 - a. As specified in this Section and in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - 3. VFD characteristics: As specified in this Section.
 - 4. Shafting and couplings: Design shafting and couplings to withstand a minimum of 1.5 times the maximum operating torque or other imposed loads.
 - 5. Supports:
 - a. Provide pump and driver supported on a common base.
 - b. Design anchor bolts to withstand a minimum of 1.5 times the maximum imposed operating loads or 1.0 times the imposed seismic loads, whichever is greater.
- D. Performance requirements:
 - 1. Systems shall deliver the pressures and volumes listed for their respective services in the Pump Schedule.
- E. Product requirements as specified in Section 01_60_00 - Product Requirements and Section 46_05_10 - Common Work Results for Mechanical Equipment.

1.05 SUBMITTALS

- A. Submit as specified in Section 01_33_00 - Submittal Procedures.
- B. Product data: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment:
 - 1. Design data, test reports, certificates, manufacturer's instructions, manufacturer's field reports:
 - a. Chemical feed pumps:
 - 1) For each pump type, submit calibration charts and tables relating flow rate to stroke length and stroke rate.
 - 2) Submit hydraulic modeling results for each pumping system:
 - a) Confirm scheduled values or recommend new pressure setpoints for the backpressure valves and pressure relief valves listed in the Pump Schedule.
 - 3) Submit calculations for each metering pump showing the suitability of each pump for the suction and discharge conditions of each application point:
 - a) Pump manufacturer shall recommend and size an accumulator to be piped to the suction side of each metering pump, when required based on calculations.

- 4) Submit calculations recommending dimensions of pulsation dampener indicated on the Drawings.
- C. Shop drawings: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment:
1. Provide a list of parameters, ratings, or other characteristics where the proposed chemical feed systems deviate from the requirements.
 2. Dimensions, including anchor bolt layout, materials of construction, size, weight, and performance data.
 3. Drawings: Provide electrical and instrumentation drawings showing coordination with electrical control devices operating in conjunction with the associated feed system.
 4. Dimensioned inlet and outlet connections.
 5. Current NSF 61 Certification for components to be in contact with associated chemical or potable water.
 6. Provide data showing chemical compatibility and history of service with the associated chemical for materials in the system.
 7. Control panel views showing equipment arrangement, doors, equipment layout inside the panel and dimensional information.
 8. Internal interconnecting wiring diagrams showing terminal strips and external devices connected to the panel as specified in Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
 9. Loop drawings for analog and discrete signals in accordance with ISA5.4.
 10. Complete schematic and diagrams including terminal block and wire identification numbers and device location symbols consistent with the Contract Documents.
 11. Panel bill of material with detailed description of components and equipment data sheets.
 12. Field cable numbers and terminations.
 13. Manufacturer's Representative's qualifications as specified in Section 01_75_17 - Commissioning.
 14. Manufacturer's certificate stating that the materials of construction are compatible with the pumped fluid.
 15. Manufacturer's Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 16. Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.
 17. Calibration curves for each pump relating stroke length and speed to flow rate shall be supplied.
 18. Capacity control shall be 0 to 100 percent with delivery repeatable within plus or minus 1 percent accuracy over at least a 10 to 1 range.
 19. Motor and VFD supplier shall carefully review the intended application of the VFD and certify in writing that sizes provided are adequate for continuous or intermittent operations (whichever is the most severe operating condition).
- D. Calculations: As specified in Section 46_05_10 - Common Work Results for Mechanical Equipment.
- E. Vendor operation and maintenance manuals: As specified in Section 01_78_23 - Operation and Maintenance Data:
1. Provide information on each piece of equipment, including instrumentation.

2. Provide all safety considerations relating to operations and handling of the associated chemical.
 3. Maintenance data shall include all information and instructions required by plant personnel to keep equipment properly cleaned, lubricated, and adjusted so that it functions economically throughout its full design life.
 4. Lubrication charts and tables of alternate lubricants.
 5. Name, address, and phone number of manufacturer and manufacturer's local service representative.
- F. Commissioning submittals:
1. Provide Certificate of Source Testing as specified in Section 01_75_17 - Commissioning.
 2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01_75_17 - Commissioning.

1.06 WARRANTY

- A. Provide warranty as specified in Section 01_78_36 - Warranties and Bonds.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Packing, shipping, handling and unloading:
1. Pack for shipping and outdoor storage at the project site for up to 6 months:
 - a. Apply temporary corrosion protective coatings to unpainted components and pack components to protect from the elements.
 2. Ship pump and drive completely assembled:
 - a. VFD shall be shipped unwired to the motor for field wiring.

PART 2 PRODUCTS

2.01 GENERAL

- A. A single pump manufacturer shall furnish and coordinate all drives and pump components specified in this Section, including motors, gears, couplings, supports, and other specified accessories and appurtenances to ensure compatibility and integrity of the individual components.
- B. The manufacturer of the pumps shall have sole-source responsibility for furnishing the complete assemblies and meeting the specified performance requirements.

2.02 PUMPS

- A. Equipment:
1. Pump:
 - a. Manufacturers: The following:
 - 1) Prominent Fluid Controls, Inc.
 2. Type: Simplex chemical proportioning pumps of the positive displacement diaphragm type.

3. Materials:
 - a. The metering pumps and their components and accessories shall be suitable for the following chemical concentrations, as scheduled in this Section:
 - 1) Magnesium chloride:
 - a) Wetted parts shall be suitable for use with 25 to 35 percent magnesium chloride solution.
 - b) Other non-specified materials are to be manufacturer's standard for continuous service with 25 to 35 percent magnesium chloride solution.
 - b. Diaphragm materials:
 - 1) Flat, composite, mechanically actuated diaphragms shall be Viton™, EPDM or PTFE faced as pump manufacturer deems suitable for the pumped liquid, fiber reinforced and bonded to an elastomeric support with a Type 316 stainless steel backing plate.
 - c. Other parts in contact with pumped liquid: PTFE, PVC, or other suitable thermoplastic.
4. Characteristics:
 - a. Diaphragm simplex chemical proportioning pumps of the positive displacement, non-loss of motion or flat disc diaphragm type.
 - b. The diaphragm shall be mechanically actuated.
 - c. Liquid end:
 - 1) Liquid end shall be sealed by means of an o-ring of material compatible with the pumped liquid.
 - 2) Liquid end of each metering pump shall be fitted with a system to detect early stage diaphragm failure. Upon actuation, the leak detector shall stop the pump, light a locally visible LED and sound a remote alarm.
5. Components:
 - a. Electronic speed and manual stroke controllers.
 - b. Suction and discharge single check valves.
 - c. Built-in internal or external, adjustable pressure relief valve to relieve pressure in the event of discharge line stoppage; which shall be factory set to relieve at 50 pounds per square inch gauge.
 - d. Hydraulic make-up and air bleed valves.
6. Accessories: As indicated on the Drawings, pumps shall be equipped with:
 - a. Calibration column in suction piping.
 - b. Diaphragm backpressure, pulsation dampener, and pressure relief valve in discharge piping.
7. Tests and inspections:
 - a. As scheduled in this Section.
8. Verification of performance.

2.03 PUMP GEARBOX DRIVE

- A. Pump gearbox shall be constructed of steel and nodular iron and be water resistant and suitable for outdoor installation:
 1. Pump and gearbox housing shall be coated in high-solids epoxy.
- B. Gearbox shall be oil bath lubricated.
- C. All fasteners shall be Type 316 stainless steel.

2.04 DRIVE AND MOTOR

A. Type:

1. Each chemical metering pump shall be motor-driven through a flexible coupling, or direct-connected to the pump when manufacturer's standard.
2. Pumps and motors shall be mounted on floor-mountable base plates.
 - a. Coupler:
 - 1) Manufacturers: One of the following or equal:
 - a) Dodge, Para-flex.
 - b) Falk, Type WA.

B. Characteristics:

1. Electric motors shall be as specified in Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
2. Motors and motor starters shall be furnished by the pump manufacturer and shall be coordinated with the requirements of the pumps and the following characteristics:

Horsepower (minimum)	1/2
Volts/phase/hertz	120/3160
Speed (maximum)	1,800 revolutions per minute
Service factor	1.15
Ambient temperature	50 degrees Centigrade
Maximum temperature rise	40 degrees Centigrade
Enclosure	TEFC
Insulation	Class B, moisture resistant, inverter duty
Bearings	Tapered rollers
Fasteners	Type 316 stainless steel

3. The motor shall be a permanent magnet type, having a 90 volt direct current armature rating, and horsepower not less than the minimum specified rating.
4. Motor shall have a thermostat for high temperature shutdown.
5. The motor brushes shall have tinned leads.

2.05 CONTROLS

A. Provide chemical metering pump control indicated on the Drawings .

B. Each chemical metering pump shall be provided with an automatically controlled, electronic speed controller to adjust the capacity from 0 to 100 percent while the pump is operating:

1. Electronic speed controller shall operate with a power source of 120 volts, and shall automatically control speed of the pump based on a 4-20 mA signal.
2. Electronic controller shall allow pump to be controlled remotely by a signal originating from the PLC or by a manually controlled external stroke adjustment wheel located on controller.

- C. 3. Stroke controller shall include a digital stroke length indicator, calibrated from 0 to 100 percent. Each chemical metering pump shall be provided with a Hand-Off-Automatic (H-O-A) selector switch:
 - 1. Switch shall have 2 contacts, 1 to be closed in the "hand" position and 1 to be closed in the "automatic" position.
 - 2. A run-indicator light shall also be provided.
- D. Motor starter shall be provided with normally open (dry) contact for remote "run" indication.
- E. Provide separate Local Control Panels (LCP) for the chemical feed systems. LCPs shall include a single non-regulated 120 volt power source:
 - 1. This power is drawn from the main plant power grid and is not filtered.
 - 2. It is subject to random noise and voltage spikes, and voltage fluctuations of up to plus or minus 15 percent.
 - 3. The manufacturer shall furnish a complete LCP including, but not limited to, the following:
 - a. NEMA Type 4X, Type 316 stainless steel, size as required.
 - b. Motor starters for each motor.
 - c. Stroke control drives as required.
 - d. Switches, push buttons, pilot lights and indicators as required for proper pump control.
 - e. Contacts for analog and discrete inputs and outputs as indicated in the P&ID drawings and Control Descriptions.
 - f. Instruments, control devices, and other devices as required to perform the operations indicated in the Control Descriptions and indicated on the Drawings.
- F. Locate panel on or near the chemical metering pumps as indicated on the Drawings.

2.06 ACCESSORIES

- A. Pulsation dampeners:
 - 1. Manufacturers: One of the following or equal:
 - a. Kemlon Products.
 - b. Blacoh Fluid Controls, Inc.
 - c. Pulsafeeder.
 - 2. Pulsation dampeners shall be furnished and installed on each chemical metering pump's discharge lines.
 - 3. Materials:
 - a. Pulsation dampeners shall have Hypalon diaphragms and CPVC, PVC, stainless steel or lined cast iron chamber:
 - 1) Materials shall be compatible with the pumped liquid at the specified concentration, and suitable for outdoor use and exposure.
 - 4. Characteristics:
 - a. Pulsation dampeners shall be gas or air charged, single diaphragm type complete with valved gas/air charge valve connection and pressure gage graduated from 0 to 200 pounds per square inch.
 - b. Pulsation dampeners shall allow no more than 6 percent discharge pressure fluctuation.
 - 5. Dampeners shall be provided with a true-union ball valve for shutoff.

- B. Calibration columns:
1. Materials:
 - a. Materials shall be compatible with the pumped liquid and concentration specified in this Section, and suitable for outdoor use and exposure.
 2. Characteristics:
 - a. Furnish and install calibration columns, 1 for each chemical metering pump, on each chemical pump's inlet line as indicated on the Drawings and specified in this Section:
 - 1) Columns shall be translucent.
 - b. Provide top cap threaded connection with vent piped to floor to prevent entry of foreign materials and to direct spillage or overflow.
 - c. End connections shall be threaded.
 - d. Capacities and graduations: 2,500 mL at 100 mL increments.
- C. Diaphragm backpressure and pressure relief valves:
1. Manufacturers: One of the following or equal:
 - a. Wallace and Tiernan.
 - b. Pulsafeeder.
 - c. Griffco.
 - d. Milton Roy Co.
 2. Materials:
 - a. Valves shall be of suitable materials for the pumped liquid.
 3. Characteristics:
 - a. Ported to serve as either a backpressure valve or a pressure relief valve.
 - b. Relief valve shall be plumbed to the nearest chemical drain, or back to the pump suction on the non-pump side of the pump suction isolation valve, to avoid spillage.
 - c. Valves shall be furnished and installed on each chemical metering pump's discharge lines.
 - d. Valves shall have an adjustable spring range of 15-50 pounds per square inch. Valves shall be factory adjusted for the backpressure recommended by the pump manufacturer.
 - e. Valves shall produce a back pressure no greater than 10 pounds per square inch above valve set pressure when metering pumps are operating at full capacity, pulsating flow.
- D. Pressure relief valves:
1. Furnish and install pressure relief valves on each chemical metering pump's discharge line as indicated on the Drawings.
 2. Materials:
 - a. Wetted materials shall be compatible with the pumped liquid.
 3. Characteristics:
 - a. Valves shall have an adjustable spring range of 25-175 pounds per square inch. Valves shall be factory adjusted for the relief pressure recommended by the pump manufacturer.

2.07 NAMEPLATES

- A. Each pump, gearbox, and motor shall have, securely affixed in a conspicuous location, a stainless steel nameplate with raised letters providing the manufacturer's model, serial number, rating, range, speed and other pertinent data.

2.08 SPARE PARTS AND SPECIAL TOOLS

- A. Spare parts: Furnish the following spare parts packed and labeled for warehouse storage:
 - 1. Complete set of inlet and outlet ball check valves (balls, seats and gaskets) and a diaphragm for each pump.
 - 2. 1 complete spare parts kit for each pump provided.
 - 3. 1 spare parts kit for each size and type of backpressure and pressure relief valve.
 - 4. An initial supply of all oils, greases, and lubricants required to start operations. Supply an amount of these materials equivalent to 1 year of continuous operation for each system.
- B. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

PART 3 EXECUTION

3.01 COMMISSIONING

- A. As specified in Section 01_75_17 - Commissioning and this Section.
- B. Manufacturer services:
 - 1. Provide certificates:
 - a. Manufacturer's Certificate of Source Testing.
 - b. Manufacturer's Certificate of Installation and Functionality Compliance.
 - 2. Manufacturer's Representative onsite requirements:
 - a. Installation: 1 trip, 2 day minimum.
 - b. Functional Testing: 1 trips, 2 day minimum each.
 - 3. Training:
 - a. Operation and Maintenance: 4 hours per session, 2 sessions.
 - 4. Process operational period:
 - a. As required by Owner or Contractor.
- C. Source testing: As specified in Pump Schedule.
- D. Functional testing: As specified in Pump Schedule.

3.02 SCHEDULES

- A. Magnesium Chloride Pumps:

Tag Number	SSPR1-PMP-0510, 0520
Feed Point	Phosphorus Precipitation System Reactor
Service	Magnesium Chloride
Pump Type	Single Diaphragm
Number of Pumps	2
Named Manufacturer	ProMinent
Torsional Analysis	Not Required

Tag Number	SSPR1-PMP-0510, 0520
<u>Pump Characteristics</u>	
Design Conditions:	
Maximum Flow, (gallons per hour)	35
Minimum Flow, (gallons per hour)	4
Normal Flow, (gallons per hour)	10-20
Pump Stroke Length Controller	Manual
Maximum Discharge Pressure (psig)	40
Minimum Suction Lift (feet)	10
Relief Valve Setting (psig)	Per Mfg.
<u>Pump Materials</u>	
Pump Housing/Enclosure	Per Mfg.
Liquid End	PTFE faced PVC or PVDF
<u>Driver Characteristics</u>	
Driver Type	Variable Speed Motor
Drive Coupling	Close-coupled, Horizontal
Minimum Driver Horsepower	0.5
Maximum Driver Speed (rpm)	1,725
Service Factor	1.15
Voltage/Phases/Hertz	480/3/60
NEMA Enclosure Type	TEFC, Severe Duty
<u>Source Testing</u>	
Test Witnessing	Not Witnessed
Performance Test Level	1
Vibration Test Level	None
Noise Test Level	None
<u>Functional Testing</u>	
Performance Test Level	1
Vibration Test Level	None
Noise Test Level	None

1. Provide pumps that deliver the maximum capacity, listed in the above table, when at full speed and maximum stroke length.

B. Flo-Foam Pumps:

Tag Number	SSPR1-PMP-0610, 0620
Feed Point	Phosphorus Precipitation System Reactor
Service	Anti-foaming agent
Pump Type	Single Diaphragm
Number of Pumps	2
Named Manufacturer	ProMinent
Torsional Analysis	Not Required
<u>Pump Characteristics</u>	
Design Conditions:	
Maximum Flow, (gallons per hour)	Per Mfg.
Minimum Flow, (gallons per hour)	Per Mfg.
Normal Flow, (gallons per hour)	Per Mfg.
Pump Stroke Length Controller	Manual
Maximum Discharge Pressure (psig)	40
Minimum Suction Lift (feet)	10
Relief Valve Setting (psig)	Per Mfg.
<u>Pump Materials</u>	
Pump Housing/Enclosure	Per Mfg.
Liquid End	PTFE faced PVC or PVDF
<u>Driver Characteristics</u>	
Driver Type	Variable Speed Motor
Drive Coupling	Close-coupled, Horizontal
Minimum Driver Horsepower	0.5
Maximum Driver Speed (rpm)	1,725
Service Factor	1.15
Voltage/Phases/Hertz	480/3/60
NEMA Enclosure Type	TEFC, Severe Duty
<u>Source Testing</u>	
Test Witnessing	Not Witnessed
Performance Test Level	1
Vibration Test Level	None
Noise Test Level	None
<u>Functional Testing</u>	
Performance Test Level	1

Tag Number	SSPR1-PMP-0610, 0620
Vibration Test Level	None
Noise Test Level	None

1. Provide pumps that deliver the maximum capacity, listed in the above table,

END OF SECTION

SECTION 43_41_43
POLYETHYLENE TANKS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Type 1 and Type 2 polyethylene storage tanks. Type 1 tank shall be made from crosslinked polyethylene resin and Type 2 shall be made from linear (non-crosslinked) polyethylene resin. Tank shall be designed with double wall containment.
- B. Related sections:
 - 1. Section 01_81_01 - Project Design Criteria.

1.02 REFERENCES

- A. American Society for Mechanical Engineers (ASME):
 - 1. B16.4 - Gray Iron Threaded Fittings.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
- B. ASTM International (ASTM):
 - 1. D638 - Standard Test Method for Tensile Properties of Plastics.
 - 2. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - 3. D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
 - 4. D1525 - Standard Test Method for Vicat Softening Temperature of Plastics.
 - 5. D1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
 - 6. D1998 - Standard Specification for Polyethylene Upright Storage Tanks.
 - 7. D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
- C. National Fire Protection Association (NFPA):
 - 1. 30 - Flammable and Combustible Liquid Code.
- D. National Electrical Manufacturer's Association (NEMA).
- E. Occupational Safety and Health Administration (OSHA):
 - 1. 29 CFR Part 1910 - Occupational Safety and Health Standards.

1.03 DESIGN CRITERIA

- A. Tanks: As scheduled.
- B. Tank wall thickness: Calculated in accordance with ASTM D1998 using design specific gravity as scheduled. Note that design specific gravity may be higher than specific gravity of tank contents.

- C. Design requirements:
1. The minimum required wall thickness of the cylindrical shell at any fluid level shall be determined by the following equation, but shall not be less than 0.187 inches thick:

$$T = P \times O.D. / 2 SD = 0.433 \times S.G. \times H \times O.D. / 2 SD.$$

T = wall thickness, in.
SD = hydrostatic design stress, psi.
P = pressure (.433 x S.G. x H), psi.
H = fluid head, ft.
S.G. = specific gravity, g/cm³.
O.D. = outside diameter, in.
- D. The hydrostatic design stress shall be determined by multiplying the hydrostatic design basis, determined by ASTM D2837 using rotationally molded samples, with a service factor selected for the application:
1. The hydrostatic design stress is 600 pounds per square inch at 73 degrees Fahrenheit for Type I and Type II materials.
 2. The tank shall have a stratiform (tapered wall thickness) wall.
- E. The hydrostatic design stress shall be derated for service above 100 degrees Fahrenheit and for mechanical loading of the tank.
- F. The minimum design specific gravity shall be 1.5.
- G. The minimum required wall thickness for the cylinder straight shell must be sufficient to support its own weight in an upright position without any external support:
1. Flat areas shall be provided to allow locating large fittings on the cylinder straight shell.
- H. The top head must be integrally molded with the cylinder shell:
1. The minimum thickness of the top head shall be equal to the top of the straight wall.
 2. The top head of tanks with 2,000 or more gallons of capacity shall be designed to provide a minimum of 1,300 square inches of flat area for fitting locations.
- I. Tanks with 2,000 or more gallons of capacity shall have a minimum of 3 lifting lugs integrally molded into the top head:
1. The lifting lugs shall be designed to allow erection of an empty tank.
- J. The tank shall be designed to provide a minimum of 4 tie-down lugs integrally molded into the top head:
1. The tie-down lugs shall be designed to allow tank retention in wind and seismic loading situations without tank damage.
- K. Tank shell thickness:
1. In accordance with ASTM D1998, Section 6.1.
 2. Design tank wall thickness for liquid with specific gravity as specified.
 3. Provide adequate thickness at all fittings and connection points for mounting of fittings to the tank without damage to the tank or causing excessive deflection.
 4. Maximum allowable hoop stress used in tank wall thickness calculations per ASTM D1998 shall be based on test data in accordance with ASTM D2837.

- L. Restraint system:
 - 1. Seismic load restraint system:
 - a. Seismic design criteria: As specified in Section 01_81_01.
 - 2. Wind load restraint system:
 - a. Wind design criteria: As specified in Section 01_81_01.
 - b. If the wind load restraint system includes the use of cables, tensioning and adjustment devices, such as turnbuckles, shall be used to allow for easy adjustment of the cables at the time of construction and as required in the future.
 - c. The tank shall be designed to provide a minimum of 4 tie-down lugs integrally molded into the top head:
 - 1) The tie-down lugs shall be designed to allow tank retention in wind and seismic loading situations without tank damage.
 - d. The tie down system shall be designed to withstand wind loads specified in Section 01_81_01:
 - 1) Tie down systems must meet seismic zone requirements per IBC code.
 - 2) Any anchor bolts shall be provided by the customer per the instructions and the base plates for the system.

1.04 SUBMITTALS

- A. Fabrication drawings for each tank including:
 - 1. Dimensions.
 - 2. Tank wall thickness.
 - 3. Materials of construction.
 - 4. Tank fittings.
 - 5. Tank appurtenances.
 - 6. Tank restraint system.
 - 7. Tank resin and hoop stress data.
- B. Chemical compatibility sheet to include:
 - 1. Chemical to be stored.
 - 2. Percentage of chemical.
 - 3. Temperature of chemical.
- C. Engineering design calculations of restraint and anchoring system signed by a registered civil or structural engineer.
- D. Installation instructions.
- E. Warranty.
- F. Certification to certify that each tank is suitable for the specified chemical service, no degradation within warranty period, including tank fittings and gasket material.
- G. Proof of qualification: Provide lists of installation and contact information with same type of application and chemical used.
- H. Color charts for proposed coating systems.

1.05 WARRANTY

- A. Manufacturer warranty against defects:
 - 1. Tank: 5 years full warranty. Prorated warranties are not acceptable.

1.06 QUALITY ASSURANCE

- A. Qualification of manufacturer: Manufacturer with experienced personnel, physical facilities, and management capacity sufficient to produce custom-made rotationally molded polyethylene tanks of the size, exposure, and chemical services specified for minimum 5 years with satisfactory performance record.

PART 2 PRODUCTS

2.01 SCOPE OF SUPPLIES

- A. Provide all materials, labor, equipment, and hardware to provide all polyethylene storage tanks with specified fittings and accessories, seismic and wind load restraint systems, anchor bolts, and flange flexible connectors for complete installation in the positions and orientations indicated on the Drawings.

2.02 MANUFACTURERS

- A. One of the following or equal:
 - 1. Poly Processing Co.
 - 2. Snyder Industries, Inc.

2.03 TANK MATERIALS

- A. Type 1 high-density crosslinked polyethylene (XLPE) or Type 2 high-density linear polyethylene (HDLPE).
- B. Resin:
 - 1. Manufacturers: One of the following or equal:
 - a. PAXON, grade 7204 resin for crosslinkable polyethylene.
 - b. Exxon, 8660-8661 for high-density linear polyethylene.
- C. The material used shall be virgin polyethylene resin as compounded and certified by the manufacturer:
 - 1. Type 1 tanks shall be made from crosslinked polyethylene resin as manufactured by ExxonMobil Chemical, or resin of equal physical and chemical properties.
 - 2. Type II tanks shall be made from high-density linear polyethylene resin as manufactured by ExxonMobil Chemical, or resin of equal physical and chemical properties.
 - 3. Resin choice would be based on the specific application, chemical to be stored and concentration.

- D. Ultra violet stabilizer:
1. The polyethylene resin material shall contain a minimum of a UV 8 stabilizer as compounded by the resin manufacturer.
 2. Pigments may be added but shall not exceed 0.25 percent (dry blended) of the total weight.
- E. Free of holes, blisters, crazing, cracking, delamination, undispersed raw materials, and any sign of contamination from foreign matter:
1. The finished tank wall shall be free of visual defects such as foreign inclusions, air bubbles, pinholes, pimples, crazing, cracking, and delaminations.
 2. All cut edges where openings are cut into the tanks shall be trimmed smooth.
- F. Resin shall meet or exceed the following properties:
1. Mechanical Properties of Type 1 of Tank Material: Current XLPE Resin:

Property	ASTM	Value
Density (Resin)	D1505	0.938-0.946 g/cc
Tensile (Yield Stress 2"/min)	D638	3,000 psi
Elongation at Break (2"/min.)	D638	>300%
ESCR (100% Igepal, Cond. A, F50)	D1693	>1000 hours
ESCR (10% Igepal, Cond. A, F50)	D1693	>1000 hours
Vicat Softening Temperature,	D1525	250
Flexural Modulus	D790	100,000 psi

2. Mechanical Properties of Type II tank material: Current HDLPE Resin:

Property	ASTM	Value
Density (Resin)	D1505	0.942-0.948 g/cc
Tensile (Yield Stress 2"/min)	D638	2,950 psi
Elongation at Break (2"/min.)	D638	>1,000%
ESCR (100% Igepal, Cond. A, F50)	D1693	550 hours
ESCR (10% Igepal, Cond. A, F50)	D1693	48 hours
Vicat Softening Temperature	D1525	235
Flexural Modulus	D790	129,000 psi

- G. Gel test: This test does not apply to Type II linear resins:
1. Inner portion of tank wall:
 - a. Not less than 65 percent.
 - b. ASTM D1998 requirements.
 2. Entire wall thickness: Not less than 80 percent.

- H. Restraint system:
1. Metal components, including anchor bolts:
 - a. Type 316 stainless steel.
 - b. The Anchor bolts shall be supplied by the tank manufacturer.
 - c. The drawings and calculations for the seismic system shall be submitted for review.
 2. Concrete anchors or flush shells shall not be used.

2.04 FITTINGS

- A. Terminate in socket, threaded, or flanged connections:
1. Flanges: 150 pound ASME B 16.5.
 2. Threaded connections: ASME B 16.4.
- B. Fittings at upper tank sidewall or top:
1. Compression threaded type, long shank, polyvinyl chloride flanged fittings with deep cut threads (not injection molded thread) and with dual wide nuts.
 2. The bulkhead fittings shall be constructed of PVC, PP, or other specified material.
 3. Gaskets shall be a minimum of 1/4 inch thickness and constructed of 40-50 durometer EPDM, 60-70 durometer Viton or other specified material.
- C. Fittings on tank top:
1. Bosses molded into the tank.
 2. Fittings shall be vertical.
 3. The top head shall be integrally molded with the cylinder shell.
 4. The minimum thickness of the top head shall be equal to the top of the straight wall.
 5. The top head of tanks with 2,000 or more gallons of capacity shall be designed to provide a minimum of 1,300 square inches of flat area for fitting locations.
- D. Flanged outlet drain fitting in the lower tank sidewall: Integrally molded into the bottom knuckle of the tank to allow full drainage of tank contents.
- E. Fittings and appurtenances for each tank:
1. 1 minimum 3-inch flanged inlet nozzle entering the tank in the top near the wall.
 2. 1 minimum 2-inch flanged outlet/drain nozzle, integrally molded with tank wall.
 3. One 4-inch flanged overflow nozzle.
 4. One 4-inch flanged roof nozzle for mounting of tank level sensor.
 5. One 4-inch flanged roof nozzle for mounting of tank level switch.
 6. One 4-inch flanged roof nozzle for mounting of tank leak detection.
 7. One 6-inch flanged roof vent.
 8. One 24-inch hinged type manway lid on top of the tank:
 - a. Manway shall be sealed and shall be constructed of the same material as tank.
 - b. Hardware shall be 316 stainless steel.
 - c. The gaskets shall be per tank manufacturer recommendation for the chemical stored.

2.05 ACCESSORIES

- A. Tank insulation:
 - 1. Not used
- B. Tank electrical heat tracing:
 - 1. Not Used
- C. Ladder and platform:
 - 1. Provide a galvanized steel or fiberglass reinforced plastic ladder and landing platform for each storage tank for access to the top manway.
 - 2. In accordance with OSHA standards.
 - 3. Steel components: Hot-dip galvanized after fabrication.
 - 4. Fasteners: Type 304 stainless steel.
 - 5. Anchor bolts: Type 304 stainless steel.
 - 6. Secure ladder to the tank using special stainless steel or Hastalloy bolts with polyethylene encapsulated heads.
 - 7. Support ladder directly on the concrete foundation and from the tank wall.
- D. Tank vents:
 - 1. Each tank shall be properly vented for the type of material and flow rates expected.
 - 2. Vents must comply with OSHA Part 1910 normal venting for atmospheric tanks or other accepted standard, or shall be as large as the filling or withdrawal connection, whichever is larger but in no case less than 2 inches nominal inside diameter with screening.

2.06 TANK FABRICATION

- A. Rotationally molded construction in accordance with ASTM D1998.
- B. Provide for each tank the following shop finishing:
 - 1. Shipping label identifying:
 - a. Tank tag number.
 - b. Chemical service.
 - 2. Permanent labels:
 - a. Identification label.
 - b. NFPA label specifically coded for the tank contents in accordance with NFPA 30.
 - c. Paint or affix label onto the tank wall to be clearly visible from outside the tank enclosure.

2.07 TESTING

- A. Each tank shall be leak tested by the manufacturer prior to shipment by filling with clean water for a period of at least 4 hours with all fittings installed and blinded:
 - 1. There shall be no measurable drop in liquid surface.
 - 2. Any leaks shall be noted and repaired and the tank shall be re-tested for an additional 4 hours minimum.
 - a. Reason for leak and method of repair shall be recorded and submitted to the Engineer.
 - 3. Any defects or leaks that have not been adequately repaired will be cause for rejection of the tank.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
1. Transportation, handling, storage of the tanks, and installation shall be in accordance with the manufacturer's printed instructions.
 2. Repair any damage to tank components or the insulation due to transportation or installation.
 3. Install piping to tank with sufficient flexibility to allow tank movement of 1 inch in any direction without damage to piping.
- B. All tank fitting attachments shall be equipped with flexible couplers or other movement provisions provided by the tank customer:
1. The tank will deflect based upon tank loading, chemical temperature and storage time duration.
 2. Tank piping flexible couplers shall be designed to allow 4 percent design movement.
 3. Movement shall be considered to occur both outward in tank radius and downward in fitting elevation from the neutral tank fitting placement.

3.02 FIELD QUALITY CONTROL

- A. Manufacturer's field service (1 day):
1. Inspect the installed tanks for proper installation.
 2. Instruct Owner's personnel on operations and maintenance of the tanks.

3.03 SCHEDULE

- A. Tank schedule as follows:

Tag Number	Magnesium Chloride Storage Tank
Service	Magnesium Chloride at 30% solution
Chemical pH	4 - 9
Chemical Specific Gravity	1.24 - 1.34
Tank Design Specific Gravity	1.5
Number of Tanks	1
Usable Capacity, each	10,000 gal
Type of Tank	Type 2 - Linear HDPE
General Design	Flat bottom, dished top, double wall containment
Installation	Vertical
Diameter (feet)	12
Height (feet)	20 (max)

Tag Number	Magnesium Chloride Storage Tank
External Inlet Nozzle Size - Ground Supported (inches)	3
External Outlet/Drain Nozzle Size - Ground Supported (inches)	2
Overflow Nozzle Size (inches)	4
Vent Nozzle Size (inches)	6
Roof Nozzle Size (inches)	4-inch nozzle for mounting ultrasonic level sensor
Roof Nozzle Size (inches)	4-inch nozzle for mounting level switch
Roof Nozzle Size (inches)	4- inch nozzle for mounting tank leak detection
Top Manway (inches)	24
Ladder	Required
Lifting Lugs	Required
Level Indicator	Mechanical, float and cable style, plus radar-style electronic level indicator for main tank High level switch for main tank and leak detection for containment tank, per drawings
Pipe and Conduit Supports	Required

END OF SECTION

SECTION 46_05_10

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Basic design and performance requirements for mechanical equipment.
- B. Related sections:
 - 1. Section 01_33_00 - Submittal Procedures.
 - 2. Section 01_60_00 - Product Requirements.
 - 3. Section 01_75_17 - Commissioning.
 - 4. Section 01_77_00 - Closeout Procedures.
 - 5. Section 01_78_23 - Operating and Maintenance Data.
 - 6. Section 01_81_01 - Project Design Criteria.
 - 7. Section 03_60_00 - Grouting.
 - 8. Section 05_05_24 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - 9. Section 05_12_00 - Structural Steel.
 - 10. Section 05_14_05 - Structural Aluminum.
 - 11. Section 09_96_01 - High-Performance Coatings.
 - 12. Section 26_05_09 - Low Voltage Motors Up to 500 Horsepower.
 - 13. Section 26_08_50 - Field Electrical Acceptance Tests.
 - 14. Section 40_05_00.01 - Common Work Results for General Piping.
 - 15. Section 40_05_06.55 - Piping Insulation.
 - 16. Section 40_80_01 - Testing, Calibration, and Commissioning.
 - 17. Section 46_05_94 - Mechanical Equipment Testing.

1.02 REFERENCES

- A. American Gear Manufacturer's Association (AGMA) Standards:
 - 1. 6001-E08 - Design and Selection of Components for Enclosed Gear Drives.
- B. American Bearing Manufacturers Association (ABMA) Standards:
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. American Petroleum Institute (API):
 - 1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.
- D. ASTM International (ASTM):
 - 1. A36 - Standard Specification for Carbon Structural Steel.
 - 2. A48 - Standard Specification for Gray Iron Castings.
 - 3. A125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
 - 4. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 6. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
 7. A536 - Standard Specification for Ductile Iron Castings.
 8. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 9. B61 - Standard Specification for Steam or Valve Bronze Castings.
 10. B62 - Standard specification for Composition Bronze or Ounce Metal Castings.
 11. B505 - Standard Specification for Copper Alloy Continuous Castings.
 12. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
 13. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 14. F594 - Standard Specification for Stainless Steel Nuts.
- E. Hydraulic Institute (HI).
- F. Occupational Safety and Health Administration (OSHA).
- G. Unified Numbering System (UNS).

1.03 DEFINITIONS

- A. Special tools: Tools that have been specifically made for use on unit of equipment for assembly, disassembly, repair, or maintenance.
- B. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.
- C. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.
- D. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.
- E. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.
- F. Rotational speed: Same as rotational frequency.
- G. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.
- H. Critical speed: Same as critical frequency.
- I. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.
- J. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

1.04 DESIGN REQUIREMENTS

A. General:

1. Product requirements as specified in Section 01_60_00.
2. Project conditions as specified in Section 01_81_01.
3. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions specified in this Section.
4. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
5. Vibration considerations:
 - a. Resonant frequency:
 - 1) For single-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
 - 2) For variable-speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
 - b. Design, balance, and align equipment to meet the vibration criteria specified in Section 46_05_94.
6. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

B. Power transmission systems:

1. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a service factor of 1.5 or greater in accordance with manufacturer recommendations:
 - a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
 - b. Apply service factors in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.

C. Equipment mounting and anchoring:

1. Mount equipment on cast-iron or welded-steel bases with structural steel support frames:
 - a. Utilize continuous welds to seal seams and contact edges between steel members.
 - b. Grind welds smooth.
2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.

4. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01_81_01, and other loads as required for proper operation of equipment.
 - a. For equipment with an operating weight of 400 pounds or greater and all equipment that is supported higher than 4 feet above the floor, provide calculations for:
 - 1) The operating weight and location of the centroid of mass for the equipment.
 - 2) Forces and overturning moments.
 - 3) Shear and tension forces in equipment anchorages, supports, and connections.
 - 4) The design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
5. Anchorage of equipment to concrete or masonry:
 - a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
 - b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05_05_24.
 - c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment:
 - 1) Adjust bolts to final location and secure the sleeve.
6. Anchorage of equipment to metal supports:
 - a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
7. Unless otherwise indicated on the Drawings, install equipment supported on concrete over non-shrink grout pads as specified in this Section.

1.05 SUBMITTALS

- A. As specified in Section 01_33_00.
- B. Product data:
 1. For each item of equipment:
 - a. Design features.
 - b. Load capacities.
 - c. Efficiency ratings.
 - d. Material designations by UNS alloy number or ASTM Specification and Grade.
 - e. Data needed to verify compliance with the Specifications.
 - f. Catalog data.
 - g. Nameplate data.
 - h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
 2. Gear reduction units:
 - a. Engineering information in accordance with applicable AGMA standards.
 - b. Gear mesh frequencies.

- C. Shop drawings:
 - 1. Drawings for equipment:
 - a. Drawings that include cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
 - 2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
 - 3. Installation instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial Installation Testing procedures.
 - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
 - 5. Recommended or normal operating parameters such as temperatures and pressures.
 - 6. Alarm and shutdown setpoints for all controls furnished.
- D. Calculations:
 - 1. Structural:
 - a. Substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design requirements specified and seismic design criteria as specified in Section 01_81_01.
 - 2. Mechanical:
 - a. ABMA 9 or ABMA 11 L10 life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
 - b. Substantiate that operating rotational frequencies meet the requirements of this Section.
 - c. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
 - 1) Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
 - 2) Results of analysis including first and second critical frequencies of system components and complete system.
 - d. Calculations shall be signed and stamped by a licensed engineer.
- E. Operation and maintenance manuals:
 - 1. As specified in Section 01_78_23.
 - 2. Equipment with bearings:
 - a. Include manufacturer and model number of every bearing.
 - b. Include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.
- F. Commissioning submittals: As specified in Section 01_75_17.
- G. Project closeout documents: As specified in Section 01_77_00.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Materials as specified in Section 01_60_00 including special requirements for materials in contact with drinking water.
- B. Ferrous materials:
 - 1. Steel for members used in fabrication of assemblies: ASTM A36.
 - 2. Iron castings: ASTM A48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
 - 3. Ductile iron castings: ASTM A536, Grade 65-45-12, free from flaws and imperfections.
 - 4. Galvanized steel sheet: ASTM A653, minimum 0.0635-inch (16-gauge).
 - 5. Expanded metal: ASTM A36, 13-gauge, 1/2-inch flat pattern expanded metal.
 - 6. Stainless steel:
 - a. As specified in Section 05_12_00.
 - b. In contact or within 36 inches of water: Type 316 or 316L.
 - c. Other locations: Type 304 or 304L.
 - d. Source cleaning and passivation as specified in Section 05_12_00.
- C. Non-ferrous materials:
 - 1. Bronze in contact with wastewater: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C89833, C89520, C92200, or C93700 in accordance with ASTM B61, B62, B505, or B584, when not specified otherwise.
 - 2. Aluminum: As specified in Section 05_14_05.
- D. Dielectric materials for separation of dissimilar metals:
 - 1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials as specified.
- E. Non-shrink grout and epoxy non-shrink grout: As specified in Section 03_60_00.

2.02 ANCHORS AND FASTENERS

- A. Mechanical anchoring to concrete and masonry:
 - 1. As specified in Section 05_05_24:
 - a. Type 316 stainless steel.
 - 2. Design as specified in Section 01_81_01.
- B. High-strength fasteners:
 - 1. As specified in Section 05_12_00.
- C. Flange bolts:
 - 1. As specified in Section 40_05_00.01.
- D. Mechanical assembly fasteners, unless otherwise shown on the Drawings:
 - 1. Stainless steel:
 - a. High-temperature service or high-pressure service:
 - 1) Bolts: ASTM A193, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
 - 2) Nuts: ASTM A194, Grade 8, heavy hex.

- 3) Washers: Alloy group matching bolts and nuts.
- b. Low-temperature service:
 - 1) Bolts: ASTM A320, Grade B8 (Type 304) or Grade B8M (Type 316), Class 1, heavy hex.
 - 2) Nuts: ASTM A194, Grade 8 (Type 304) or Grade B8M (Type 316), heavy hex.
 - 3) Washers: Alloy group matching bolts and nuts.
- c. General service:
 - 1) Bolts: ASTM F593, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
 - 2) Nuts: ASTM F594, Alloy Group 1 (Type 304) or Alloy Group 2 (Type 316).
 - 3) Washers: Alloy group matching bolts and nuts.

2.03 SHAFT COUPLINGS

- A. General:
 - 1. Type and ratings: Provide non-lubricated type, designed for not less than 50,000 hours of operating life.
 - 2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.
- B. Shaft couplings for close-coupled electric-motor-driven equipment:
 - 1. Use for:
 - a. Equipment 1/2 horsepower or larger.
 - b. Reversing equipment.
 - c. Equipment subject to sudden torque reversals or shock loading:
 - d. Examples:
 - 1) Reciprocating pumps, blowers, and compressors.
 - 2) Conveyor belts.
 - 2. Manufacturers: One of the following or equal:
 - a. Lovejoy.
 - b. T.B. Woods.
 - 3. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
 - 4. Manufacture flexible component of coupling from synthetic rubber or urethane.
 - 5. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
 - 6. Do not allow metal-to-metal contact between driver and driven equipment.
- C. Shaft couplings for direct-connected electric-motor-driven equipment:
 - 1. Use for 1/2 horsepower or larger and subject to normal torque, non-reversing applications.
 - 2. Manufacturers: One of the following or equal:
 - a. Rexnord.
 - b. T.B. Woods.
 - 3. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
 - 4. Provide flexible connecting element of rubber and reinforcement fibers.
 - 5. Provide service factor of 2.0.
 - 6. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

- D. Spacer couplings: Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.
- E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer:
 - 1. Includes any engine-driven equipment.

2.04 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

- A. General:
 - 1. Unless otherwise noted in the equipment section, provide cartridge-type, double mechanical shaft seals for pumps.
 - 2. Provide a stuffing box large enough for a double mechanical seal.
 - 3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
 - 4. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.
- B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
 - 1. Wastewater, water, and sludge applications:
 - a. Asbestos free.
 - b. PTFE (Teflon) free.
 - c. Braided graphite.
 - d. Manufacturers: One of the following or equal:
 - 1) Chesterton, 1400.
 - 2) John Crane, equivalent product.
- C. Mechanical seals: Provide seal types specified in the equipment sections and as specified.
 - 1. Provide seal types meeting the following requirements:
 - a. Balanced hydraulically.
 - b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
 - c. O-ring: Viton 747.
 - d. Gland: Type 316L stainless steel.
 - e. Set screws: Type 316L stainless steel.
 - f. Faces: Reaction bonded, silicon carbide.
 - g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.
 - 2. Cartridge-type double mechanical: Manufacturers:
 - a. One of the following or equal:
 - 1) Chesterton, S20.
 - 2) John Crane, 5620 Series.
 - 3. Cartridge-type flushless mechanical:
 - a. Manufacturers: One of the following or equal:
 - 1) Chesterton, 156.
 - 2) John Crane, 5870.

2.05 GEAR REDUCTION UNITS

- A. Type: Helical or herringbone, unless otherwise specified.
- B. Design:
 - 1. Made of alloys treated for hardness and for severe service.
 - 2. AGMA Class II service:
 - a. Use more severe service condition when such is recommended by unit's manufacturer.
 - 3. Cast-iron housing with gears running in oil.
 - 4. Anti-friction bearings.
 - 5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.
 - 6. Manufactured in accordance with applicable AGMA standards.
- C. Planetary gear units are not to be used.

2.06 BEARINGS

- A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
- B. Oil-lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash-type system:
 - 1. Size oil-lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degrees Fahrenheit above the maximum design temperature as specified in Section 01_81_01.
 - 2. Provide an external oil cooler when required to satisfy the specified operating conditions:
 - a. Provide air-cooled system if a water-cooling source is not indicated on the Drawings.
 - b. Equip oil cooler with a filler pipe and external level gauge.
- C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
 - 1. Lubrication lines and fittings:
 - a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
 - b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
 - c. Use standard hydraulic-type grease supply fittings:
 - 1) Manufacturers: One of the following or equal:
 - a) Alenite.
 - b) Zerk.
- D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.07 MOTORS

- A. As specified in Section 26_05_09.

2.08 GEAR MOTORS

- A. Motors as specified in Section 26_05_09.
- B. Helical gearing for parallel shaft drives and worm gearing for right-angle drives.
- C. Manufactures: One of the following or equal:
 - 1. Baldor Electric Company.
 - 2. Bodine Electric Company.

2.09 VENDOR CONTROL PANELS

- A. As specified in Section 40_61_00.

2.10 EQUIPMENT SUPPORT FRAMES

- A. Bolt holes shall not exceed bolt diameter by more than 25 percent, up to a limiting maximum diameter oversize of 1/4-inch.

2.11 PIPING AND VALVES

- A. Piping as specified in Section 40_05_00.01.
- B. Valves as specified in Section 40_05_51.01.

2.12 SAFETY EQUIPMENT

- A. Safety guards:
 - 1. Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
 - 2. Requirements:
 - a. Allow visual inspection of moving parts without removal.
 - b. Allow access to lubrication fittings.
 - c. Prevent entrance of rain or dripping water for outdoor locations.
 - d. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
 - 3. Materials:
 - a. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
 - b. Fasteners: Type 304 stainless steel.
- B. Insulation:
 - 1. Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level.
 - 2. Insulation thickness such that temperature is below 120 degrees Fahrenheit.
 - 3. Insulation Type 3 and cover Type 5 as specified in Section 40_05_06.55.
- C. Warning signs:
 - 1. Provide warning signs in accordance with OSHA requirements for equipment that starts automatically or remotely.
 - 2. Mount warning signs with stainless steel fasteners at equipment.

2.13 SPRING VIBRATION ISOLATORS

- A. Design requirements:
 - 1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.
 - 2. Use steel coil springs.
 - 3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01_81_01.
- B. Performance requirements:
 - 1. Minimum spring deflection of 1 inch under static load and capable of limiting transmissibility to 10 percent maximum at design operating load.
 - 2. Rotary-lobe blowers:
 - a. Each package shall be supplied with vibration isolating feet with a minimum efficiency of 80 percent.
 - b. Blower manufacturer shall be responsible for attenuating noise and vibration in the blower package such that no special installation base shall be required, nor shall any additional measures be required to reduce vibrations from the blower package being transmitted to the base or the piping.
- C. Manufacturers: One of the following or equal:
 - 1. California Dynamics Corporation, Type RJSD.
 - 2. Mason Industries, equivalent product.
- D. Materials:
 - 1. Fabricate isolators using welded-steel or shatterproof ductile iron in accordance with ASTM A536 Grade CS-45-12.
 - 2. Spring steel: ASTM A125.

2.14 NAMEPLATES

- A. Fastened to equipment at factory in an accessible and visible location.
- B. Stainless steel sheet engraved or stamped with text, holes drilled or punched for fasteners.
- C. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.
- D. Text:
 - 1. Manufacturer's name, equipment model number and serial number, motor horsepower when appropriate, and identification tag number.
 - 2. Indicate the following additional information as applicable:
 - a. Maximum and normal rotating speed.
 - b. Service class per applicable standards.
 - 3. Include for pumps:
 - a. Rated total dynamic head in feet of fluid.
 - b. Rated flow in gallons per minute.
 - c. Impeller, gear, screw, diaphragm, or piston size.
 - 4. Include for gear reduction units:
 - a. AGMA class of service.
 - b. Service factor.
 - c. Input and output speeds.

2.15 SHOP FINISHES

- A. Provide appropriate factory coatings as recommended by manufacturer for service conditions.
 - 1. Motors and gear reducers: Shop finish paint with manufacturer's standard coating, unless otherwise specified in the individual equipment specification.

2.16 SPECIAL TOOLS

- A. Supply 1 set of special tools as specified in Section 01_60_00.

2.17 SOURCE TESTING

- A. Testing requirements unless specified otherwise in the individual equipment specifications:
 - 1. Mechanical equipment: Level 1 General Equipment Performance Test as specified in Section 46_05_94.
 - 2. Motors: As specified in Section 26_05_09.
 - 3. Vendor control panels: As specified in Section 40_80_01.

2.18 SHIPPING

- A. As specified in Section 01_60_00.
- B. Prior to shipment of equipment:
 - 1. Bearings (and similar items):
 - a. Pack separately or provide other protection during transport.
 - b. Greased and lubricated.
 - 2. Gear boxes:
 - a. Oil filled or sprayed with rust preventive protective coating.
 - 3. Fasteners:
 - a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 DELIVERY, HANDLING, STORAGE, AND PROTECTION

- A. As specified in Section 01_60_00.
- B. Inspect fasteners for proper torques and tightness.
- C. Storage:
 - 1. Bearings:
 - a. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
 - 2. Gear boxes:
 - a. Inspect to verify integrity of protection from rust.
- D. Protection:
 - 1. Equipment Log shall include description of rotation performed as part of maintenance activities.

3.02 INSTALLATION

- A. Field measurements:
 - 1. Prior to shop drawings preparation, take measurements and verify dimensions indicated on the Drawings.
 - 2. Ensure equipment and ancillary appurtenances fit within available space.
- B. Sequencing and scheduling:
 - 1. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place.
 - 2. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
- C. Metal work embedded in concrete:
 - 1. Accurately place and hold in correct position while concrete is being placed.
 - 2. Clean surface of metal in contact with concrete immediately before concrete is placed.
- D. Concrete surfaces designated to receive non-shrink grout:
 - 1. Heavy sandblast concrete surface in contact with non-shrink grout.
 - 2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
 - 3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.
- E. Install equipment in accordance with manufacturer's installation instructions and recommendations.
- F. Lubrication lines and fittings:
 - 1. Support and protect lines from source to point of use.
 - 2. Fittings:
 - a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
 - b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
 - c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.
- G. Alignment of drivers and equipment:
 - 1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.

2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
 - a. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
 - b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
 3. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
 4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
 5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
 - a. Allow minimum 48 hours for grout to harden.
 - b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
 - c. Correct alignment as required.
 6. After functional testing is complete, dowel motor or drivers and driven equipment:
 - a. Comply with manufacturer's instructions.
- H. Grouting under equipment bases, baseplates, soleplates, and skids:
1. Unless otherwise indicated on the Drawings, grout with non-shrink grout as specified in Section 03_60_00.
 - a. Non-shrink epoxy grout required only when indicated on the Drawings.
 2. Comply with equipment manufacturer's installation instructions for grouting spaces, and tolerances for level and vertical and horizontal alignment.
 3. Install grout only after:
 - a. Equipment is leveled and in proper alignment.
 - b. Piping connections are complete and in alignment with no strain transmitted to equipment.
 4. Do not use leveling nuts on equipment anchors for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting.
 5. Use jack screws for supporting and leveling equipment bases, baseplates, soleplates, and skids for grouting following the procedure defined below:
 - a. Drill and tap equipment base plates, sole plates, and skids for jack screws.
 - b. Use suitable number and size of jack screws.
 - c. End of jack screws shall bear on circular steel plates epoxy bonded to equipment foundation.
 - d. Jack screw threads that will be in contact with grout: Wrap with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding to threads.
 - e. Place and cure grout as specified in Section 03_60_00.
 - f. After grout is cured, remove jack screws and material used to prevent bonding to grout.
 - 1) Provide jack screws to Owner for future use.

- g. Tighten equipment anchors in accordance with equipment manufacturer requirements.
- h. Fill holes where jack screws have been removed with grout.
- i. Cure as specified in Section 03_60_00.
- 6. For equipment bases, baseplates, soleplates, and skids where it is not practical to use jack screws, use steel wedges and shims.
 - a. Wrap wedges and shims that contact grout with multiple layers of tape or other material, acceptable to Engineer, to prevent grout from bonding.
 - b. Place and cure grout as specified in Section 03_60_00
 - c. Remove wedges or shims.
 - d. Tighten equipment anchors to in accordance with equipment manufacturer requirements.
 - e. Fill voids where wedges and shims have been removed with grout.
 - f. Cure as specified in Section 03_60_00.
- 7. Preparation of equipment bases, baseplates, soleplates, and skids for grouting:
 - a. Metal in contact with grout: Grit blast to white metal finish.
 - b. Clean surfaces of equipment bases, baseplates, soleplates, and skids in contact with grout of dirt, dust, oil, grease, paint, and other material that will reduce bond.
- 8. Preparation of concrete equipment foundation for grouting:
 - a. Rough concrete surfaces in contact with grout.
 - b. Concrete contact surface shall be free of dirt, dust, laitance, particles, loose concrete, or other material or coatings that will reduce bond.
 - c. Saturate concrete contact surface area with water for minimum of 24 hours prior to grouting.
 - d. Remove standing water just prior to grout placement, using clean rags or oil-free compressed air.
- 9. Forms and header boxes:
 - a. Build forms for grouting of material with adequate strength to withstand placement of grouts.
 - b. Use forms that are rigid and liquid tight. Caulk cracks and joints with an elastomeric sealant.
 - c. Line forms with polyethylene film for easy grout release. Forms carefully waxed with 2 coats of heavy-duty paste wax will also be acceptable.
- 10. Grout placement requirements:
 - a. Minimum ambient and substrate temperature: 45 degrees Fahrenheit and rising:
 - 1) Conform to grout manufacturer's temperature requirements.
 - b. Pour grout using header box.
 - c. Keep level of grout in header box above bottom of equipment bases, baseplates, soleplates, and skids at all times to prevent air entrapment.
 - d. Grout shall flow continuously from header box to other side of forms without trapping air or forming voids.
 - e. Vibrate, rod, or chain grout to facilitate grout flow, consolidate grout, and remove entrapped air.
 - f. After grout sets, remove forms and trim grout at 45-degree angle from bottom edge of equipment bases, baseplates, soleplates, and skids.
 - g. Cure as specified in Section 03_60_00.

- I. Field welding:
 - 1. Use welding procedures, welders, and welding operators qualified and certified in accordance with AWS D1.1.
 - 2. Shielded arc welding.
- J. Field finishes:
 - 1. Protect motors.
 - 2. Clean equipment.
 - 3. Apply primer and coating systems as specified in Section 09_96_01.
- K. Special techniques:
 - 1. Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.
- L. Tolerances:
 - 1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.
- M. Warning signs:
 - 1. Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

3.03 FIELD PAINTING

- A. Compatible with factory painting.
- B. As specified in Section 09_96_01.

3.04 COMMISSIONING

- A. As specified in Section 01_75_17.
- B. Functional testing requirements unless specified otherwise in the individual equipment specifications:
 - 1. Mechanical equipment: Level 1 tests as specified in Section 46_05_94.
 - 2. Motors: As specified in Sections 26_05_09 and 26_08_50.
 - 3. Vendor control panels: As specified in Section 40_80_01.

END OF SECTION

SECTION 46_05_94

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Testing of mechanical equipment and systems.
- B. Related sections:
 - 1. Section 01_75_17 - Commissioning.
 - 2. Section 26_05_09 - Low Voltage Motors up to 500 Horsepower.
 - 3. Section 40_05_00.09 - Piping Systems Testing.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. S1.4 Specification for Sound Level Meters.
- B. Hydraulic Institute (HI).
- C. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

- A. Schedule of source (factory) tests, Owner training, installation testing, functional testing, clean water facility testing, closeout documentation, process start-up and process operational period as specified in this Section and in Section 01_75_17 and equipment sections.
- B. Test instrumentation calibration data.
- C. Operation and maintenance manual:
 - 1. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.
- D. Commissioning and Process Start-up Plan: As specified in Section 01_75_17.
- E. Test plan as specified in Section 01_75_17 and equipment sections.
- F. Test reports as specified in this Section and in Section 01_75_17 and equipment sections.
- G. Coordinate with mechanical equipment testing requirements specified under each technical equipment specification.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

- A. Commissioning and process start-up of equipment as specified in:
 - 1. This Section.
 - 2. Section 01_75_17.
 - 3. Equipment sections:
 - a. If testing requirements are not specified, provide Level 1 Tests.
- B. Comply with latest version of applicable standards.
- C. Test and prepare piping as specified in Section 40_05_00.09.
- D. Operation of related existing equipment: Owner will operate related existing equipment or facilities necessary to accomplish the testing. Schedule and coordinate testing as required by Section 01_75_17.
- E. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source:
 - 1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
 - 2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.
- F. Test measurement and result accuracy:
 - 1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments:
 - a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
 - 2. Do not adjust results of tests for instrumentation accuracy:
 - a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.
- G. Report features:
 - 1. Report results in a bound document in generally accepted engineering format with title page, written summary of results compared to specified requirements, and appropriate curves or plots of significant variables in English units.
 - 2. Include appendix with a copy of raw, unmodified test data sheets indicating test value, date and time of reading, and initials of person taking the data.
 - 3. Include appendix with sample calculations for adjustments to raw test data and for calculated results.
 - 4. Include appendix with the make, model, and last calibration date of instrumentation used for test measurements.
 - 5. Include in body of report a drawing or sketch of the test system layout showing location and orientation of the test instruments relative to the tested equipment features.

- H. Provide necessary fluids, utilities, temporary piping, temporary supports, temporary access platforms or access means and other temporary facilities and labor necessary to safely operate the equipment and accomplish the specified testing:
 - 1. With Owner's permission, some utilities may be provided by fully tested permanently installed utilities that are part of the Work.
- I. Prepare and submit test reports as specified.
- J. Testing levels:
 - 1. Level 1 Tests:
 - a. Level 1 General Equipment Performance Test:
 - 1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
 - 2) Operate at rated design load conditions.
 - 3) Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
 - b. Level 1 Pump Performance Test:
 - 1) Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
 - 2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09 or the applicable equipment section. Use actual driver for field tests.
 - 3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
 - c. Level 1 Vibration Test:
 - 1) Test requirement:
 - a) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
 - b) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
 - 2) Equipment operating condition: Test at specified maximum speed.
 - d. Level 1 Noise Test:
 - 1) Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.
 - 2. Level 2 Tests:
 - a. Level 2 General Performance Test:
 - 1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
 - 2) Operate at rated design load conditions.

- 3) Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
- b. Level 2 Pump Performance Test:
 - 1) Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
 - 2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09. Use actual driver for field tests.
 - 3) Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
 - 4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.
- c. Level 2 Vibration Test:
 - 1) Test requirement:
 - a) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
 - b) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
 - 2) Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
 - 3) Natural frequency test of field installed equipment:
 - a) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
 - b) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
 - c) Perform with equipment and attached piping full of intended service or process fluid.
- d. Level 2 Noise Test:
 - 1) Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

3. Level 3 Tests:
 - a. Level 3 General Equipment Performance Tests:
 - 1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
 - 2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
 - 3) Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
 - 4) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
 - 5) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.
 - b. Level 3 Pump Performance Test:
 - 1) Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
 - 2) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 26_05_09. Use actual driver for field tests.
 - 3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
 - 4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
 - c. Level 3 Vibration Test:
 - 1) Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
 - 2) Perform High Frequency Enveloping Analysis for gears and bearings.
 - a) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
 - b) Report results in units of acceleration versus frequency in cycles per minute.
 - 3) Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).

- 4) Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
- d. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plan view; report results for each of 8 octave band mid-points beginning at 63 hertz.
4. Level 4 Tests:
 - a. Level 4 General Equipment Performance Test:
 - 1) For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
 - 2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
 - 3) Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration, or temperatures are observed.
 - 4) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
 - 5) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
 - b. Level 4 Pump Performance Test:
 - 1) Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
 - 2) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
 - 3) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
 - 4) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
 - 5) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
 - a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.

- b) Perform efficiency testing with test fluids at maximum rated speed.
 - c) Perform priming time testing with test fluids at maximum rated speed.
 - c. Level 4 Vibration Test: Same as Level 3 vibration test.
 - d. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.
- K. Variable speed equipment tests:
 - 1. Establish performance over the entire speed range and at the average operating condition.
 - 2. Establish performance curves for the following speeds:
 - a. The speed corresponding to the rated maximum capacity.
 - b. The speed corresponding to the minimum capacity.
 - c. The speed corresponding to the average operating conditions.
- L. Pump tests, all levels of testing:
 - 1. Test in accordance with the following:
 - a. Applicable HI Standards.
 - b. This Section.
 - c. Equipment sections.
 - 2. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
 - a. From 0 to plus 5 percent of head at the specified flows.
 - b. From 0 to plus 5 percent of flow at the rated design point head.
 - c. No negative tolerance for the efficiency at the specified flows.
 - d. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.
- M. Drivers tests:
 - 1. Test motors as specified in Section 26_05_09.
 - 2. Test other drivers as specified in the equipment section.
- N. Noise requirements and control:
 - 1. Perform noise tests in conjunction with vibration test analysis.
 - 2. Make measurements in relation to reference pressure of 0.0002 microbar.
 - 3. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.
 - 4. Set sound level meter to slow response.
 - 5. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.
- O. Pressure testing:
 - 1. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.
- P. Inspection and balancing:
 - 1. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

2. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
3. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

Q. Critical speed of rotating equipment:

1. Satisfy the following:
 - a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
 - b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
 - c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

R. Vibration tests:

1. Definitions:
 - a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
 - b. Peak-to-peak displacement: The root mean squared average of the peak-to-peak displacement multiplied by the square root of 2.
 - c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
 - d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
 - e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
 - 1) Manufacturers: One of the following or equal:
 - a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
 - b) CSI, "PeakVue."
 - f. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
 - g. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
 - h. Preferred operating range: Manufacturer's defined preferred operating range (POR) for the equipment.
 - i. Allowable operating range: Manufacturer's defined allowable operating range (AOR) for the equipment.
2. Vibration instrumentation requirements:
 - a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12 bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles

per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.

- 1) Manufacturers: One of the following or equal:
 - a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
 - b) Pruftechnik, VIBXPERT II.
- b. Analyzer settings:
 - 1) Units: English, inches/second, mils, and gravitational forces.
 - 2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
 - 3) Sample averages: 4 minimum.
 - 4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
 - 5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
 - 6) Fast fourier transform windowing: Hanning Window.
 - 7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.
- c. Accelerometers:
 - 1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
 - a) Manufacturers: One of the following or equal:
 - (1) Wilcoxon Research, Model 797L.
 - (2) PCB, Model 393C.
 - 2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
 - a) Manufacturers: One of the following or equal:
 - (1) Wilcoxon Research, Model 793.
 - (2) Entek-IRD Model 943.
3. Accelerometer mounting:
 - a. Use magnetic mounting or stud mounting.
 - b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
 - c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.
4. Vibration acceptance criteria:
 - a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.

- b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions & Application Data	Overall Peak-to-Peak Displacement	
	Field, mils	Factory, mils
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

- c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type) Vertical Solids Handling Centrifugal Pumps	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
	Below 33 hp	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	Below 268 hp	0.15	0.19
	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	
Gear Reducers, Radial	268 hp and above	0.17	
Slurry Pumps		0.25	0.30

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Motors		See Applicable Motor Specification	See Applicable Motor Specification
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

- d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.
- e. Additional criteria:
 - 1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.
 - 2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
 - 3) For motors, the following shall be cause for rejection:
 - a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that are more than 40 percent of the peak at rotational frequency.
 - b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
 - c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
 - d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
 - 4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.
5. Vibration testing results presentation:
 - a. Provide equipment drawing with location and orientation of measurement points indicated.
 - b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
 - c. When Vibration Spectra Data required:
 - 1) Plot peak vibration velocity versus frequency in cycles per minute.

- 2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
- 3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
- 4) Plot motor spectra on a log amplitude scale versus frequency.
- d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
- e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.02 PLANNING PHASE

- A. Submit test plans as specified in Section 01_75_17 and this Section.
 - 1. Indicate test start time and duration, equipment to be tested, other equipment involved or required; temporary facilities required, number and skill or trade of personnel involved; safety issues and planned safety contingencies; anticipated effect on Owner's existing equipment and other information relevant to the test.
 - 2. Provide locations of all instruments to be used for testing. Provide calibration records for all instrumentation.

3.03 COMMISSIONING PHASE

- A. Source testing:
 - 1. Witnessing not required unless specified otherwise in equipment section.
 - 2. Witnessed tests: Schedule test date and notify Engineer at least 30 days prior to start of test.
 - 3. Test equipment as specified in Section 01_75_17 and equipment sections.
 - 4. Test fluids as specified in Section 01_75_17.
 - 5. Submit reports as specified in Section 01_75_17.
- B. Installation testing:
 - 1. Test equipment as specified in Section 01_75_17 and equipment sections.
- C. Functional testing:
 - 1. Witnessing required as specified in Section 01_75_17.
 - 2. Schedule test date and notify Engineer at least 7 days prior to start of test.
 - 3. Test equipment as specified in equipment sections. Test fluids as specified in Section 01_75_17.
 - 4. Submit reports as specified in Section 01_75_17.
- D. Clean Water Facility Testing:
 - 1. Test equipment as specified in Section 01_75_17 and equipment sections.
- E. Closeout documentation:
 - 1. Provide closeout documentation as specified in Section 01_75_17 and equipment sections.

3.04 PROCESS START-UP PHASE

- A. Process start-up:
 - 1. Process start-up equipment as specified in Section 01_75_17 and equipment sections.
- B. Process Operational Period:
 - 1. Operate equipment as specified in Section 01_75_17 and equipment sections.
 - 2. Test fluids as specified in Section 01_75_17.

END OF SECTION

SECTION 46_63_83.01

PHOSPHORUS PRECIPITATION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Scope of Work for Phosphorous Precipitation System Supplier (Supplier):
 - 1. The Supplier shall furnish the process equipment for a Phosphorus Precipitation System (System), as shown on the Drawings and specified herein.
 - 2. Process equipment to be furnished by Supplier under this Section includes, but is not limited to, the following:
 - a. Phosphorus Precipitation Reactors (Reactors), complete with Reactor support legs, access platforms, pipe connections, and removable Reactor cover.
 - b. Phosphorus Precipitation Blowers.
 - c. Phosphorus Precipitation Aeration Diffusers and Appurtenances.
 - d. Phosphorus Precipitation Struvite Pumps.
 - e. Magnesium Chloride Bulk Storage Tank.
 - f. Magnesium Chloride Chemical Feed System.
 - g. Antifoam Chemical Feed System.
 - h. Instrumentation.
 - i. Process Control Panel and PLC Control System (including all programming and integration).
- B. Unless stated otherwise herein, process equipment to be furnished by the to-be-determined contractor (Contractor) to complete System includes, but is not limited to, the following:
 - 1. Motor control center (MCC) including variable frequency drives (VFD) for control of Phosphorus Precipitation Blowers.
 - 2. Air, chemical and sludge/struvite piping and valves that interconnects the System process equipment.
 - 3. Power supply and communication connection including conduits and wiring to System process equipment.
 - 4. Concrete support pads and building to house System process equipment.
- C. Supplier agrees that the System design, as specified in this Specification, the related specification sections, and on the Drawings, will meet all performance requirements. Any modifications to the specified equipment required to meet the performance requirements that are attributed to the performance of the System shall be the full responsibility of the Supplier.
- D. Responsible Parties:
 - 1. The following define the responsible parties associated with the Project:
 - a. Owner: City of Meridian, ID.
 - b. Contractor: To be determined by future bidding.
 - c. Engineer: Carollo Engineers.
 - d. Supplier: CNP Technology Water and Biosolids Corp.

E. Related sections:

1. Section 01_33_00 - Submittal Procedures.
2. Section 01_75_17 - Commissioning.
3. Section 01_78_23 - Operation and Maintenance Data.
4. Section 01_78_36 - Warranties and Bonds.
5. Section 01_81_01 - Project Design Criteria.
6. Section 43_11_33 - Rotary Lobe Blowers.
7. Section 43_23_57.10 - Progressing Cavity Pumps.
8. Section 43_33_20.01 - Liquid Chemical Diaphragm-Type Metering Pumps.
9. Section 43_41_43 - Polyethylene Tanks.
10. Section 46_05_94 - Mechanical Equipment Testing.
11. Section 46_63_83 - Phosphorus Recovery System.
12. Section 40_61_00 - Common Work Results for Process Control and Instrumentation Systems.
13. Section 40_61_05 - Packaged Control System Components.
14. Section 40_71_15 - Flow Measurement: Magnetic Flowmeters.
15. Section 40_72_24 - Level Measurement: Radar Pulse Time of Flight.
16. Section 40_72_36 - Level Measurement: Capacitance
17. Section 40_72_76 - Level Measurement: Switches.
18. Section 40_73_13 - Pressure/Vacuum Measurement: Gauges.
19. Section 40_73_23 - Pressure/Vacuum Measurement: Direct.
20. Section 40_73_64 - Pressure/Vacuum Instrument Valves.
21. Section 40_74_66 - Temperature Measurement: Temperature Switches.
22. Section 40_75_13 - Analyzers: pH.

23. Section 40_80_01 - Commissioning for Instrumentation and Controls.

1.02 SYSTEM DESCRIPTION

- A. The System supplies magnesium chloride and low-pressure air to welded stainless steel Reactors receiving anaerobically digested material. Positive displacement blowers provide air for Reactor mixing and pH control. Magnesium chloride is dosed based on a magnesium to soluble phosphorus ratio to the top of the Reactor for the precipitation of struvite. Struvite crystals are removed periodically from the bottom of the Reactor using an automated valve and progressive cavity pump. Struvite crystals are either pumped to the top of the reactor (recycle mode) or to the Owner's existing Digester No. 3 - Sludge Storage Tank (waste).

1.03 DESIGN CRITERIA

- A. The System shall be designed based on the flow and load conditions listed below:
1. Design flow to the reactors (2020): 76 gpm.
 2. Design flow to the reactors (2040): 145 gpm
 3. Intermittent flushing flow to the reactors: up to 400 gpm:
 - a. Design intent is to provide flushing capabilities for several times per day at up to 2 minutes per flush. Ultimate flushing schedule will be dictated by the Owner's staff based on prevailing treatment conditions at solids handling.
 4. Minimum reactor detention time (all tanks) at 2040 design flow: 4.5 hours.

5. Digested solids feed properties:
 - a. TSS: 1.3 percent to 2.5 percent.
 - b. Dissolved ortho-phosphate: 310-340 mg/L.
 - c. Dissolved ammonia nitrogen: Greater than 900 mg/L.
- B. The guaranteed system performance shall be:
 1. The content of free (dissolved) ortho-phosphate between inlet and outlet of the reactor is reduced by 90 percent.
 2. The dose of magnesium required to achieve the above phosphorus removal performance shall be no greater than 1.5 moles of magnesium added per 1.0 moles of free ortho-phosphate fed to the reactor.
 3. Struvite particle size:
 - a. The minimum size of struvite particles produced in the system should be sufficiently large and dense to achieve a minimum of 80 percent of struvite mass removal during digested sludge dewatering.
- C. The airflow to the Reactors will be supplied by rotary lobe blowers and the airflow varied to maintain the desired flow rate to achieve sufficient mixing and sludge pH to meet the performance requirements of the System. The rotary lobe blowers shall be sized by the Supplier such that there is sufficient air volume and pressure to operate the System as designed.
- D. Comply with structural design requirements included in the contract documents.
- E. Coordinate with mechanical equipment and instrumentation requirements specified under each technical equipment specification.

1.04 QUALITY ASSURANCE

- A. All equipment required for the System shall be furnished by a single entity (Supplier) who, with the Contractor, shall be responsible for completeness of the system. The Supplier shall be the sole source of information on all equipment furnished regardless of the manufacturing source of the equipment.
- B. Requirements of regulatory agencies and reference standards:
 1. Comply with all local and federal regulations.
 2. Comply with all necessary local and federal codes.
 3. Also refer to Section 01_81_01.

1.05 SUBMITTALS

- A. Submittals shall be submitted and approved by Owner, Contractor, and Engineer prior to fabrication of equipment provided by Supplier. Submit all documentation in electronic format (searchable PDF) to Engineer and Contractor. Except as may be provided in technical specifications or under special circumstances, a submittal will be returned to Supplier within 10 working days. If resubmittal required, Supplier shall provide resubmittal within 15 calendar days.
- B. Submit product data and shop drawings, operation and maintenance manuals, and test reports to the Engineer for review as specified in Sections 01_33_00, 01_78_23, and as specified under each technical equipment specification.

- C. Other:
 - 1. Operation and maintenance manual in accordance with Owner requirements.
 - 2. Unless noted otherwise, a list of spare parts and tools necessary to maintain the equipment for a period of 5 years shall be provided.
 - a. Aeration diffusers:
 - 1) 20 percent of the total diffuser membranes utilized on the project.
 - 2) 10 percent of the perforated diffuser mounting hardware.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling of specified equipment and appurtenances will be in accordance with Supplier recommendations.
- B. Supplier's instructions shall be provided for unloading, examination, preparation, and installing of the specified equipment and appurtenances.

1.07 GUARANTEE

- A. The performance requirements of the system will be demonstrated by a performance test during the first 6 months of operation, following stabilization of the process. The performance test will demonstrate that the Supplier has complied with the phosphorus removal criteria and chemical feed criteria specified herein.

1.08 PATENTS

- A. The Supplier shall indicate if any patents or licenses are involved because of equipment furnished, or process employed. The Supplier shall assume all costs of patent fees or licenses for equipment or processes, and shall defend and save harmless the Contractor, Owner and Engineer, and their agents from damages, judgments, claims and expenses arising from license fees or claimed infringements or any letters of patent or patent right, or because of royalty or fee for the use of any equipment or process, structural feature or arrangement of any of the component parts of the equipment supplied by Supplier when operated and maintained as instructed by Owner; and the price stipulated for all such patent fees, licenses, or other costs pertaining thereto.
- B. License fees or royalties required in connection with use of the System shall be included in the Contract Price.

PART 2 PRODUCTS

2.01 SUPPLIER

- A. Subject to compliance with the Contract Documents, the following Suppliers are acceptable:
 - 1. CNP Technology Water and Biosolids Corp, Kenosha, WI.
 - 2. No equal.

2.02 GENERAL

- A. All flanges shall be ANSI 125# standard sizes.

- B. Allow for future struvite product recovery by accommodating the addition of reactor tanks or extensions to the reactor tanks, plus the addition of pumps, blowers, metering pumps, accessories, and a grit washer for separation of the product. Submittals shall indicate the location and size of all connections to future equipment and piping.
- C. All metallic components in contact with process fluid shall be constructed of Type 316 stainless steel, unless specified otherwise under each technical equipment specification.

2.03 COMPONENTS

- A. Phosphorus precipitation reactors:
 - 1. Provide reactors per Section 46_63_83.
 - 2. Provide at least two reactor tanks, so that retention time at 2020 flow is within the 4-5 hour HRT range and meeting the minimum HRT at 2040 flow provided above.
- B. Aeration equipment:
 - 1. Provide rotary lobe blowers per Section 43_11_33.
 - 2. Provide Abwasser Belüftungs Und Klartechnik (ABK) IFU Type VMS perforated diffusers, or Supplier's recommended diffusers. Perforated diffuser system furnished with the System shall be designed to meet the aeration requirements as calculated by the Supplier.
- C. Pumping equipment:
 - 1. Provide progressing cavity pump per Section 43_23_57.10.
 - 2. Pumps will be installed inside a building, underneath the Phosphorus Precipitation Reactor.
- D. Chemical storage and feed:
 - 1. Provide magnesium chloride metering pump system and antifoam metering pump system per Section 43_33_20.01.
 - 2. Provide magnesium chloride storage tank and unloading station per Section 43_41_43.
- E. Instrumentation:
 - 1. Magnetic flow meters in accordance with Section 40_71_15.
 - 2. Thermal mass flow meters in accordance with Section 40_71_76.
 - 3. Level transmitter in accordance with Section 40_72_24 and 40_72_36.
 - 4. Level switches in accordance with Section 40_72_76
 - 5. Pressure gauges in accordance with Section 40_73_13.
 - 6. Pressure devices in accordance with Section 40_73_23.
 - 7. Pressure instrument valves in accordance with Section 40_73_64.
 - 8. Temperature switches in accordance with Section 40_74_66.
 - 9. pH analyzer in accordance with Section 40_75_13.
- F. Controls:
 - 1. PLC Cabinet and control system programming provided in accordance with Sections 40_61_05 and 40_64_01.
 - 2. Programming and integration by Supplier.

- G. Accessories:
 - 1. Valves:
 - a. Provide 1 manual and 2 electrically actuated knife gate valves for each reactor discharge in accordance with Section 40_05_65.01.

PART 3 EXECUTION

3.01 GENERAL

- A. The Contractor shall inspect interior and exterior of the Reactors for defects upon receipt at the job site and after installation. Any defects shall be repaired by Supplier.
- B. The Contractor shall provide the following for installation of system components: Concrete slab and building for Phosphorus Precipitation Reactor and appurtenances.

3.02 INSTALLATION

- A. General
 - 1. Supplier shall provide installation instructions. Contractor to install products in accordance with manufacturer's and Supplier's instructions.
 - 2. Contractor shall furnish all consumables prior to operation of the reactor.
 - 3. Unless specified otherwise under each technical equipment specification, Supplier shall furnish all anchoring hardware for the supplied equipment.

3.03 CLEANING

- A. Supplier shall provide recommendations for cleaning all Reactor surfaces, inside and out, and appurtenances after installation.

3.04 SOURCE TESTING:

- A. Conduct Factory Acceptance Test (FAT) in accordance with Section 40_80_01.

3.05 FIELD QUALITY CONTROL

- A. A Supplier's factory representative, who has complete knowledge of the proper operation and maintenance of the specified equipment, shall be provided to instruct representatives of the Contractor, Engineer, and Owner on the proper installation and operation and maintenance.
- B. Field testing, calibrating, and training of the control system and instrumentation in accordance with Section 40_80_01.
- C. Pre-demonstration Test:
 - 1. The Supplier shall provide the services of a factory trained I&C engineer to check and verify the PLC program functionality (Dry testing).

2. Instruments and other devices that require calibration and checkout will be carried out after the Contractor has the equipment installed and verified continuity. Instruments and devices shall be configured and demonstrated to function prior to start-up. A document indicating the set points and calibration shall be furnished for documentation records.
3. Complete pressure testing for all piping connected to or included in the System. Include testing of feed, discharge, and overflow piping.
4. Fill the Phosphorus Precipitation Reactor with clean water and verify no leakage from any component in the system:
 - a. Verify water tight seal on valves below the reactor using the flushing/drain connections.
5. Demonstrate gravity flow from the system through the normal discharge piping and emergency overflow piping.
6. Complete Pre-demonstration Testing for individual components of the system specified in other specification sections.
7. Operate the complete System using water as the working fluid:
 - a. Fill the reactor with water and operate for a minimum of 24 hours without providing continuous forward flow to the system.
 - 1) Operate chemical metering pumps in manual mode.
 - 2) Operate blowers in manual mode.
 - 3) Operate the phosphorus precipitation pump in manual mode.
 - 4) Verify operation of motorized valves.
 - 5) Operate antifoam metering pumps in automatic mode. Demonstrate operation of the pump based on high level signal from the reactor.
 - 6) Demonstrate operation of the emergency overflow.
 - 7) Add process water during the test as required to maintain the necessary reactor volume.
 - b. Operate the system for a minimum of 8 hours while providing continuous forward flow to the system using process water:
 - 1) Provide process water to the system at a rate of approximately 60 gpm.
 - 2) Demonstrate operation of the normal overflow from the reactor.
 - 3) Operate chemical metering pumps in automatic mode. Demonstrate control of the pump based on operator dosing setpoint and measured flow to the reactor.
 - 4) Operate blowers in automatic mode as recommended by the Supplier.
 - 5) Operate the struvite pump in automatic mode.
 - 6) Operate antifoam metering pumps in automatic mode. Demonstrate operation of the pump based on high level signal from the reactor.
 - 7) Demonstrate operation of the emergency overflow.

3.06 DEMONSTRATION TEST

- A. See Specification Section 01_75_17.
- B. Performance testing:
 1. The Owner shall be responsible for carrying out the performance testing, for collecting all samples, for carrying out all laboratory tests and for keeping such detailed records as may be necessary for determining whether the performance guarantees have been met.

- a. Copies of the laboratory results and records shall be submitted to the Supplier and Engineer.
 - b. For the duration of the Performance Test, the Owner shall maintain daily log sheets, operator notes, sample inspections, and instrument charts produced in operation of the System.
 - c. Supplier shall review the records and laboratory results and provide guidance to the Owner regarding the System operation.
2. The performance test shall be subject to the following general conditions:
 - a. All volumes specified shall be measured by tank gauges or calibrated meters.
 - b. All laboratory analysis methods will be performed by the Owner or Owner's representative laboratory. A list of methods will be provided to the Supplier prior to the start of the Performance Test.
 - c. The Owner shall furnish all materials, utilities, services and personnel as required to operate the plant during the performance tests.
 - d. The Contractor will notify the Supplier in writing thirty days in advance of beginning the performance test.
- C. The duration of the performance test shall be 30 days. The result of the performance test shall be based on the average of the daily measurements.
- D. The following recordings and samples shall be taken and analyzed by Owner to be used for evaluation of the System during the Performance Test. All samples shall be taken once daily for purposes of Performance Test:
 1. System Flow: Influent (continuously measured - gallons per day).
 2. TSS: Influent (mg/L).
 3. Mg: Influent/Effluent (mg/L).
 4. Alkalinity: Influent/Effluent (mg/L).
 5. NH₄-N: Influent/Effluent (mg/L).
 6. Ortho-P: Influent/Effluent (mg/L).
 7. Total-P: Effluent/Centrates (mg/L).
 8. pH: Influent/Effluent (S.U.).
 9. Temperature: Influent (degrees Celsius).
- E. The Supplier and Owner will jointly review performance of the process system to determine compliance with performance guarantees. Review will include, but not be limited to, a comparison of influent and process design basis with the actual performance results.
- F. The Owner will promptly notify the Supplier of the failure to meet any process guarantee and specify the respect in which such guarantee has not been met.
- G. If the Supplier disputes any claimed failure, notice of such dispute shall be furnished promptly to Owner.
- B. Performance standards and exclusive remedy:
 1. In the event that the system does not achieve the required level of performance during the test period, the Supplier shall be permitted to conduct two additional tests to meet the specified process guarantee criteria.
 2. All additional testing must be concluded within three months upon completion of the Pre-Demonstration Period.

3. If the system fails to achieve the required phosphorus removal and chemical dose during the performance test period and fails any additional tests, the Supplier shall pay for modifications to improve the performance.

END OF SECTION

SECTION 46_63_83

PHOSPHORUS PRECIPITATION SYSTEM REACTOR

PART 1 GENERAL

1.01 SUMMARY

- A. Scope of Work for Phosphorous Precipitation System Reactor Supplier (Supplier):
 - 1. The Supplier shall furnish the process equipment for a Phosphorus Precipitation Reactor (Reactor), as shown on the Drawings and specified herein. Other Phosphorous Precipitation System (System) components are covered under separate specifications.
 - 2. Process equipment to be furnished under this Section includes, but is not limited to, the following:
 - a. Phosphorus precipitation Reactor, complete with Reactor support legs, access platforms, pipe connections, and removable Reactor cover.
 - b. System accessories required for a complete and functional Reactor system including, but not limited to, internal diffuser ring, diffuser supports, baffles, manhole with access door, and pipe and electrical conduit supports.
 - c. Design of anchor bolts for anchorage of Reactor to concrete pad. Supply of anchor bolts by supplier, installation by Contractor.
- B. Supplier agrees that the design, as specified in this Specification and on the Drawings, will meet all performance requirements. Any modifications to the Reactor required to meet the performance requirements that are attributed to the performance of the System shall be the full responsibility of the Supplier.
- C. Responsible Parties:
 - 1. The following define the responsible parties associated with the Project:
 - a. Owner: City of Meridian.
 - b. Contractor: To be determined pending bidding by OWNER.
 - c. Engineer: Carollo Engineers.
 - d. Supplier: CNP Technology Water and Biosolids Corp.
- D. Related sections:
 - 1. Section 01_81_01 - Project Design Criteria.

1.02 REFERENCE STANDARDS

- A. American Institute of Steel Construction (AISC) - 360 - Specification for Structural Steel Buildings, 13th Edition or newer.
- B. American Water Works Association (AWWA):
 - 1. AWWA D100 – Welded Steel Tanks, 2011 Edition or newer.
- C. American Petroleum Institute (API):
 - 1. 650 - Welded Steel Tanks for Oil Storage, 11th Edition with addendum and errata through 2011.

- D. American Society of Mechanical Engineers (ASME):
 - 1. Boiler and Pressure Vessel Code.
- E. International Society for Testing and Materials (ASTM):
 - 1. A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 2. A304 - Standard Specification for Stainless Steel.
 - 3. A325 - Standard Specification for High-Strength Bolts for Structural Steel Joints.
 - 4. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
- F. American Welding Society (AWS):
 - 1. B2.1 - Standard for Welding Procedure and Performance Qualifications.
 - 2. D1.6 - Structural Welding Code for Stainless Steel.
 - 3. D10.4 - Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing.
- G. Occupational Safety and Health Act (OSHA).
- H. 2015 International Building Code (IBC).

1.03 SYSTEM DESCRIPTION

- A. The System supplies magnesium chloride and low-pressure air to a welded stainless steel Reactor receiving anaerobically digested material. Positive displacement blowers provide air for Reactor mixing and pH control. Magnesium chloride is dosed based on a magnesium to soluble phosphorus ratio to the top of the Reactor for the precipitation of struvite. Struvite crystals are removed periodically from the bottom of the Reactor using an automated valve and progressive cavity pump.

1.04 DESIGN CRITERIA

- A. Phosphorus Precipitation Reactor:
 - 1. Reactor tank dimensions and capacity (CNP Reactor):
 - a. Inside diameter: 13.78 feet.
 - b. Height: 34.00 feet.
 - c. Minimum volume: 20,000 gallons.
 - d. Number of tanks: 2.
 - 2. Maximum instantaneous design Reactor inlet flow rate: 400 gallons per minute.
 - 3. The design of all items covered by this Section, including Reactor anchor bolts, shall be designed and sealed, or reviewed and sealed by a registered professional engineer in the State of Idaho.
 - 4. The Reactor will be installed in accordance with the specified requirements of this Section and the Supplier's instructions.
 - 5. Pipe supports shall be the same material as the Reactor shell and shall be provided and designed by the Supplier as indicated on the Drawings. Pipe support systems shall be suitable for support of insulated and heat traced piping.
 - 6. Fittings: Pipe connections, nozzles, manholes, and accessories, as indicated on the Drawings and in this Section, shall be by the Supplier.

7. Design Loads:
- a. Pressure: Vent Reactor to prevent pressurization of the tank caused by air flowing in and out of the Reactor with the cover installed. Design Reactor vent for the airflow anticipated to enter the tank during normal operation as well as under vacuum conditions if the tank was drained with the cover installed.
 - b. Structural Design Requirements:
 - 1) The structural design criteria to be used shall be as specified in Section 01_81_01. Where not explicitly stated in that section, the Reactor Engineer of Record shall select design criteria based upon reference documents such as ASCE7-10 or API Standard 650.
 - 2) Structural design for concrete anchors (anchor bolts) shall conform to the requirements of American Concrete Institute (ACI) Standard 318 – Building Code Requirements for Structural Concrete and Commentary, year 2011 edition. As a minimum, the provisions of Appendix D – Anchoring to Concrete, shall be applied to the design of the anchorage.
 - c. Reactor supports: Designed by Supplier in accordance with project requirements and specification requirements herein.
 - d. Assembly bolts:
 - 1) Bolted connection shall be avoided wherever suitable welded connection can be provided.
 - 2) In accordance with ASTM A193, Grade B8M.
 - 3) Stainless steel.
 - e. Concrete anchors (anchor bolts) and chairs:
 - 1) Anchor bolts, nuts and washers used for design of the Reactor anchorage to concrete foundations shall conform to the following material standards:
 - a) Type 316 stainless steel.
 - f. Openings in Reactor shell:
 - 1) Locate openings in the tank shell where indicated on the Drawings.
 - 2) Design and provide suitable reinforcement and welding around opening in the Reactor shell:
 - a) Reinforcement and welding shall meet the minimum requirements of reference document API 650, Section 5.
 - g. Pipe supports:
 - 1) Provide process pipe, chemical pipe and electrical conduit supports attached to the shell and framing that extend from the Reactor out to the location of the items to be supported.
 - 2) Pipe and conduit supports shall be spaced a maximum of 5 feet on center.
 - 3) Pipe supports shall be fabricated, including predrilled with holes, as required for the attachment of the supported items. Pipe support locations and other requirements shall be coordinated with the Drawings.
 - h. Pipe and nozzle connections:
 - 1) Locate pipe connections where indicated on the Drawings.
 - 2) Provide suitable reinforcement and weld around pipe connections to the Reactor shell.
 - 3) Capable of resisting the following loads:
 - a) Dead loads.
 - b) Hydraulic thrust loads.

- c) Wind loads.
 - d) Seismic loads.
 - e) Pipe Loads.
- i. Shell plates:
 - 1) Roll curved shell plates to the required radius regardless of thickness.
- j. Corrosion Allowance:
 - 1) Shell plates and structural framing members used to fabricate the Reactor tank, support legs and bracing shall include an additional corrosion allowance thickness of 0.0625 inch.
- k. Reactor overflow:
 - 1) Design the Reactor overflow for 1.25 times the maximum flow rate.
 - 2) Overflow type, locations, and details as indicated on the Drawings.
- l. Flashing skirt:
 - 1) The Reactor will be installed outside with a new treatment building installed around the legs of the reactor, as indicated on the Drawings.
 - 2) The Supplier shall provide a continuous and weather tight flashing skirt around the full circumference of the Reactor. The skirt shall extend horizontally off the shell of the Reactor.

1.05 QUALITY ASSURANCE

- A. All equipment required for the System shall be furnished by a single entity (Supplier) who, with the Contractor, shall be responsible for completeness of the system. The Supplier shall be the sole source of information on all equipment furnished regardless of the manufacturing source of the equipment.
- B. Qualifications:
 - 1. Fabricator qualifications:
 - a. Regularly engaged in the design, fabrication, and erection of welded steel tanks of the type specified in this Section.
 - b. Provide a list of all steel tank projects completed in the last 5 years, including names, addresses, and telephone numbers of the reference for each project.
 - c. Reactor designer shall be a registered professional civil or structural engineer in the State of Idaho, or a registered professional civil or structural engineer in the State of Idaho shall review and stamp the Reactor design.
 - d. Familiar with applicable regulations, codes, fire and safety orders.
 - e. Located within the United States.
- C. Welder and Weld Inspector Qualifications:
 - 1. Fabrication certification requirements:
 - a. Qualify personnel and procedures according to AWS B2.1 and D1.6 Structural Welding Code.
 - 2. Weld inspection certification requirements:
 - a. Certified Welding Inspector (CWI): Certified by American Welding Society to Standards AWS QC-1-88 and prior inspection experience using governing welding codes.

- b. Weld testing personnel: Personnel certified to perform non-destructive testing (NDT) in accordance with current American Society of Nondestructive Testing. Recommended practice No. SNT-TC-1A and all supplements, NDT Level II.

D. Warranty:

- 1. Phosphorus Precipitation System Reactor:
 - a. Supplier shall guarantee the Reactor is suitable for intended service.
 - b. Supplier to warrant against defects in materials and workmanship of the Reactor and that the Reactor will not fail or leak for a period of two (2) years from the date of acceptance. Reactor Supplier shall provide the warranty and repair any failures or leaks at no cost to the Owner.

1.06 SUBMITTALS

- A. Submittals shall be submitted and approved by Owner, Contractor and Engineer prior to fabrication of Reactor and any other equipment by Supplier. Submit all documentation in electronic format (searchable .PDF) to Contractor. Except as may be provided in technical specifications or under special circumstances, a submittal will be returned to Supplier within 10 working days. If resubmittal required, Supplier shall provide resubmittal within 15 calendar days.
- B. Calculations and shop drawings:
 - 1. Phosphorus Precipitation System Reactor:
 - a. Submit design calculations prior to or at same time that the detailed Reactor drawings are submitted.
 - b. Design calculations shall be signed and sealed by a structural engineer who is experienced in the design of steel tanks and registered in the State of Idaho.
 - c. Submitted calculations shall include the following minimum data:
 - 1) Printout or written hand calculations for each component of the Reactor, its anchorage and appurtenances. These calculations shall report as a minimum:
 - 2) Actual design force or stress when subject to the specified design criteria and calculated loads.
 - 3) Available force or stress capacity.
 - 4) Where applicable, deflection of individual members and the total horizontal drift of the installed Reactor, when subject to controlling loading combinations, assuming a fixed base support at the top of the concrete foundation(s).
 - 5) Reactor foundation loads (basic uncombined and combined) including but not limited to dead, live, snow, ice, wind, and seismic.
 - d. Member sizes, dimensions, standard shape designations where applicable and anchor bolt layouts.
 - e. Detail drawings with dimensions and callouts of all framing and bolted connections, clips and lugs, hold down lugs, pipe brackets, and anchor bolts.
 - f. Details of structural support members and lifting lugs.
 - g. Reactor and equipment weight when empty and when in service.

- C. Certifications:
 - 1. Phosphorus Precipitation System Reactor:
 - a. Documentation that demonstrates compliance with quality assurance requirements.
 - b. Certified mill tests for stainless steel plate, structural members and each component of bolted connections.
 - c. Fabricator's Certificate of Compliance with fabrication requirements.
 - d. Certify that the Reactors and accessories have been properly designed, fabricated, erected, installed, inspected, and tested in accordance with, and are ready for full-time service.
- D. Shop Drawings:
 - 1. Product technical data including:
 - a. Supplier's installation instructions for all equipment provided as part of the System.
 - 2. Complete fabrication and/or layout drawings including overall equipment layout and piping interconnection drawings.
 - a. Show locations of all equipment, instrumentation, control panels, and piping.
 - b. Show delineation of interfaces between Supplier and Contractor supplied equipment, piping, and wiring for the complete System.
- E. Welding:
 - 1. Quality Assurance Inspection Reports.
- F. Stainless Steel:
 - 1. Product data.
 - 2. Submit pickling and passivation procedures and material descriptions.
- G. Other:
 - 1. Operation and maintenance manual in accordance with Owner requirements.
 - 2. A list of spare parts and tools necessary to maintain the equipment for a period of 5 years.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling of specified equipment and appurtenances will be in accordance with Supplier recommendations.
- B. Supplier's instructions shall be provided for unloading, examination, preparation, and installing of the specified equipment and appurtenances.
- C. Phosphorus Precipitation Reactor:
 - 1. Prepare and protect Reactor for shipment in accordance with Supplier's recommendations. In addition, prepare and protect the Reactor for shipment as follows:
 - a. Mount Reactor on padded cradles supporting 120 degrees of the Reactor circumference.
 - b. Reactor shall be mounted on protective framework so constructed as to provide for easy handling with lifting lugs, cleats, to permit handling by crane. Pipe connections, manways, or other fittings shall not be used for lifting.

- c. Protect all flanged pipe connections with wooden blinds bolted to the flange and having a diameter of 2 inches greater than the outside diameter of the flange. All openings are to be securely covered to prevent entrance of dirt, water, and debris.
- d. Do not ship components or other pieces loose inside the Reactor.
- e. Load Reactor with at least 2 inches of clearance between the Reactor (including fittings) and the bulkheads or bed of the vehicle.
- f. Regardless of the mode of transportation, firmly fasten and pad all components to prevent shifting of the load or flexing of components when in transit.

1.08 EXTRA MATERIALS

- A. Phosphorus Precipitation Reactor:
 - 1. Provide the following spare parts: Two (2) sets of each size of gasket used for the Reactor.

1.09 PATENTS

- A. The Supplier shall indicate if any patents or licenses are involved because of equipment furnished, or process employed. The Supplier shall assume all costs of patent fees or licenses for equipment or processes, and shall defend and save harmless the Contractor, Owner and Engineer, and their agents from damages, judgments, claims and expenses arising from license fees or claimed infringements or any letters of patent or patent right, or because of royalty or fee for the use of any equipment or process, structural feature or arrangement of any of the component parts of the equipment supplied by Supplier when operated and maintained as instructed by Owner; and the price stipulated for all such patent fees, licenses, or other costs pertaining thereto.
- B. License fees or royalties required in connection with use of the System shall be included in the Contract Price.

PART 2 PRODUCTS

2.01 SUPPLIER

- A. Subject to compliance with the Contract Documents, the following Suppliers are acceptable:
 - 1. CNP Technology Water and Biosolids Corp, Kenosha, WI.
 - 2. Schwing BioSet, Inc., Somerset, WI.

2.02 GENERAL

- A. All flanges shall be ANSI 125# standard sizes.
- B. Phosphorus Precipitation Reactor:
 - 1. Reactor shall be constructed of Type 316L stainless steel.
 - 2. Reactor shall be free standing and installed outside of the equipment building.
 - 3. The hopper bottom will be supported by a minimum of four columns.
 - 4. Flow baffles and aeration diffusers will be provided as required to meet the Supplier's design requirements.

5. The steel shell of the Reactor shall be of all welded construction utilizing rolled flat plates that meet the material requirements of ASTM A240.
6. Nozzles shall have reinforcing pads where necessary for structural strength.
7. Reactors shall be completely shop welded. No field welding of Reactors is permitted.
8. All welding shall be complete prior to installation.
9. Manholes in shell:
 - a. One 36-inch diameter manhole with bolted cover.
 - b. Provide suitable means to hold the manhole in an open position.
 - c. Use loose hinges to allow for easy bolting.
 - d. Provide gaskets for a watertight seal.
 - e. Provide suitable reinforcement and welding around openings in the Reactor shell.
10. Pipe connections:
 - a. Provide flanged connections for all process piping including air, Reactor feed, Reactor overflow, emergency overflow, and hopper discharge, as indicated on the Drawings.
 - b. Locate pipe connections where indicated on the Drawings.
 - c. Provide suitable reinforcement and welding around pipe connections to the Reactor shell.
11. Reactor cover:
 - a. Provide Reactor cover with construction and materials to match the Reactor.
 - b. Provide lifting lugs and complete rigging plan for installation by Contractor.
 - c. Provide bolted connections with the Reactor shell with suitable reinforcement and welding around the bolted connections between the Reactor and Reactor cover.
 - d. Locate the following where indicated on the Drawings:
 - 1) 24-inch access hatch.
 - 2) Flanged connections for:
 - a) Reactor feed.
 - b) Reactor recycle.
 - c) Odorous air takeoff.
 - d) Process instrumentation.
 - e) Chemical conveyance.
 - f) Any other piping as indicated on the Drawings.
 - e. Provide suitable reinforcement and welding around pipe connections to the Reactor cover.
12. Reactor Access:
 - a. Provide intermediate manway. Provide internal cross members suitable to support scaffolding boards inserted through intermediate manway, to support personnel access to diffusers for cleaning and replacement of diffusers.
 - b. Provide platform at top of Reactor for access to all instrumentation, manways, and access for cleaning.
 - c. Provide guardrail and handrail for platform.
 - d. All platform guardrail shall comply with OSHA 29 CFR 1910.24.
 - e. All grating and handrail shall be hot dipped galvanized. Structural support members connected to the Reactor tank shall be stainless steel or hot dip galvanized.

2.03 FABRICATION

A. Phosphorus Precipitation System Reactor:

1. In assembly and during welding, the component parts shall be adequately clamped, supported and restrained to minimize distortion and for control of dimensions. Weld reinforcement shall be as specified by the Reference Standards, and excessive reinforcement shall be as ground down to within the requirements. Upon completion of welding all weld splatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a workmanlike appearance, with uniform contours and dimensions. All external corners and edges shall be ground to a 1/16-inch radius. All internal corners and edges shall be ground to a 1/8-inch radius, or a greater radius if required by the coating system.
2. All openings 4 inches and greater in nominal diameter shall be reinforced.
3. Reactor details shall use continuous seam welded joints and eliminate unwelded joints that will promote corrosion or pockets that will accumulate debris.
4. Stiffener and doubler plates shall be used where attachments to the shell will result in excessive localized stresses due to welding supports or imposed loads.
5. The entire Reactor interior shall present a smooth surface free of marked depressions, offsets, abrupt edges, or other protrusions.
6. The Reactor and appurtenances shall be fabricated from a minimum number of pieces, and longitudinal shell seams shall be staggered. Welding seams shall be located to clear all nozzle openings. All flange faces shall be true to the centerline of the nozzles, and bolt holes shall straddle center lines unless noted elsewhere.
7. Manways shall be flanged, and, unless otherwise specified, have a nominal diameter of at least 24 inches. The cover plate and flange shall each have a net thickness, after machining, of at least 1/2 inch.
8. All fittings shall be flanged, unless specified otherwise.
9. Lifting lugs to be provided per the Supplier's recommendations to allow lifting and placement of the Reactor. A safety factor of 2.0 applied to the maximum permissible lifting load shall be used to design all lifting lugs. Lifting lug material shall be the same as Reactor material.
10. Reactor Finish: Pickle and passivate after welding in accordance with ASTM A380, prior to delivery on site. Do not deliver or install stainless steel components that do not have an unblemished, uniform, even passivation layer free of pitting, rust spots, heat tint, or discoloration of any kind.

PART 3 EXECUTION

3.01 GENERAL

- A. The Contractor shall inspect interior and exterior of the Reactor for defects or discoloration of stainless steel upon receipt at the job site and after installation. Any defects upon delivery shall be repaired off-site by Supplier and re-delivered to job site.
- B. The Contractor shall provide the following for installation of system components: Concrete slab, stairs, and building for Phosphorus Precipitation Reactor.

3.02 SHOP INSPECTION AND TESTING

- A. After fabrication, but before any coating work, Reactor shall be subjected to a hydrostatic pressure test in accordance with API 650.
- B. Phosphorus Precipitation System Reactor
 - 1. Reactor inspection includes, but is not limited to:
 - a. Visual inspection of all welds.
 - b. Spot radiography of the Reactor per API 650.
 - c. Dye pen test of the Reactor shell to the cone bottom joint.
 - d. Pneumatic test of all repads.
 - e. Hydrotesting.
- C. All NDE including, but not limited to Magnetic Particle Testing (MT), Liquid Dye Penetrant Testing (PT), Visual Examination (VT) will be performed to comply with the requirements of API 650.

3.03 INSTALLATION

- A. General
 - 1. Supplier shall provide installation instructions.
- B. Phosphorus Precipitation System Reactor:
 - 1. The Reactor and components shall be adequately protected during transportation. Damaged units will be rejected and shall be replaced with undamaged units (or repaired in the field if acceptable by Owner).
 - 2. Coating repairs, if required, shall be in accordance with Supplier recommendations.

3.04 CLEANING

- A. Supplier shall provide recommendations for cleaning all Reactor surfaces after installation.

3.05 FIELD TESTING

- A. Phosphorus Precipitation System Reactor
 - 1. Hydrostatic leak test (24-hour duration) shall be conducted with the Reactor full of clean water. If leakage occurs, the Reactor may be rejected and replaced by Supplier with a new Reactor or repaired if repair approach is acceptable to Owner.
- B. A Supplier's factory representative, who has complete knowledge of the proper operation and maintenance of the specified equipment, shall be provided to instruct representatives of the Contractor on the proper installation and operation and maintenance.

END OF SECTION

SYMBOL	DRAWING VISIBLE FIELDS	FIELD - 1	FIELD - 2	FIELD - 3	FIELD - 4	FIELD - 5	FIELD - 6
HMI/SCADA SYSTEM OPERATOR INTERFACE TERMINAL	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- DESCRIPTION 5- DESCRIPTION 6- EXISTING/FUTURE	REFER 1 2	REFER 3	ACTION ALARM NUM - NUMERIC SP - SET POINT STATUS TREND	DESCRIPTION 2 5	DESCRIPTION	E - EXISTING F - FUTURE
HARDWIRED I/O POINT	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- DESCRIPTION 5- LOCATION 6- EXISTING/FUTURE	REFER 1 2 4	REFER 3	AI - ANALOG INPUT AO - ANALOG OUTPUT DI - DISCRETE INPUT DO - DISCRETE OUTPUT HSC - HIGH SPEED COUNTER INPUT RTD - RTD INPUT	DESCRIPTION	PAC - PROGRAMMABLE AUTOMATION CONTROLLER NO. PLC - PROGRAMMABLE LOGIC CONTROLLER NO. RIO - REMOTE I/O VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE
NETWORK / SOFT I/O	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- DESCRIPTION 5- LOCATION 6- EXISTING/FUTURE 7- DIGITAL NETWORK TABLE	REFER 1 2	REFER 3	BUS ID CNET - CONTROLNET DNET - DEVICENET ENET - ETHERNET/IP FF - FOUNDATION FIELDBUS MB - MODBUS RTU MB+ - MODBUS PLUS MBTCP - MODBUS TCP DP - PROFIBUS DP PA - PROFIBUS PA PNET - PROFINET SERIAL - PROPRIETARY PROTOCOL	DESCRIPTION	PAC - PROGRAMMABLE AUTOMATION CONTROLLER NO. PLC - PROGRAMMABLE LOGIC CONTROLLER NO. RIO - REMOTE I/O VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE
LOCAL OPERATOR INTERFACE	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- DESCRIPTION 5- LOCATION 6- EXISTING/FUTURE	REFER 1 2	REFER 3	ACTION ALARM NUM - NUMERIC SP - SET POINT STATUS	DESCRIPTION 2 5	LOI - LOCAL OPERATOR INTERFACE NO. LCP - LOCAL CONTROL PANEL NO. PCM - PROCESS CONTROL MODULE NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE
PILOT DEVICE OPERATOR INTERFACE	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- DESCRIPTION 5- LOCATION 6- EXISTING/FUTURE	REFER 1 2	REFER 3	AM - AUTO/MANUAL BYPASS - BYPASS CL - CLOSE E-STOP - EMERGENCY STOP FRLR - FIXED RATE/LEVEL RATE HOA - HAND OFF/AUTO JOHC - JOG OPEN/HOLD/CLOSE JIOC - JOG OPEN/JOG CLOSE LH - LOW/HIGH LOR - LOCAL/OFF/REMOTE LOS - LOCK OUT STOP LS - LEAD/STANDBY LSR - LOCAL/STOP/REMOTE NOOT - NO OFFLINE/OFFLINE TRANSITION OC - OPEN/CLOSE CLOL - ON LINE/OFF LINE OO - OFF/ON OP - OPEN OSC - OPEN/STOP/CLOSE RST - RESET SAAM - SEMI AUTO/AUTO/MANUAL SEL - SELECT SP - STOP SPD - SPEED SS - START/STOP ST - START	DESCRIPTION	LCP - LOCAL CONTROL PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. RVSS- REDUCED VOLTAGE SOLID STARTER NO. VCP - VENDOR CONTROL PANEL NO. VFD - VARIABLE FREQUENCY DRIVE NO.	E - EXISTING F - FUTURE
POWER DEVICE PRIMARY FUNCTION OPERATOR ACCESSIBLE	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- VOLTAGE-POLE 5- LOCATION 6- EXISTING/FUTURE	CB - CIRCUIT BREAKER DISC - DISCONNECT FU - FUSE	REFER 3	TM - THERMAL MAGNETIC CIRCUIT BREAKER	24VDC - 1P 120VAC - 1P 208VAC - 2P 208VAC - 3P 240VAC - 2P 240VAC - 3P 480VAC - 3P 2400VAC - 3P 4160VAC - 3P	DP - DISTRIBUTION PANEL NO. LCP - LOCAL CONTROL PANEL NO. LP - LIGHTING PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. PP - POWER PANEL NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE
POWER DEVICE AUXILIARY FUNCTION FOR OPERATOR ACCESSIBLE DEVICES	1- TAG 2- LOOP NUMBER 3- DESCRIPTION 4- DESCRIPTION 5- DESCRIPTION 6- EXISTING/FUTURE	DISC - DISCONNECT	REFER 3	DESCRIPTION	DESCRIPTION	DESCRIPTION	E - EXISTING F - FUTURE
POWER DEVICE PRIMARY FUNCTION OPERATOR INACCESSIBLE	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- VOLTAGE-POLE 5- LOCATION 6- EXISTING/FUTURE	CB - CIRCUIT BREAKER FU - FUSE	REFER 3	MCP - MOTOR CIRCUIT PROTECTOR SS - SOLID STATE CIRCUIT BREAKER TM - THERMAL MAGNETIC CIRCUIT BREAKER	24VDC - 1P 120VAC - 1P 208VAC - 2P 208VAC - 3P 240VAC - 2P 240VAC - 3P 480VAC - 3P 2400VAC - 3P 4160VAC - 3P	DP - DISTRIBUTION PANEL NO. LCP - LOCAL CONTROL PANEL NO. LP - LIGHTING PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. PP - POWER PANEL NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE

SYMBOL	DRAWING VISIBLE FIELDS	FIELD - 1	FIELD - 2	FIELD - 3	FIELD - 4	FIELD - 5	FIELD - 6
INSTRUMENT PRIMARY ELEMENT	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- FURNISHED BY 5- LOCATION 6- EXISTING/FUTURE	REFER 1	REFER 3	DESCRIPTION 5	DESCRIPTION 6	AREA NO. BUILDING NO. ROOM NO.	E - EXISTING F - FUTURE
INSTRUMENT/CONTROL ELEMENT PRIMARY FUNCTION OPERATOR ACCESSIBLE	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- FURNISHED BY 5- DESCRIPTION 6- EXISTING/FUTURE	REFER 1	REFER 3	DESCRIPTION 5	DESCRIPTION 6	DESCRIPTION	E - EXISTING F - FUTURE
INSTRUMENT/CONTROL ELEMENT AUXILIARY FUNCTION OPERATOR ACCESSIBLE	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- FURNISHED BY 5- DESCRIPTION 6- EXISTING/FUTURE	REFER 1	REFER 3	DESCRIPTION	DESCRIPTION 6	DESCRIPTION	E - EXISTING F - FUTURE
INSTRUMENT/CONTROL ELEMENT PRIMARY FUNCTION OPERATOR INACCESSIBLE	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- FURNISHED BY 5- LOCATION 6- EXISTING/FUTURE	REFER 1 3 XR - PROTECTION RELAY CR - CONTROL RELAY IR - INTERPOSING RELAY	REFER 3	DESCRIPTION	DESCRIPTION 6	LCP - LOCAL CONTROL PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE
INSTRUMENT/CONTROL ELEMENT AUXILIARY FUNCTION OPERATOR INACCESSIBLE	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- FURNISHED BY 5- LOCATION 6- EXISTING/FUTURE	REFER 1 3 XR - PROTECTION RELAY CR - CONTROL RELAY IR - INTERPOSING RELAY	REFER 3	DESCRIPTION	DESCRIPTION 6	LCP - LOCAL CONTROL PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE
FIELD EQUIPMENT NON-POWERED	1- TAG 2- LOOP NUMBER 3- FUNCTION/SIZE 4- FURNISHED BY 5- LOCATION 6- EXISTING/FUTURE	REFER 3	REFER 3	DESCRIPTION	DESCRIPTION 6	AREA NO. BUILDING NO. ROOM NO.	E - EXISTING F - FUTURE
FIELD EQUIPMENT PRIMARY FUNCTION POWERED	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- FURNISHED BY 5- LOCATION 6- EXISTING/FUTURE	REFER 3	REFER 3	DESCRIPTION	DESCRIPTION 6	AREA NO. BUILDING NO. ROOM NO.	E - EXISTING F - FUTURE
FIELD EQUIPMENT AUXILIARY FUNCTION POWERED	1- TAG 2- LOOP NUMBER 3- FUNCTION 4- FURNISHED BY 5- DESCRIPTION 6- EXISTING/FUTURE	MWH - MOTOR WINDING HEATER TSH - TEMPERATURE SWITCH XSH - TORQUE SWITCH	REFER 3	DESCRIPTION	DESCRIPTION 6	DESCRIPTION	E - EXISTING F - FUTURE
FIELD EQUIPMENT STARTER/DRIVE CUBICLE/CABINET	1- TAG 2- LOOP NUMBER 3- TYPE 4- VOLTAGE-POLE 5- POWER SOURCE 6- EXISTING/FUTURE	MS - MOTOR STARTER RVAT - REDUCED VOLTAGE AUTO TRANSFORMER STARTER RVSS- REDUCED VOLTAGE SOLID STATE STARTER VFD - VARIABLE FREQUENCY DRIVE	REFER 3	FVNR - FULL VOLTAGE NON-REVERSING STARTER FVR - FULL VOLTAGE REVERSING STARTER PWS - PART-WINDING STARTER RVAT - REDUCED VOLTAGE AUTO TRANSFORMER STARTER RVSS- REDUCED VOLTAGE SOLID STATE STARTER TS1W- TWO SPEED SINGLE WINDING TS2W- TWO SPEED TWO WINDINGS VFD - VARIABLE FREQUENCY DRIVE	120VAC - 1P 208VAC - 2P 208VAC - 3P 240VAC - 2P 240VAC - 3P 480VAC - 3P 2400VAC - 3P 4160VAC - 3P	LCP - LOCAL CONTROL PANEL NO. MCC - MOTOR CONTROL CENTER NO. PCM - PROCESS CONTROL MODULE NO. VCP - VENDOR CONTROL PANEL NO.	E - EXISTING F - FUTURE

INSTRUMENT BUBBLE LOCATIONS

PCS

CONTROL PANEL

FIELD POWER SOURCE

NOTES

1 INSTRUMENT TAG IDENTIFICATION LETTERS TABLE

2 OPERATOR PILOT DEVICE LEGEND

3 EQUIPMENT TAGGING TABLE

4 I/O TYPE DESIGNATIONS TABLE

5 INSTRUMENT TYPE DESIGNATIONS TABLE

6 FURNISHED BY: FBO FURNISHED BY OWNER
FBV FURNISHED BY VENDOR

INSTRUMENT TAG IDENTIFICATION LETTERS

INSTRUMENT FUNCTION MEASURED VARIABLE		ELEMENT	TRANSMITTER	INDICATING TRANSMITTER	CONVERTER TRANSDUCER/RELAY SPECIAL DEVICES	INDICATOR	RECORDER	CONTROLLER	INDICATING CONTROLLER	RECORDING CONTROLLER	SWITCH	SWITCH LOW LOW	SWITCH LOW	SWITCH HIGH	SWITCH HIGH HIGH	SWITCH COMBINATION HIGH LOW	ACTION	ALARM LOW LOW	ALARM LOW	ALARM HIGH	ALARM HIGH HIGH	TOTALIZE INDICATOR TRANSMITTER	VALVE	GAUGE	LIGHT	SPEED SETTING
A	ANALYSIS	AE	AT	AIT	AY	AI	AR	AC	AIC	ARC	AS	ASLL	ASL	ASH	ASHH	ASHL		AALL	AAL	AAH	AAHH				AL	
B	BURNER FLAME	BE	BT	BIT	BY	BI	BR	BC	BIC	BRC	BS	BSLL	BSL	BSH	BSHH			BALL	BAL	BAH	BAHH				BL	
C	CONDUCTIVITY	CE	CT	CIT	CY	CI	CR	CC	CIC	CRC	CS	CSLL	CSL	CSH	CSHH	CSHL		CALL	CAL	CAH	CAHH				CL	
D	DENSITY	DE	DT	DIT	DY	DI	DR	DC	DIC	DRC	DS	DSLL	DSL	DSH	DSHH	DSHL		DALL	DAL	DAH	DAHH				DL	
E																										
F	FLOW	FE	FT	FIT	FY	FI	FR	FC	FIC	FRC	FS	FSLL	FSL	FSH	FSHH	FSHL		FALL	FAL	FAH	FAHH	FQI	FCV	FG	FL	
FF	FLOW RATIO				FFY	FFI		FFC	FFIC		FFS														FFL	
G	GAUGING (DIMENSION)																									
H	HAND (MANUAL)*							HC			HS*						HA*						HV		HL	HSS
I	CURRENT		IT	IIT	IY	II	IR	IC	IIC	IRC	IS	ISLL	ISL	ISH	ISHH			IALL	IAL	IAH	IAHH				IL	
J	POWER																									
K	TIME				KY	KI	KR	KC	KIC	KRC	KS	KSLL	KSL	KSH	KSHH			KALL	KAL	KAH	KAHH		KV		KL	
L	LEVEL	LE	LT	LIT	LY	LI	LR	LC	LIC	LRC	LS	LSLL	LSL	LSH	LSHH	LSHL		LALL	LAL	LAH	LAHH		LCV	LG	LL	
M	MOISTURE OR HUMIDITY	ME	MT	MIT	MY	MI	MR	MC	MIC	MRC	MS	MSLL	MSL	MSH	MSHH			MALL	MAL	MAH	MAHH				ML	
N	EMERGENCY SHUTDOWN																									
O																										
P	PRESSURE OR VACUUM	PE	PT	PIT	PY	PI***	PR	PC	PIC	PRC	PS****	PSLL	PSL	PSH	PSHH	PSHL		PALL	PAL	PAH	PAHH		PCV		PL	
PD	DIFFERENTIAL PRESSURE		PDT	PDIT	PDY	PDI	PDR	PDC	PDIC	PDRC	PDS	PDSLL	PDSL	PDSH	PDSHH			PDALL	PDAL	PDAH	PDAHH		PDCV		PDL	
Q	QUANTITY	QE	QT	QIT	QY	QI	QR				QS	QSLL	QSL	QSH	QSHH			QALL	QAL	QAH	QAHH					
R	RADIOACTIVITY																									
S	SPEED	SE	ST	SIT	SY	SI	SR	SC	SIC	SRC	SS	SSLL	SSL	SSH	SSHH			SALL	SAL	SAH	SAHH					
T	TEMPERATURE	TE	TT	TIT	TY	TI	TR	TC	TIC	TRC	TS	TSLL	TSL	TSH	TSHH	TSHL		TALL	TAL	TAH	TAHH		TCV		TL	
TD	DIFFERENTIAL TEMPERATURE		TDT	TDIT	TDY	TDI	TDR	TDC	TDIC	TDRC	TDS	TDSLL	TDSL	TDSH	TDSHH			TDALL	TDAL	TDAH	TDAHH		TDCV		TDL	
U	MULTIVARIABLE					UI	UR	UC	UIC	URC	US														UL	
V	VISCOSITY	VE	VT	VIT	VY	VI	VR	VC	VIC	VRC	VS	VSLL	VSL	VSH	VSHH			VALL	VAL	VAH	VAHH				VL	
W	WEIGHT	WE	WT	WIT	WY	WI	WR				WS	WSLL	WSL	WSH	WSHH			WALL	WAL	WAH	WAHH					
X	UNCLASSIFIED	XE	XT	XIT	XY	XI	XR	XC	XIC	XRC	XS	XSLL	XSL	XSH	XSHH			XALL	XAL	XAH	XAHH		XCV	XG	XL	
XV	VIBRATION	XVE	XVT		XVY	XVI	XVR				XVS			XVSH	XVSHH					XVAH	XVAHH				XVL	
Y	STATUS***					YI***																			YL	
Z	POSITION	ZE	ZT	ZIT	ZY	ZI					ZS**												ZV		ZL**	

* REFER TO OPERATOR PILOT DEVICE LEGEND
** LETTER INDICATES POSITION (O=OPEN, C=CLOSED, R=RAISE, L=LOWER, ETC)
*** P# # = 1,2,3 ETC. AND REPRESENTS A UNIQUE IDENTIFIER AND IS APPLICABLE TO ALL ITEMS IN THE TABLE ABOVE

**** COULD ALSO BE PIS - FOR PRESSURE INDICATING SWITCH

OPERATOR PILOT DEVICE LEGEND

PILOT DEVICE FUNCTION DEVICE TYPE	LOCAL-OFF-REMOTE (LOR) OR LOCAL-STOP-REMOTE (LSR)	STOP (SP)	START (ST)	HAND-OFF-AUTO (HOA)	OFF-ON (OO)	SELECT (SEL)	OPEN-STOP-CLOSE (OSC)	JOG OPEN-HOLD-CLOSE (JOHC)	SEMI-AUTO-AUTO-MANUAL (SAAM)	LEAD-LAG-STANDBY (LLGS)	JOG OPEN-JOG CLOSE (JOJC)	ONLINE-OFFLINE (OLOF)	AUTO-MANUAL (AM)	FIXED RATE-LEVEL RATE (FRLR)	OPEN-CLOSE (OC)	NO OFFLINE- OFFLINE TRANSITION (NOOT)	LOW-HIGH (LH)	RESET (RST)	SPEED (SPD)	START-STOP (STSP)	E-STOP (E-SP)	BYPASS (BYP)			SILENCE	POSITION (POS)
	PILOT DEVICE TAG (HAND SWITCHES)	HSA*	HSB	HSC	HSD*	HSE	HSF	HSG*	HSH*	HSI	HSJ*	HSK*	HSL*	HSM*	HSN	HSO*	HSP	HSQ*	HSR	HSS	HST*	HSU	HSV	HSW	HSX	HSY
SCADA/HMI TAG (HAND ACTION)	HAA	HAB	HAC	HAD	HAE	HAF	HAG	HAH	HAI	HAJ	HAK	HAL	HAM	HAN	HAO	HAP	HAQ	HAR	HAS	HAT	HAU	HAV	HAW	HAX	HAY	HAZ

HSA* SELECTOR SWITCH POSITION EG: HSA(R) R = REMOTE, HSD(A) A = AUTO, ETC

I/O TYPE DESIGNATIONS

AUX1	RUNNING	MSL	MOTOR START LOW
AUX2	FAILED/FAULT	MSM	VALVE MODULATE
AUXF1	RUNNING FORWARD	MSP	MOTOR STOP
AUXH1	RUNNING HIGH	MSR	MOTOR START REVERSE
AUXL1	RUNNING LOW	MST	MOTOR START
AUXR1	RUNNING REVERSE	SS	SPEED SIGNAL
SVC	SOLENOID VALVE CLOSE	ZC	POSITION COMMAND
SVO	SOLENOID VALVE OPEN	ZCC	POSITION COMMAND CLOSE
MS	RUN	ZCO	POSITION COMMAND OPEN
MSF	MOTOR START FORWARD		
MSH	MOTOR START HIGH		

INSTRUMENT TYPE DESIGNATIONS

AM	AMMONIA	O3	OZONE	SH	SODIUM HYPOCHLORITE
CAP	CAPACITANCE	ORP	OXIDATION REDUCTION POTENTIAL	TDR	TIME DOMAIN REFLECTOMETRY
CGD	COMBUSTIBLE GAS DETECTOR	P	PRESSURE	TH	THERMAL
CL	CHLORINE	P-SUB	PRESSURE SUBMERSIBLE	TSS	TOTAL SUSPENDED SOLIDS
COND	CONDUCTIVITY	PC	PARTICLE COUNTER	TURB	TURBIDITY
DO	DISSOLVED OXYGEN	PO	PHOSPHOROUS	US	ULTRASONIC
FMCW	FREQ. MODULATED CONT. WAVE	PTOF	PULSE TIME OF FLIGHT	UVI	UV INTENSITY
HSF	FLUORIDE	R/I	RESISTANCE TO CURRENT	UVT	UV TRANSMITTANCE
IS	INTRINSIC SAFETY BARRIER	ROT	ROTAMETER	VAC	VACUUM
LEL	LOWER EXPLOSIVE LIMIT	RTD	RESISTANCE TEMP DETECTOR		
MAG	MAGNETIC	SC	STREAMING CURRENT		

SPECIFIC ABBREVIATIONS

APH	A PHASE	MWH	MOTOR WINDING HEATER
BPH	B PHASE	SSG	SECONDARY SWITCHGEAR
BRB	BEARING BOTTOM	SV*	SOLENOID VALVE
BRT	BEARING TOP	SPD	SURGE PROTECTIVE DEVICE
BTFLY	BUTTERFLY	UPS	UNINTERRUPTIBLE POWER SUPPLY
CPH	C PHASE	YA	STATUS AUTO
CC*	CALIBRATION COLUMN	YR	STATUS REMOTE
HTR	HEATER	Y1	STATUS RUNNING
HTU	HEAT TRACE UNIT	Y2	ALARM FAILED/FAULT

* CC# AND SV# # = 1, 2, 3 ETC. AND REPRESENTS A UNIQUE IDENTIFIER

INSTRUMENT LINE SYMBOLS

INSTRUMENT OR CONNECTION TO PROCESS	
PNEUMATIC SIGNAL	
ELECTRIC SIGNAL	
HYDRAULIC SIGNAL	
CAPILLARY TUBE	
ELECTROMAGNETIC OR SONIC SIGNAL (GUIDED)	
ELECTROMAGNETIC OR SONIC SIGNAL (NOT GUIDED)	
INTERNAL SYSTEM LINK (SOFTWARE OR DATA LINK)	
COPPER ETHERNET	
FIBER OPTIC ETHERNET	
WIRELESS ETHERNET	
PROFIBUS DP	
PROFIBUS PA	
DEVICENET	
FOUNDATION FIELDBUS	

PROCESS LINE SYMBOLS

PRIMARY PROCESS FLOW IN PIPE	
SECONDARY PROCESS FLOW IN PIPE	
PRIMARY PROCESS FLOW IN CHANNEL	
SECONDARY PROCESS FLOW IN CHANNEL	

DESIGNATIONS

EQUIPMENT ENCLOSURE	
EXISTING	
FUTURE	

MISCELLANEOUS P&ID SYMBOLS

CONTINUATION TAG	
PIPE CALLOUT	
SIGNAL CONTINUATION	

NO.

REVISION

BY

DATE

DESIGN
GEB

DRAWN
KMM

CHECKED

APPROVED

PRELIMINARY
DRAFT NOT FOR
CONSTRUCTION

ENGINEERING AND ENVIRONMENTAL SOLUTIONS

1161 W. RIVER ST. SUITE 130
BOISE, IDAHO 83702
208.780.3990

IDAHO OFFICES
BOISE · LEWISTON · MCCALL

MERIDIAN WASTEWATER FACILITY

MERIDIAN, IDAHO

INSTRUMENTATION

SYMBOLS AND ABBREVIATIONS - II

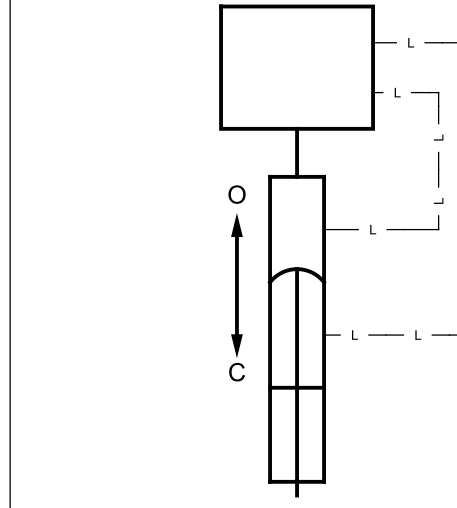
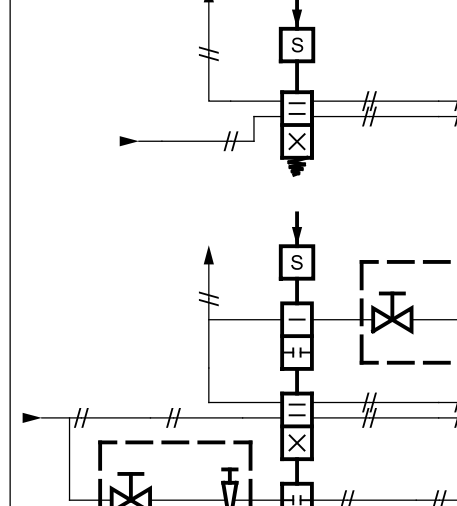
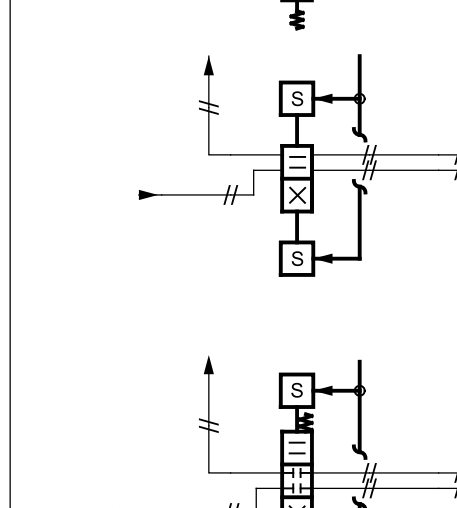
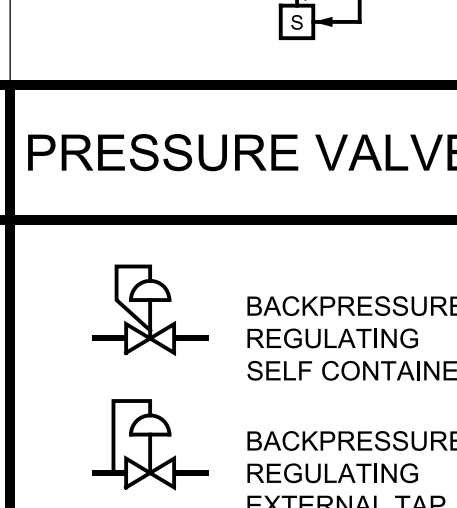
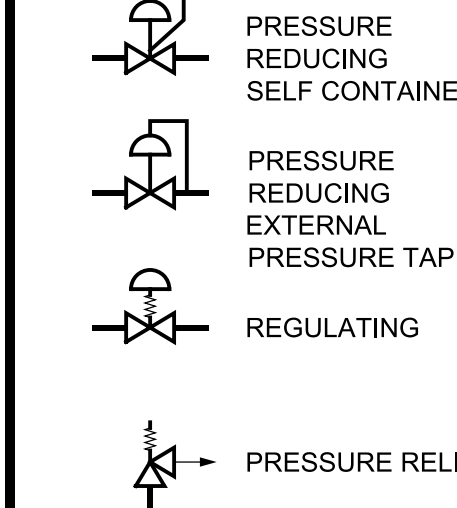
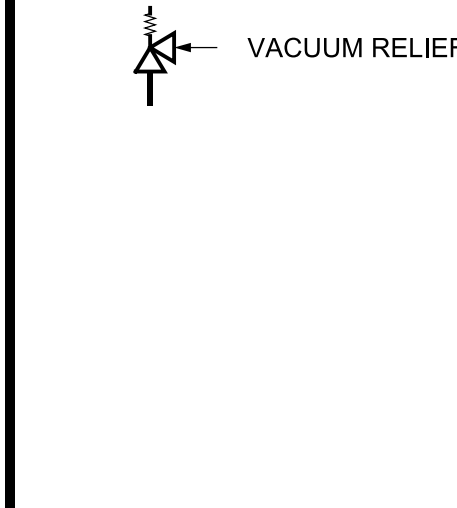
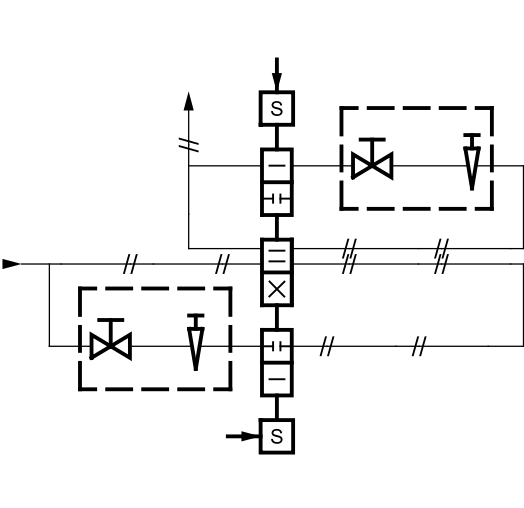
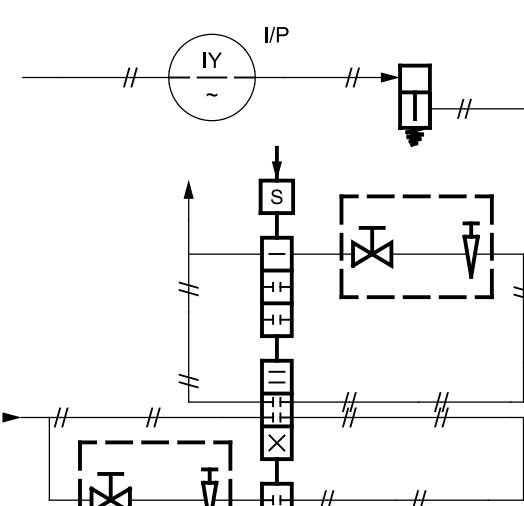
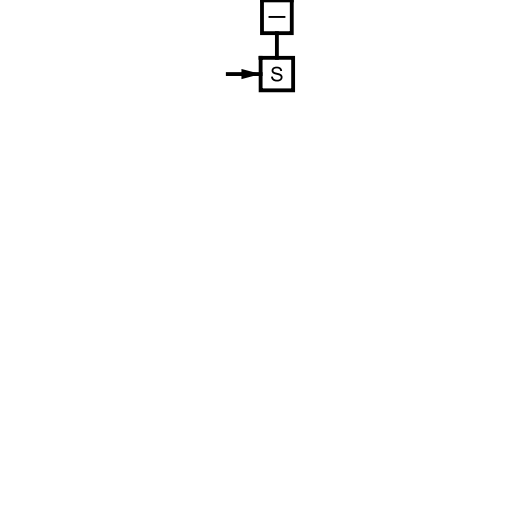
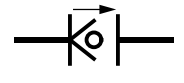
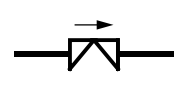
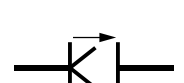
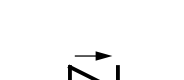
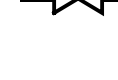
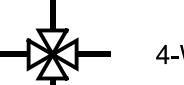
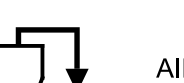
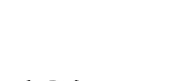
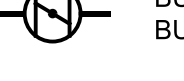
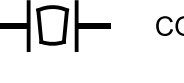
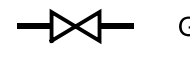
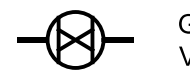
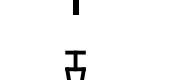
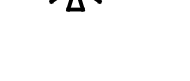
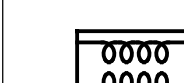
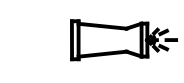
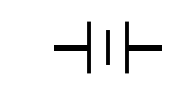
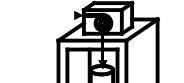
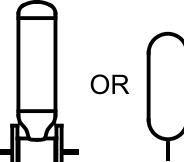
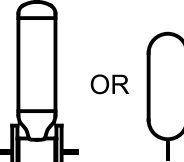
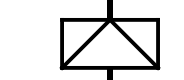
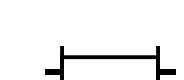
VERIFY SCALE
BAR IS ONE INCH ON
FULL SIZE DRAWING
0 1"

PROJECT 11700A.10

DATE JANUARY 2021

DRAWING NO. SHEET NO.

GN02

ACTUATORS										PIPING										PUMPS										BLOWERS/COMPRESSORS																																																	
 DIAPHRAGM  ELECTRIC DISCRETE  ELECTRIC MODULATING  ELECTRIC HYDRAULIC  HAND  HYDRAULIC  PNEUMATIC  SOLENOID  HYDRAULIC MODULATING  PNEUMATIC SINGLE SOLENOID OPEN/CLOSE  PNEUMATIC SINGLE SOLENOID w/ SPEED CONTROL  PNEUMATIC DUAL SOLENOID OPEN/CLOSE  PNEUMATIC DUAL SOLENOID OPEN/CLOSE  PNEUMATIC DUAL SOLENOID OPEN/CLOSE  PNEUMATIC DUAL SOLENOID OPEN/CLOSE w/ SPEED CONTROL  PNEUMATIC MODULATING  PNEUMATIC MODULATING OPEN/CLOSE w/ SPEED CONTROL										 AIR GAP  BLIND FLANGE  CAPPED OR PLUGGED  CONCENTRIC INCREASE  CONCENTRIC REDUCER  DRAIN  ECCENTRIC INCREASE  TEE  UNION  ECCENTRIC REDUCER  EXPANSION COUPLING  EXPANSION JOINT VIBRATION CENTER  FLEXIBLE CONNECTION  QUICK DISCONNECT										 AIR DRIVEN  CENTRIFUGAL  CHEMICAL FEED DIAPHRAGM  DIAPHRAGM  GEAR  PERISTALTIC OR HOSE  PISTON  PROGRESSIVE CAVITY  SUBMERSIBLE  VERTICAL TURBINE  VERTICAL CHOPPER  WATER CHAMP										 CENTRIFUGAL SINGLE STAGE BLOWER  CENTRIFUGAL MULTI STAGE BLOWER  RECIPROCATING COMPRESSOR  SCREW COMPRESSOR  FAN  LIQUID RING COMPRESSOR  ROTARY LOBE BLOWER																																																	
CHECK VALVES										PRESSURE VALVES										VALVES										MISC																																																	
 BACK FLOW PREVENTER  BALL  DIAPHRAGM CHECK  DOUBLE FLAP  FLAPPER  SPRING LOADED GENERAL  SPRING LOADED SWING  SWING										 BACKPRESSURE REGULATING SELF CONTAINED  BACKPRESSURE REGULATING EXTERNAL TAP  PRESSURE REDUCING SELF CONTAINED  PRESSURE REDUCING EXTERNAL PRESSURE TAP  REGULATING  PRESSURE RELIEF  VACUUM RELIEF										 3-WAY  3-WAY PLUG  4-WAY  AIR-RELIEF  ANGLE  BALL  BALL V-NOTCH  BUTTERFLY  BUTTERFLY-BURIED VALVE BOX  CONE  DIAPHRAGM										 GATE  GATE-BURIED VALVE BOX  GLOBE  HOSE  MUD  NEEDLE  PINCH  PLUG ECCENTRIC  PLUG ECCENTRIC w-VALVE BOX  PLUG ECCENTRIC LUBRICATED  PLUG ECCENTRIC LUBRICATED BURIED VALVE BOX										 PLUG CONCENTRIC  PLUG CONCENTRIC -BURIED VALVE BOX  PLUG CONCENTRIC LUBRICATED  PLUG CONCENTRIC LUBRICATED BURIED VALVE BOX  PUMP DISCHARGE  TELESCOPING VALVE DESIGNATIONS NO NORMALLY OPEN NC NORMALLY CLOSED FO FAIL OPEN FC FAIL CLOSE FLP FAIL LAST POSITION										 AIR DAMPER  AIR / CHEMICAL DIFFUSER  BASKET STRAINER  BLOW-OFF SILENCER  CALIBRATION COLUMN  COALESCKER  DESICCANT DRYER  EDUCTOR/EJECTOR  EQUIPMENT/INSTRUMENT LOCATOR  EXHAUST FAN  EYEWASH  FILTER  FILTER SEPARATOR  FINE FILTER  FIRE ALARM/SENSOR  FLAME ARRESTER  FLAME ARRESTER w/THERMALLY OPERATED VALVE										 FLOW CONDITIONER  GAS CANNON  GRINDER  HEAT EXCHANGER  HOIST  HORIZONTAL MIXER  HOSE CONNECTION  INLET STRAINER  INLINE STATIC MIXER  MATERIAL CHANGE  MIXER  MOTOR  NOZZLE  ORIFICE RESTRICTION  PERISTALTIC COMPOSITE SAMPLER  PULSATION DAMPENOR OR  PULSATION DAMPENOR  REFRIGERATED DRYER  RUPTURE DISK  SAMPLE PORT  SIGHT TUBE										 SMOKE DETECTOR  STRAINER - MECHANICALLY CLEANED  STRAINER WITH BLOW OFF  STRAINER WYE TYPE  VAPOR HEATER  VAPORIZER  VENT  VENT TO ATMOSPHERE									
NO.	REVISION				BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL																				MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION SYMBOLS AND ABBREVIATIONS - III										VERIFY SCALE BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"		PROJECT 11700A.10		DATE JANUARY 2021		DRAWING NO.		SHEET NO.		GN03																												
							DRAWN KMM																																																																								
							CHECKED																																																																								
							APPROVED																																																																								

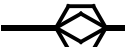
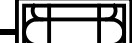
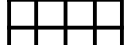
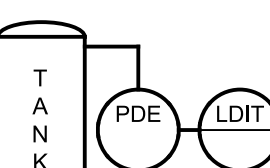
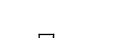
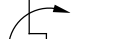
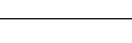
 TEE UNION ECCENTRIC REDUCER EXPANSION COUPLING EXPANSION JOINT VIBRATION CENTER FLEXIBLE CONNECTION QUICK DISCONNECT

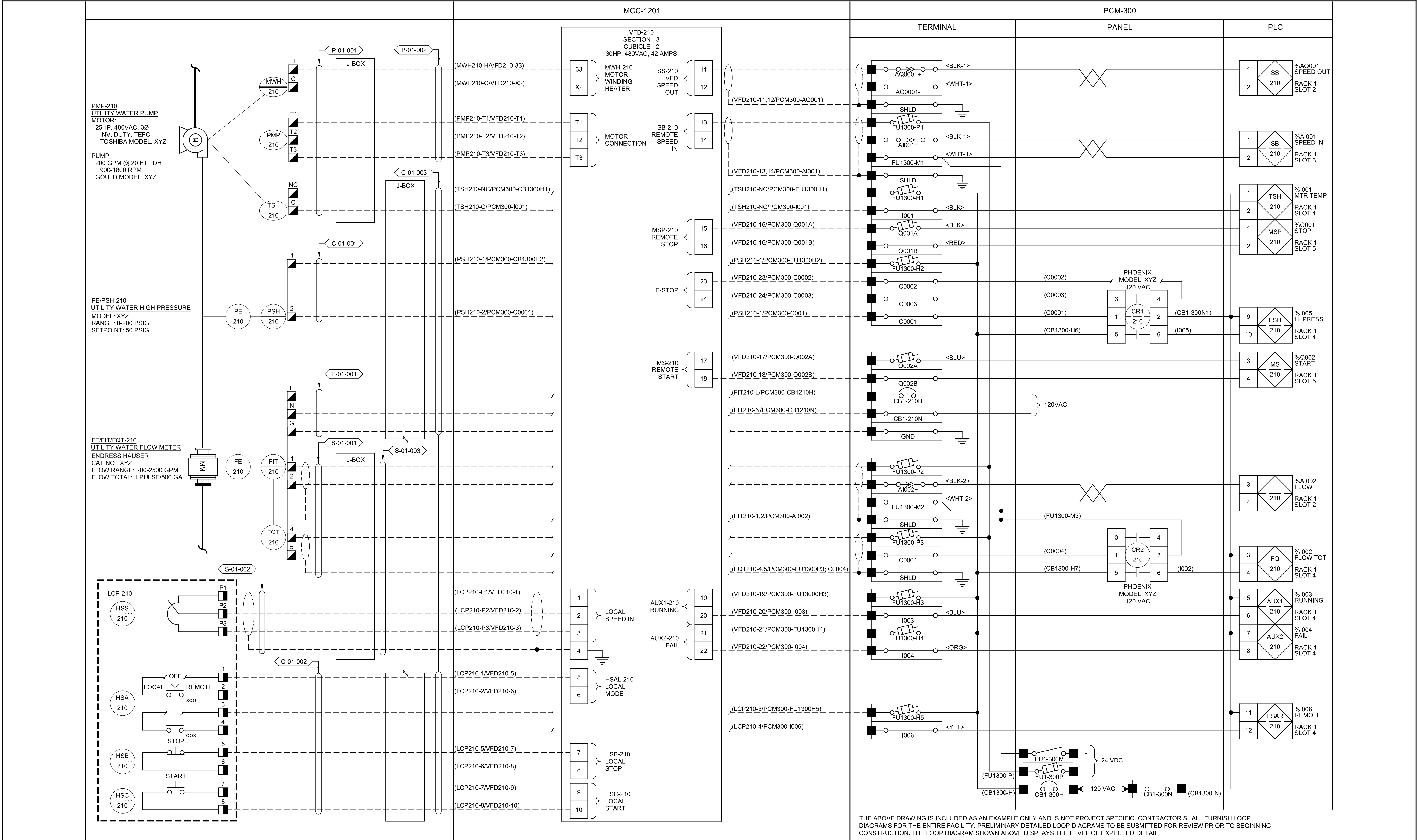
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User: svcPW

Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1

LAST SAVED BY: kmiller

FLOW				FLUMES		GATES		LEVEL										
 BATCH	 V-CONE	 LEOPOLD-LAGCO	 SLIDE	 FLAP	 BUBBLER	 SUSPENDED/ SUBMERSIBLE												
 CORIOLIS	 VENTURI TUBE OR FLOW NOZZLE	 PALMER-BOWLUS	 SLUICE	 KNIFE	 CAPACITANCE	 TUNING FORK												
 MAGNETIC	 VORTEX	 PARSHALL	 STOP	 SLIDE	 DIFFERENTIAL PRESSURE	 ULTRASONIC												
 ORIFICE		 REGULAR CUTTHROAT		 SLUICE														
 PADDLE WHEEL		 TRAPEZOIDAL		 STOP	 ELECTRODE													
 PISTON				 WEIR	 FLOAT													
 ANNUBAR				 BUTTERFLY	 INVERTED COLUMN													
 PITOT TUBE					 PROBE													
 POSITIVE- DISPLACEMENT					 RADAR PTOF													
 PROPELLER- TURBINE					 RADAR (FREQUENCY MODULATED CONTINUOUS WAVE)													
 ROTAMETER					 RADAR TDR													
 THERMAL																		
 ULTRASONIC																		
 ULTRASONIC BIOGAS																		
PRESSURE/VACUUM				TEMPERATURE		WEIRS												
PRESSURE		DIFFERENTIAL PRESSURE		PRESSURE SEALS		SIDE VIEW		PLAN VIEW										
 GAUGE	 GAUGE DIFFERENTIAL INDICATOR	 SEAL ANNULAR	 TEMPERATURE w/THERMOWELL	 RECTANGULAR w/o END CONTRACTIONS	 RECTANGULAR w/o END CONTRACTIONS													
 MANOMETER	 DIFFERENTIAL PRESSURE SWITCH	 SEAL DIAPHRAGM	 TEMPERATURE GAUGE	 RECTANGULAR w/ END CONTRACTIONS	 RECTANGULAR w/ END CONTRACTIONS													
 PRESSURE SWITCH	 DIFFERENTIAL PRESSURE TRANSMITTER	 SEAL SANITARY	 THERMOMETER	 V-NOTCH (TRIANGULAR)	 V-NOTCH (TRIANGULAR)													
 PRESSURE TRANSMITTER	 DIFFERENTIAL PRESSURE TRANSMITTER	 PRESSURE SWITCH	 HYDRAULIC	 TRAPEZOIDAL (CIPOLLETTI)	 TRAPEZOIDAL (CIPOLLETTI)													
			 STRAIN GAUGE															
NO.		REVISION		BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION		 		ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL				MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION SYMBOLS AND ABBREVIATIONS - IV		VERIFY SCALE	
				BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"														
				PROJECT 11700A.10														
				DATE JANUARY 2021														
				DRAWING NO. SHEET NO.														
																GN04		



NO.	REVISION	BY	DATE	DESIGN GEB	DRAWN KMM	CHECKED	APPROVED	VERIFY SCALE
								BAR IS ONE INCH ON FULL SIZE DRAWING 1"
								PROJECT 11700A.10
								DATE JANUARY 2021
								DRAWING NO. SHEET NO.
								GN05

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User: svcPW

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LAST SAVED BY: kmiller

EQUIPMENT TAGGING SYSTEM

EQUIPMENT

EXAMPLE: SSPR1FIT0010 REPRESENTS MAJOR PIECE OF EQUIPMENT

EQUIPMENT TAGGING:

AAAAxBBBYYYY

FOUR DIGIT NUMERIC LOOP
NUMBER
ASSET TYPE FROM TABLE
FACILITY INDENTIFICATION FROM
TABLE

FACILITY IDENTIFICATION	
FACILITY CODE	DESCRIPTION
SDGC5	DIGESTER 4/5 CONTROL BUILDING
SDGC4	DIGESTER 4/5 ANNEX BUILDING
SDIGF	DIGESTER GAS FLARE
SDIGF2	DIGESTER GAS FLARE 2
SDIG6	DIGESTER 6
SDGC6	DIGESTER 6/7 ANNEX BUILDING
SSPR1	SIDESTREAM BUILDING

ASSET TYPE			
Equipment Type	Description	Equipment Type	Description
ACN	Air Condenser	LCP	Local Control Panel
ACT	Actuator, Valve	LIT	Level Indicator
ADL	Auto Dialer	LPR	Life Preserver Ring
AED	Automated External Defibrillator	LVC	Level Controller
AHU	Air Handler Unit	LVR	Louver
AIT	Analyzer IndicatorTransmitter	MCC	Motor Control Center
ALC	Active Line Conditioner	MDM	Modem, SCADA
ARC	Air Conditioner	MDP	Main Distribution Panel
ARU	Air Unit	MEC	Mechanism
AUX	Auxiliary Supporting Equip	MIX	Mixer
BFL	Biofilter	MKU	Make-Up Unit
BKP	Breaker Panel	MPC	Mini Power Center
BLW	Blower	MPS	Module Power Supply (UV)
BOL	Boiler	MTR	Motor
CDT	Condensate Trap	PDC	Power Distribution Center (UV)
CFD	Chemical Feeder	PHC	Phase Converter
CMP	Compressor	PIT	Pressure Indicator
CRN	Crane	PLC	Programming Logic Controller
CTF	Centrifuge	PMP	Pump
DMP	Dampener, Ventilation	RCK	Rack, SCADA
DTC	Detector	RDC	Reducer
ELE	Elevator	RTU	Roof Top Return Unit
EWS	Eye Wash Station	SCB	Scrubber
EXH	Exhaust	SCD	SCADA System
FAK	First Aid Kit	SCG	Security Gate
FAP	Fire Alarm Panel	SCN	Screen
FAR	Flame Arrestor	SCV	Screw Conveyor
FCV	Flow Control Valve	SDS	Service Disconnect
FIT	Flow Indicator	SGT	Slide Gate
FLT	Filter	SMP	Sampler (Composite)
GBX	Gearbox	SRV	Server, SCADA
GDT	Gas Detector	STN	Strainer
GEN	Generator	SWC	Screen Washer Compactor
GRD	Grinder	SWH	Switch
GTC	Grit Classifier	SYS	System
GTD	Grit Dewaterer/Snail	TDR	Transducer
GTS	Grit Settler	TIT	Temperature Indicator
GTW	Grit Washer/Slurry	TNK	Tank
HEX	Heat Exchanger	TRS	Transformer
HFI	Harmonic Filter	UPS	Uninterruptible Power Supply
HMI	Human-Machine Interface	UVM	UV Module
HSC	Hydraulic Systems Center	UVW	UV System Bulb Washer
HST	Hoist	VAL	Valve
HTR	Heater	VFD	Variable Frequency Drive
HUM	Humidifier	VNT	Ventilator
HVC	HVAC	WHT	Water Heater
IOJ	I/O Junction Box	WRT	Wireless Router
ITC	Intermediate/Timing Chamber	WRW	Weir Washer
LBC	Load Bank Controller	WST	Work Station
LBK	Load Bank	YLT	Yard Lighting

NO.	REVISION	BY	DATE	DESIGN GEB
				DRAWN KMM
				CHECKED
				APPROVED

PRELIMINARY
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CONSTRUCTION



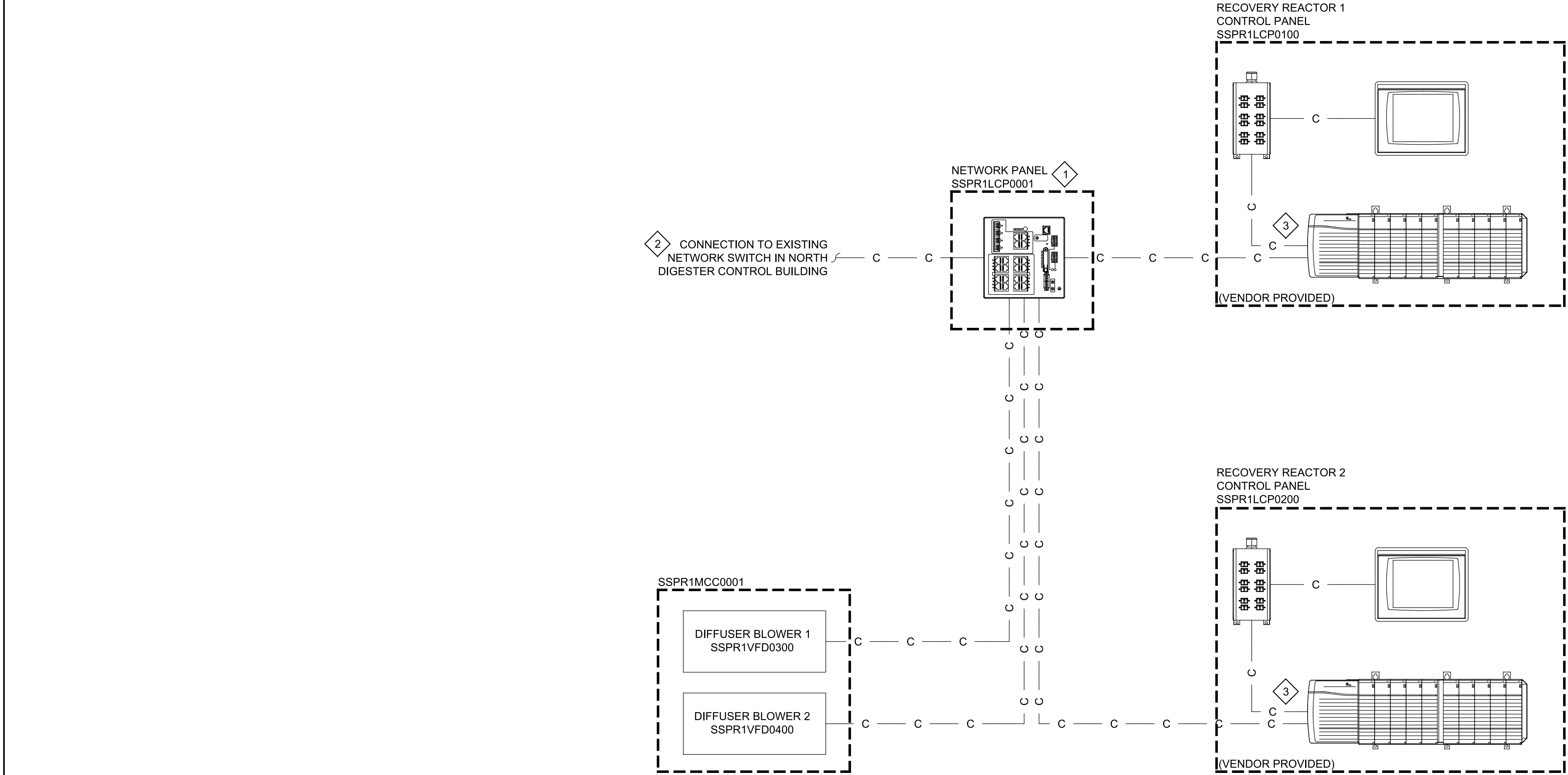
ENGINEERING AND ENVIRONMENTAL SOLUTIONS
1161 W. RIVER ST. SUITE 130
BOISE, IDAHO 83702
208.780.3990

IDAHO OFFICES
BOISE · LEWISTON · MCCALL



MERIDIAN WASTEWATER FACILITY
MERIDIAN, IDAHO
INSTRUMENTATION
EQUIPMENT TAGGING SYSTEM

VERIFY SCALE	
BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
PROJECT	11700A.10
DATE	JANUARY 2021
DRAWING NO.	SHEET NO.
GN07	



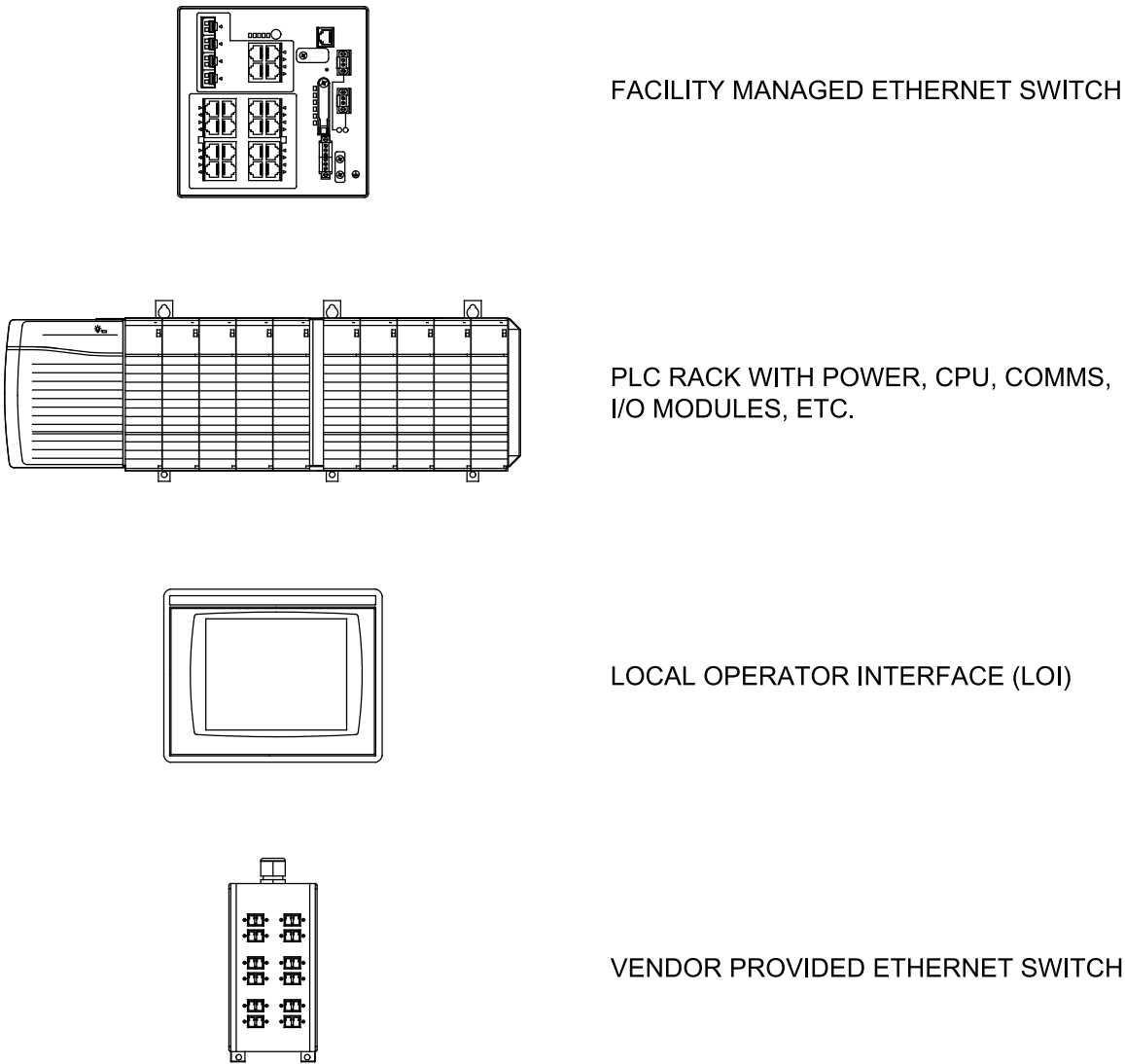
GENERAL NOTES:

1. ALL ETHERNET CABLE TO BE CAT-6.

KEY NOTES:

1. PROVIDE NETWORK PANEL INCLUDING NEMA 12 WALL MOUNT ENCLOSURE, BACK PANEL, REDUNDANT 5-AMP 24 VDC POWER SUPPLIES, 8-PORT MANAGED 10/100/1000 Mbps ETHERNET SWITCH, AND ALL ANCILLIARY COMPONENTS NECESSARY FOR A FUNCTIONING NETWORK PANEL AS REQUIRED BY SPECIFICATION SECTION 40_67_01.
2. COORDINATE NETWORK TERMINATION PORT WITH OWNER.
3. VENDOR TO PROVIDE SEPARATE NETWORK CONNECTIONS FOR FACILITY SCADA AND INTERNAL VENDOR SYSTEMS.

LEGEND:



NO.	REVISION	BY	DATE	DESIGN GEB
				DRAWN KMM
				CHECKED
				APPROVED

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CONSTRUCTION



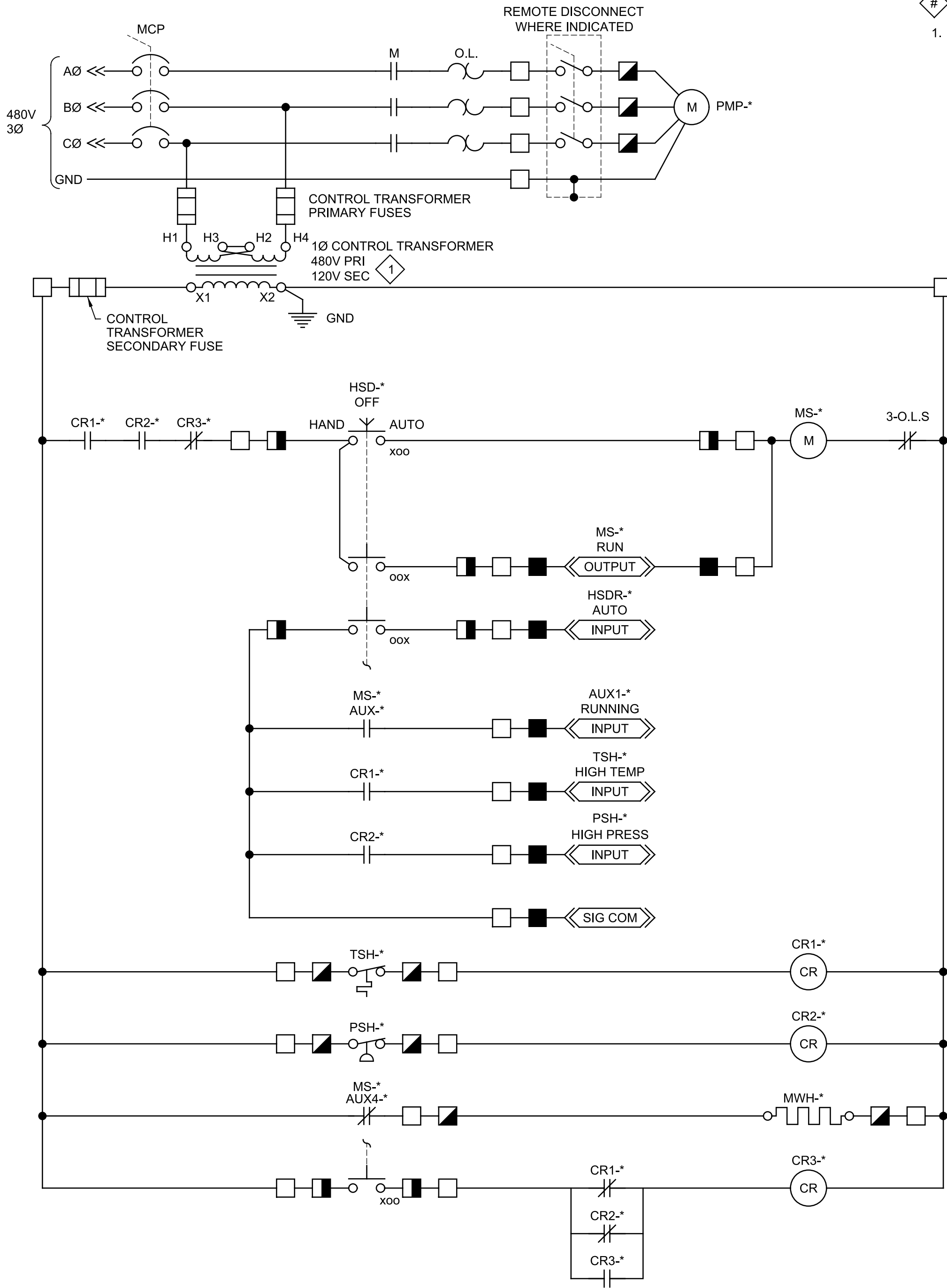
ENGINEERING AND ENVIRONMENTAL SOLUTIONS
1161 W. RIVER ST. SUITE 130
BOISE, IDAHO 83702
208.780.3990

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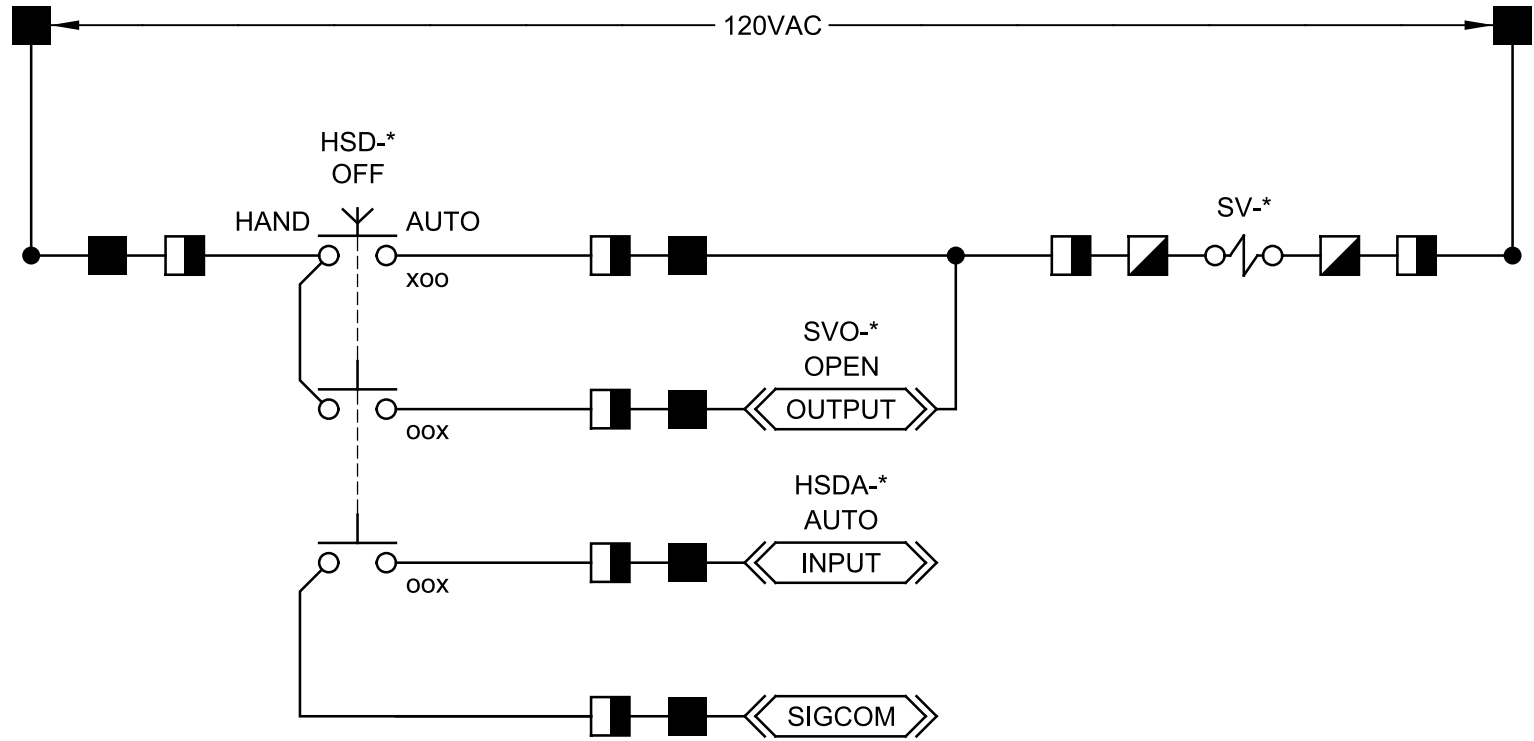


MERIDIAN WASTEWATER FACILITY
MERIDIAN, IDAHO
INSTRUMENTATION
NETWORK BLOCK DIAGRAM

VERIFY SCALE	
BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
PROJECT	11700A.10
DATE	JANUARY 2021
DRAWING NO.	SHEET NO.
N01	



- # KEY NOTES:
1. SIZE CONTROL POWER TRANSFORMER IN ACCORDANCE WITH ALL INDICATED LOADS.



1 STRUVITE PUMP

N07, N08

* = 0120 → SSPR1PMP0120
* = 0220 → SSPR1PMP0220

2 SOLENOID VALVE

N14

* = 0601 → SSPR1VAL0601
* = 0602 → SSPR1VAL0602

NO.	REVISION	BY	DATE	DESIGN GEB
				DRAWN KMM
				CHECKED
				APPROVED

PRELIMINARY
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CONSTRUCTION

carollo



ENGINEERING AND ENVIRONMENTAL SOLUTIONS
1161 W. RIVER ST. SUITE 130
BOISE, IDAHO 83702
208.780.3990
IDAHO OFFICES
BOISE · LEWISTON · MCCALL



MERIDIAN WASTEWATER FACILITY
MERIDIAN, IDAHO
INSTRUMENTATION
CONTROL SCHEMATICS - I

VERIFY SCALE	
BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
PROJECT	11700A.10
DATE	JANUARY 2021
DRAWING NO.	SHEET NO.
N02	



* = 0300 $\longleftrightarrow$ SSPR1BLR0300
* = 0400 $\longleftrightarrow$ SSPR1BLR0400

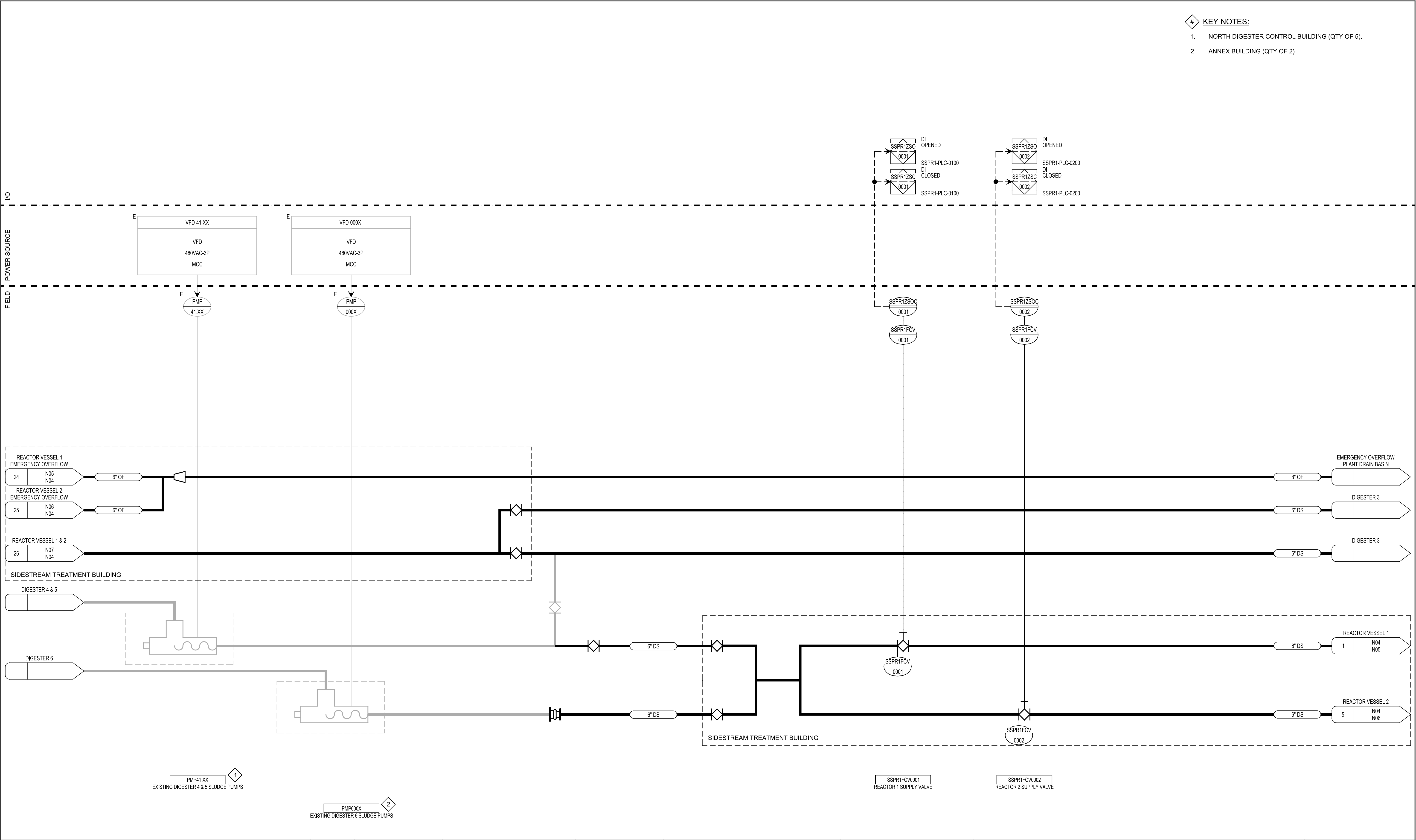
NO.	REVISION	BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL		MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION CONTROL SCHEMATICS - II	VERIFY SCALE	
			DRAWN KMM	BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"								
			CHECKED	PROJECT							11700A.10	
			APPROVED	DATE							JANUARY 2021	
				DRAWING NO.							SHEET NO.	
					N03							

1. SCHEMATIC WIRING IS BASED ON ONE OF THE NAMED MANUFACTURERS. REVISE SCHEMATIC AS REQUIRED TO PERFORM THE OPERATION SHOWN HERE AND DESCRIBED IN 17100 AND 17101 BASED ON THE SELECTED MANUFACTURER.
2. SIZE CONTROL POWER TRANSFORMER IN ACCORDANCE WITH ALL INDICATED LOADS.
3. REFER TO SPECIFICATION 17101 FOR CONTROL DESCRIPTIONS.

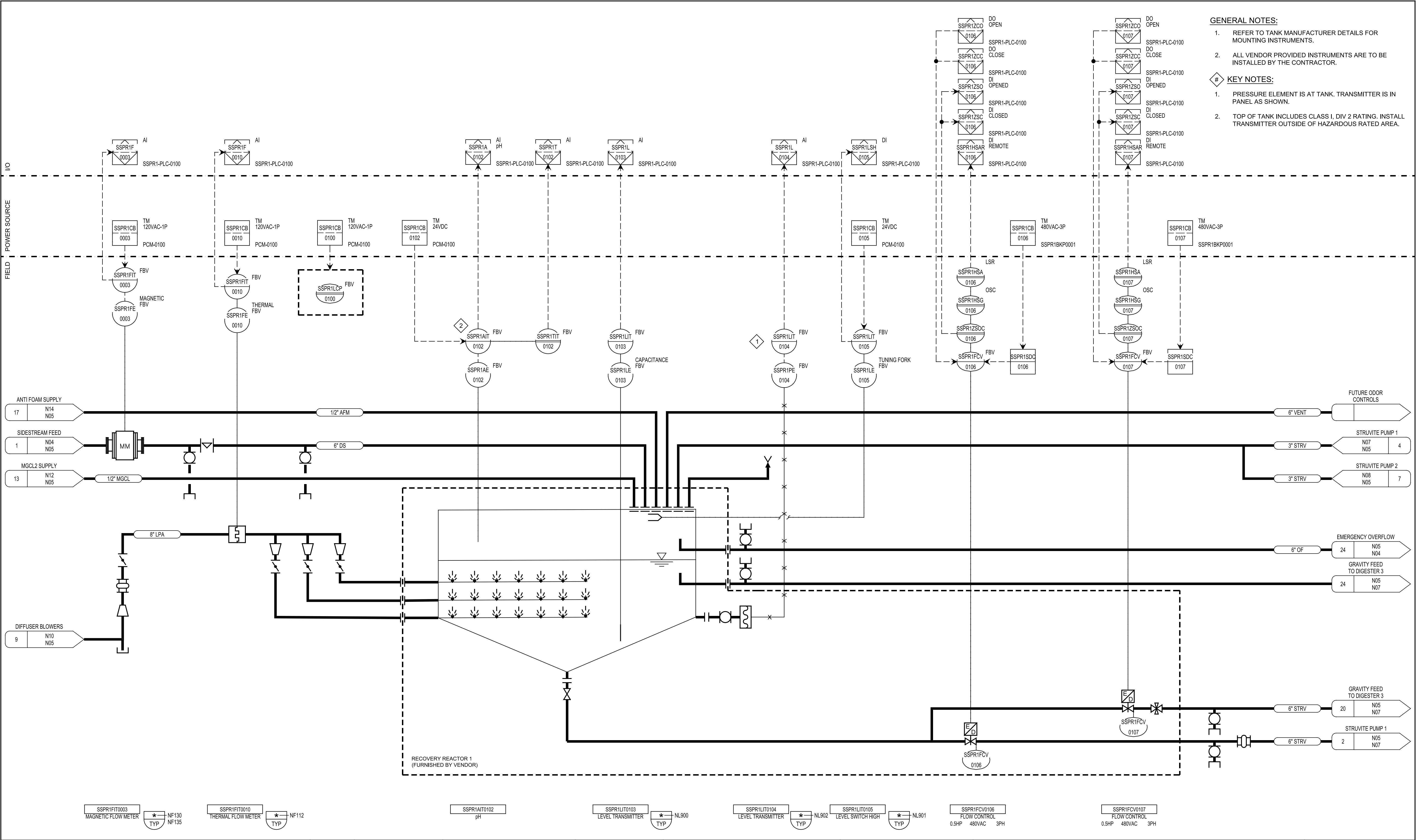
1. INCLUDE THE FOLLOWING MONITORING AND CONTROL SIGNALS THROUGH THE ETHERNET CONNECTION.

- RUN
- FAIL
- LOCAL CONTROL
- REMOTE CONTROL
- SPEED
- HIGH TEMPERATURE ALARM
- HIGH DISCHARGE TEMPERATURE ALARM

- RUN
- FAIL RESET
- SPEED REFERENCE



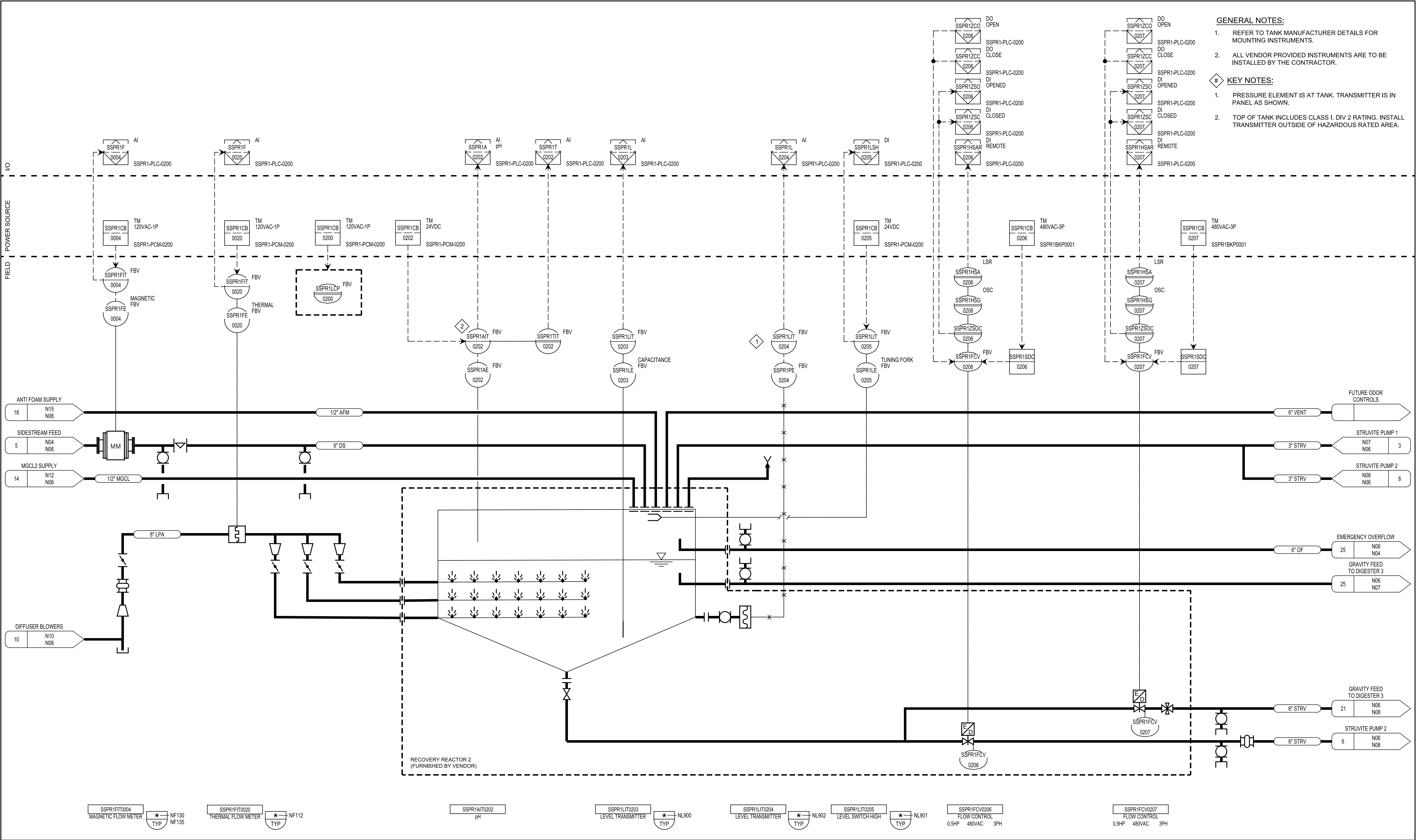
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				DRAWN KMM							PROJECT	11700A.10
				CHECKED							DATE	JANUARY 2021
				APPROVED							DRAWING NO.	SHEET NO.
											N04	107



- GENERAL NOTES:**
- REFER TO TANK MANUFACTURER DETAILS FOR MOUNTING INSTRUMENTS.
 - ALL VENDOR PROVIDED INSTRUMENTS ARE TO BE INSTALLED BY THE CONTRACTOR.
- # KEY NOTES:**
- PRESSURE ELEMENT IS AT TANK. TRANSMITTER IS IN PANEL AS SHOWN.
 - TOP OF TANK INCLUDES CLASS I, DIV 2 RATING. INSTALL TRANSMITTER OUTSIDE OF HAZARDOUS RATED AREA.

NO.	REVISION	BY	DATE	DESIGN GEB	DRAWN KMM	CHECKED	APPROVED	VERIFY SCALE
								BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"
								PROJECT 11700A.10
								DATE JANUARY 2021
								DRAWING NO. SHEET NO.
								N05 107

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PlotScale: 1:1
LAST SAVED BY: kmiller



NO.	REVISION	BY	DATE	DESIGN GEB	DRAWN KMM	CHECKED	APPROVED

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CONSTRUCTION

ENGINEERING AND ENVIRONMENTAL SOLUTIONS
1161 W. RIVER ST. SUITE 130
BOISE, IDAHO 83702
208.780.3990

IDAHO OFFICES
BOISE · LEWISTON · MCCALL

MERIDIAN WASTEWATER FACILITY
MERIDIAN, IDAHO
INSTRUMENTATION
RECOVERY REACTOR 2
P&ID

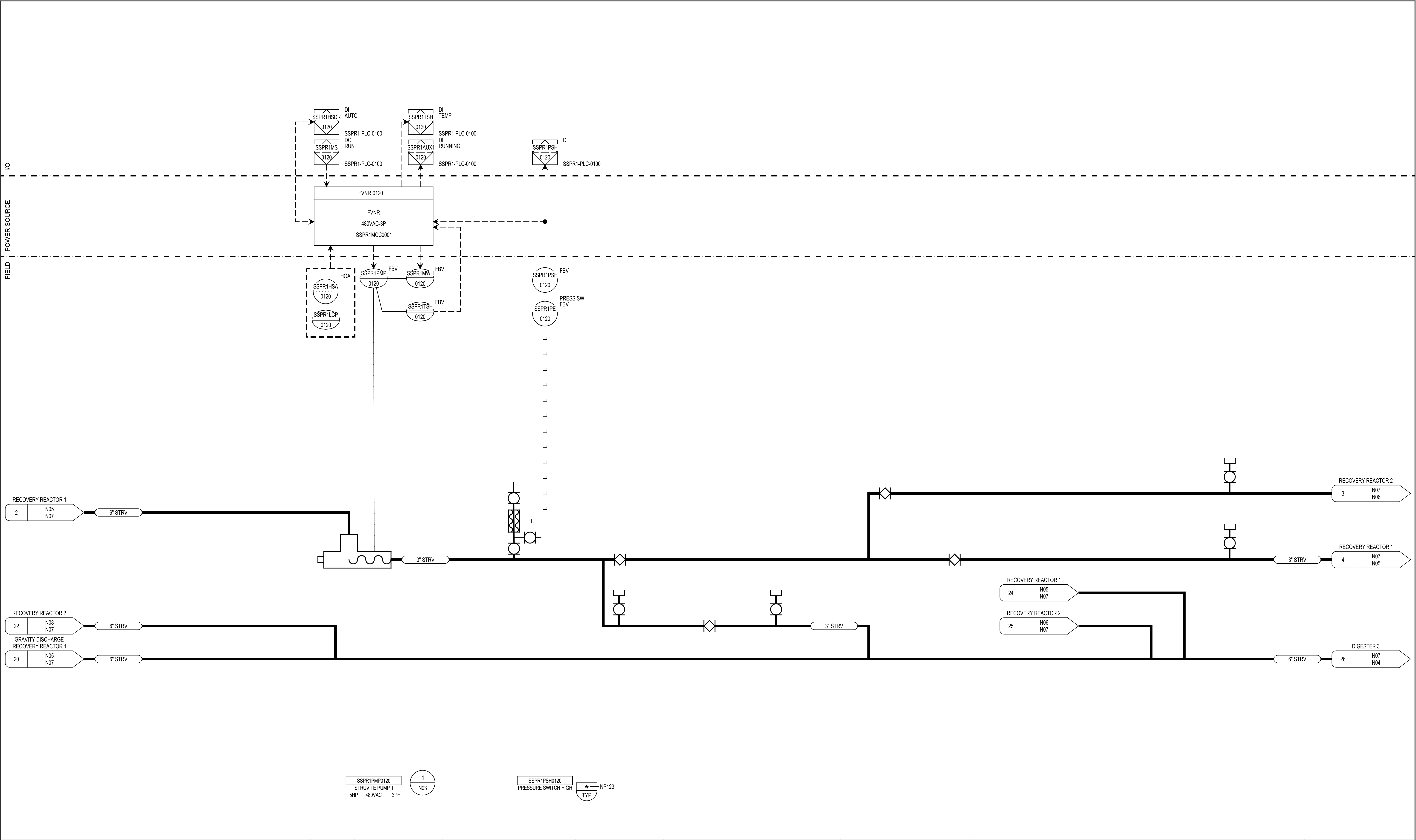
VERIFY SCALE
BAR IS ONE INCH ON
FULL SIZE DRAWING
0 1"

PROJECT 11700A.10

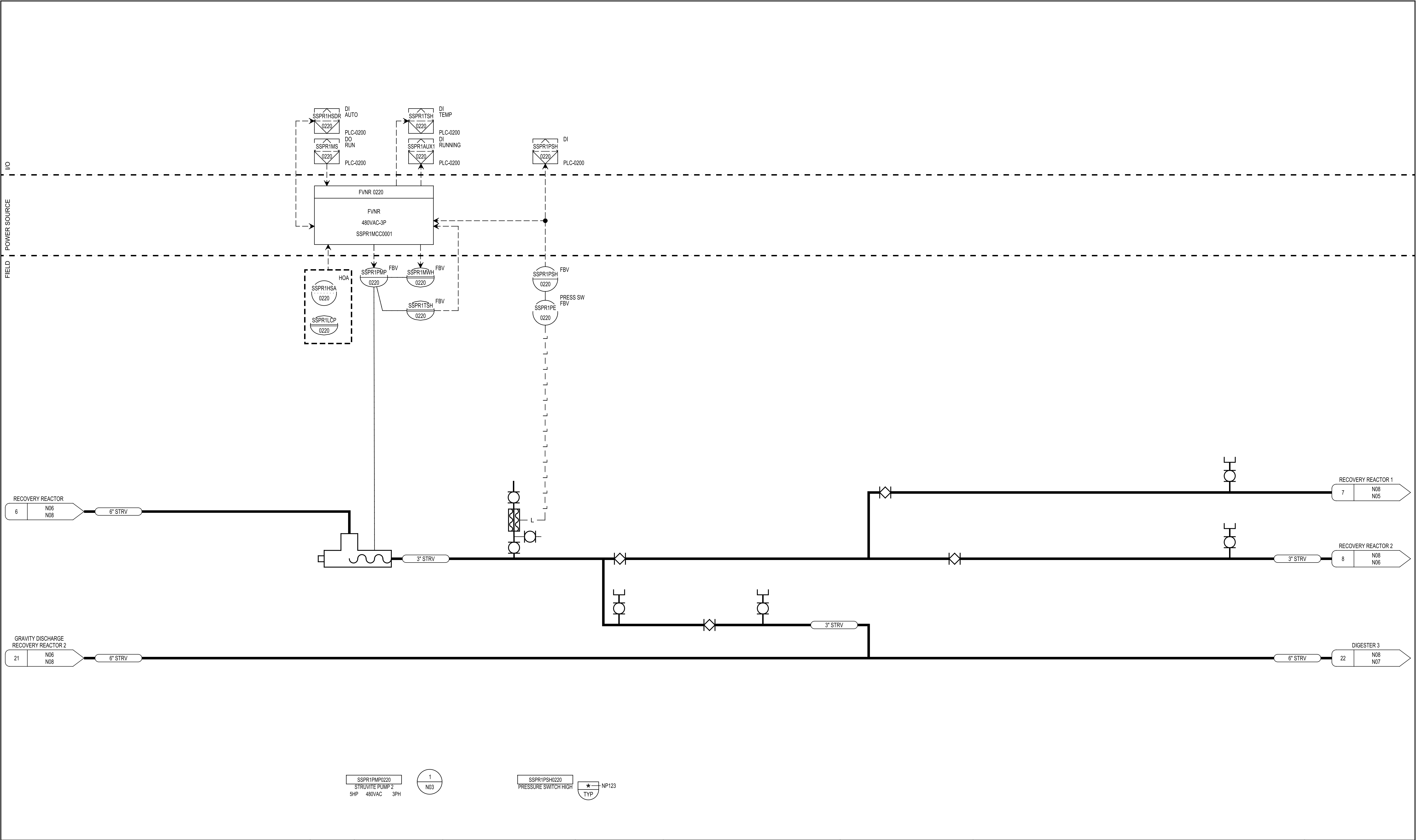
DATE JANUARY 2021

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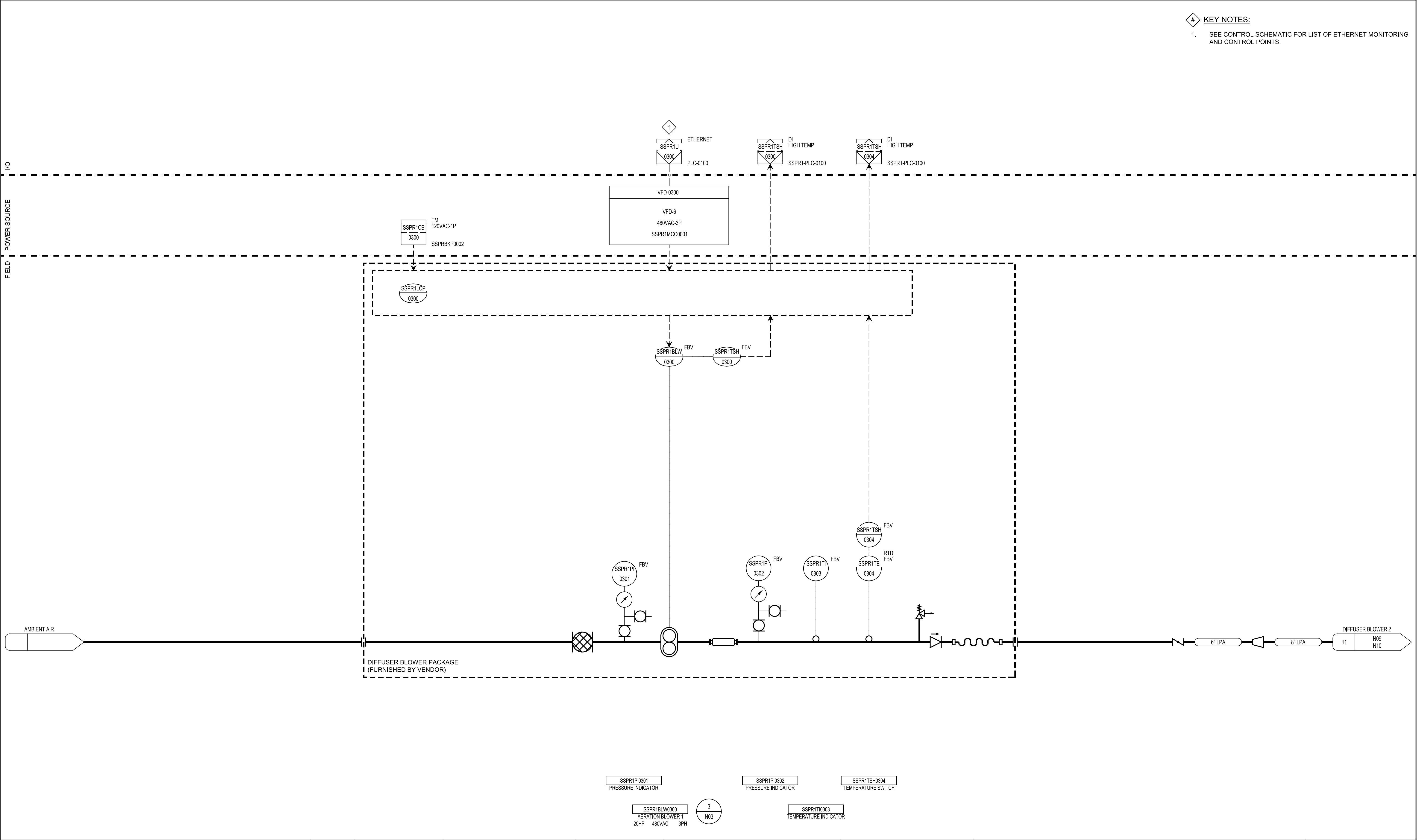
SHEET NO. 107



NO.	REVISION	BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL		MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION RECOVERY REACTOR 1 STRUVITE PUMP P&ID	VERIFY SCALE BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"
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				CHECKED							DATE JANUARY 2021
				APPROVED							DRAWING NO. SHEET NO.
											N07 107

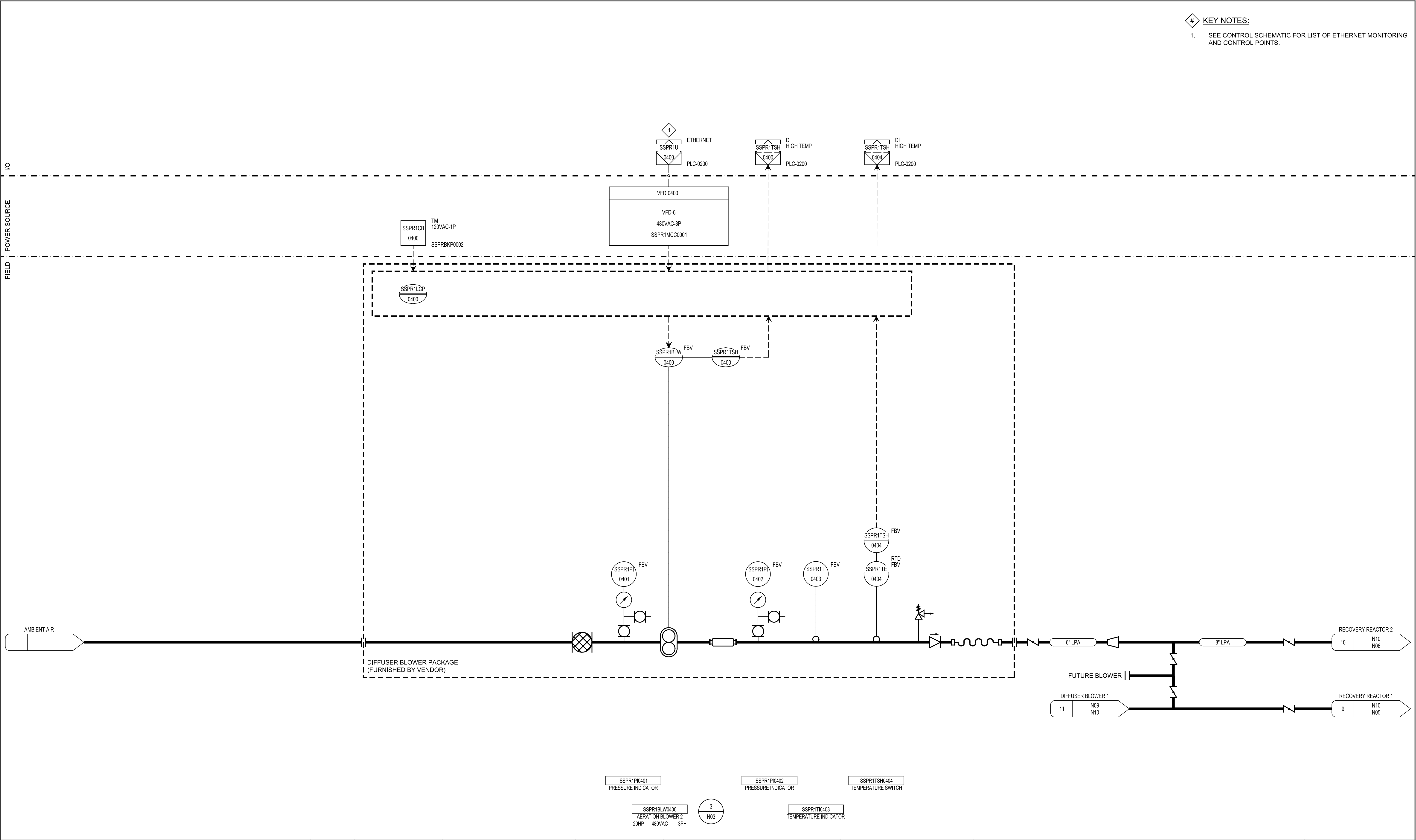


NO.	REVISION	BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL		MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION RECOVERY REACTOR 2 STRUVITE PUMP P&ID	VERIFY SCALE	
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				APPROVED							DATE	JANUARY 2021
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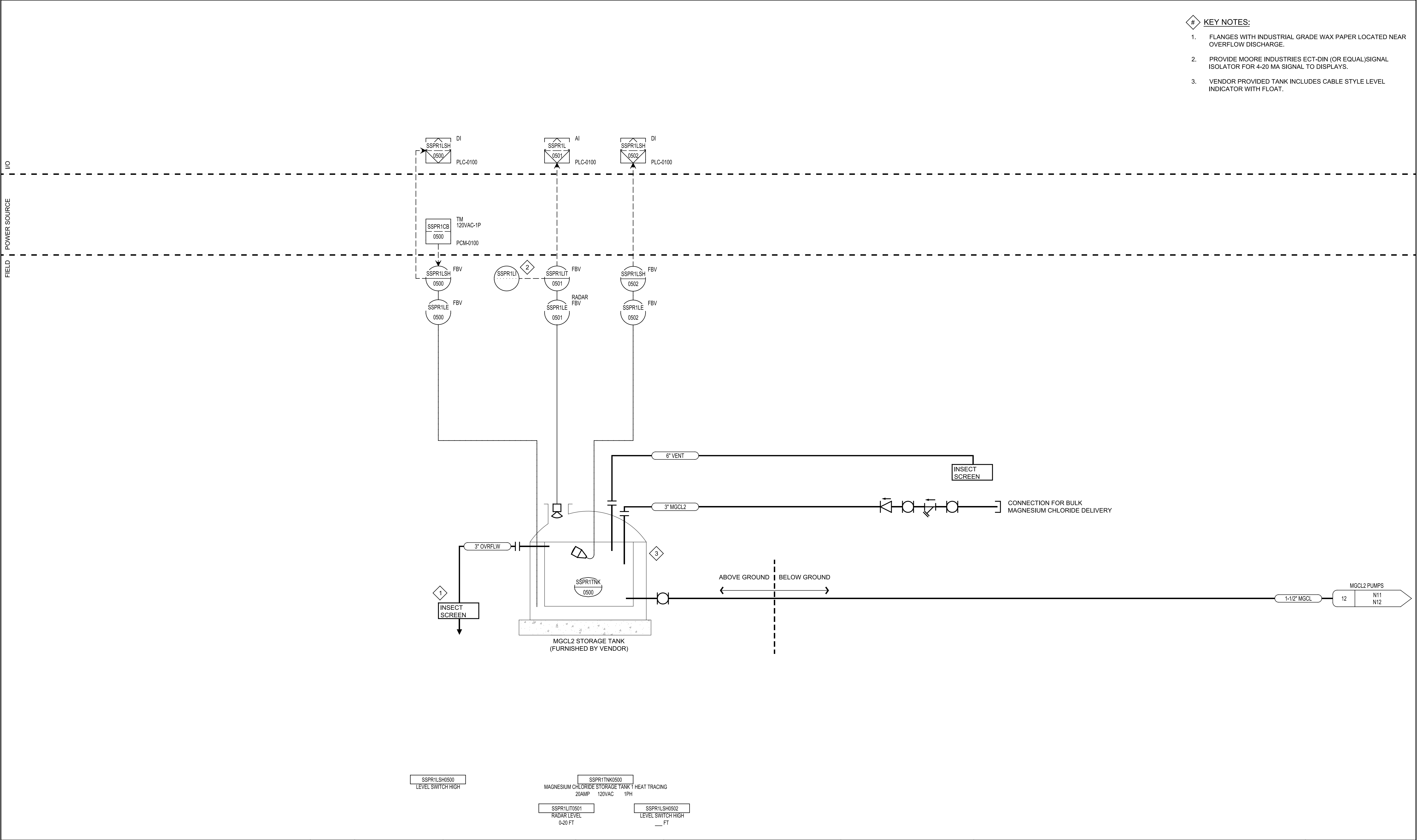
- #
- KEY NOTES:
1. SEE CONTROL SCHEMATIC FOR LIST OF ETHERNET MONITORING AND CONTROL POINTS.

NO.	REVISION	BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL		MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION DIFFUSER BLOWER 1 P&ID	VERIFY SCALE BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
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				CHECKED							DATE	JANUARY 2021
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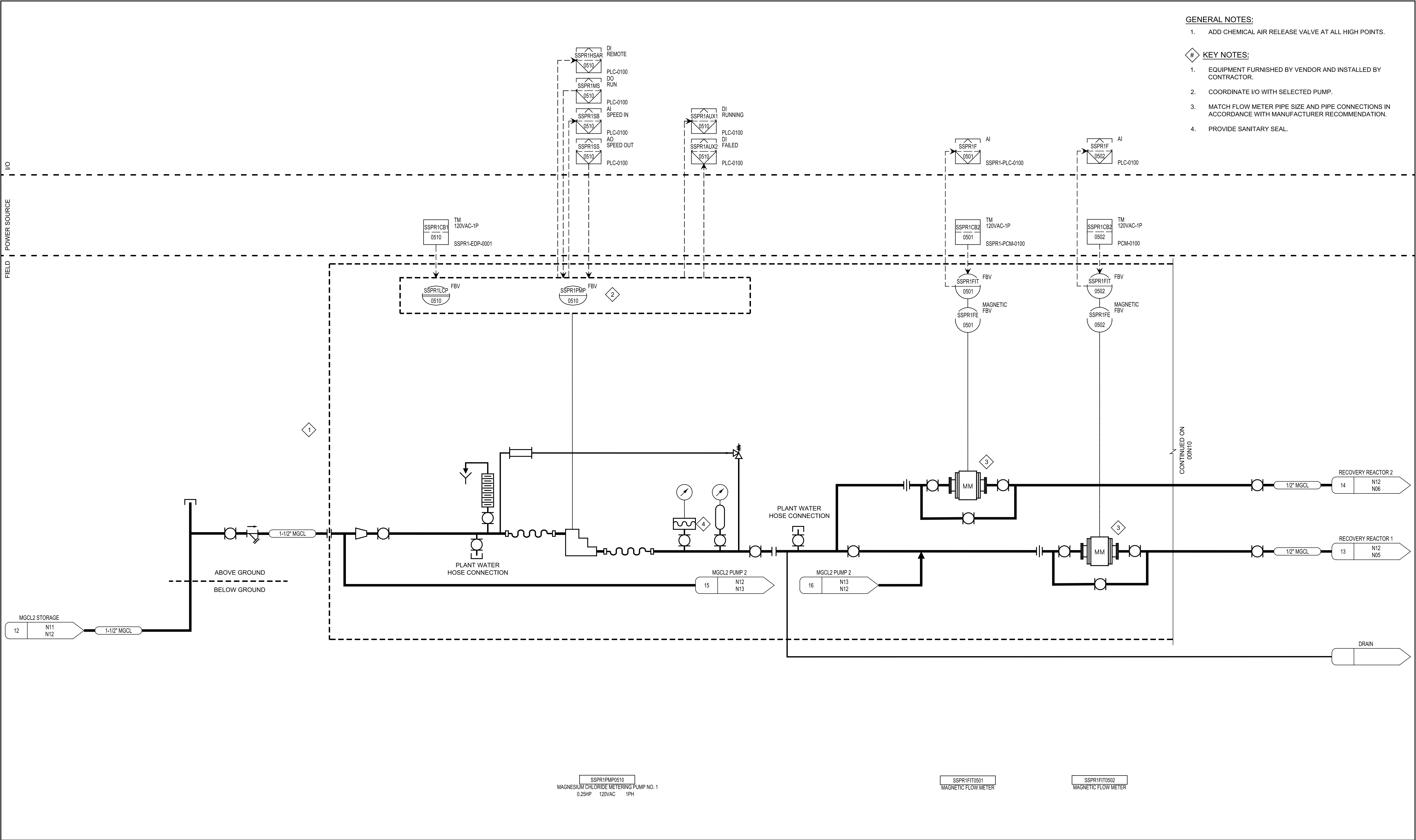


- # KEY NOTES:
- SEE CONTROL SCHEMATIC FOR LIST OF ETHERNET MONITORING AND CONTROL POINTS.

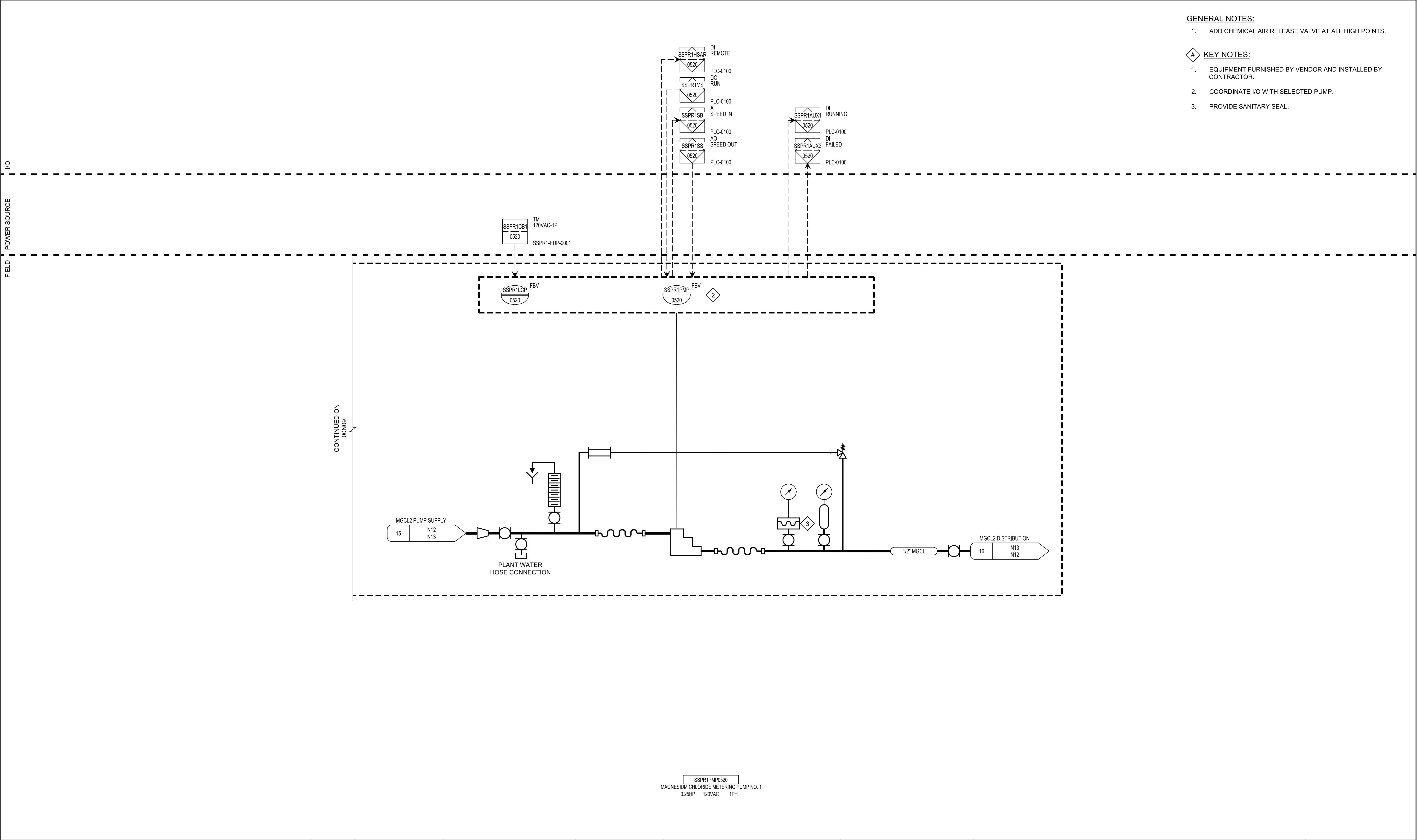
NO.	REVISION	BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL		MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION DIFFUSER BLOWER 2 P&ID	VERIFY SCALE BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
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				CHECKED							DATE	JANUARY 2021
				APPROVED							DRAWING NO.	SHEET NO.
											N10	107



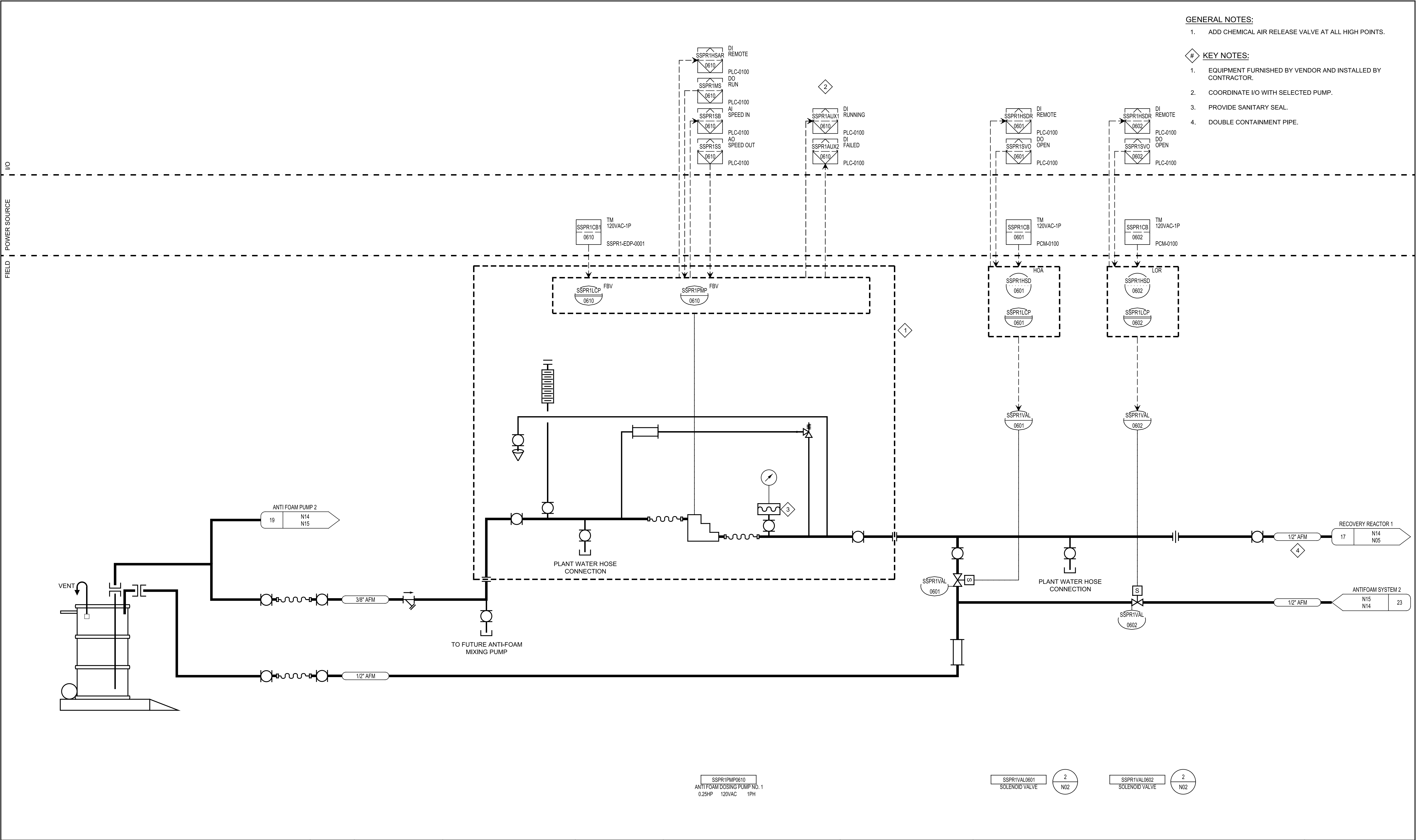
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				DRAWN KMM							PROJECT	11700A.10
				CHECKED							DATE	JANUARY 2021
				APPROVED							DRAWING NO.	SHEET NO.
											N11	107



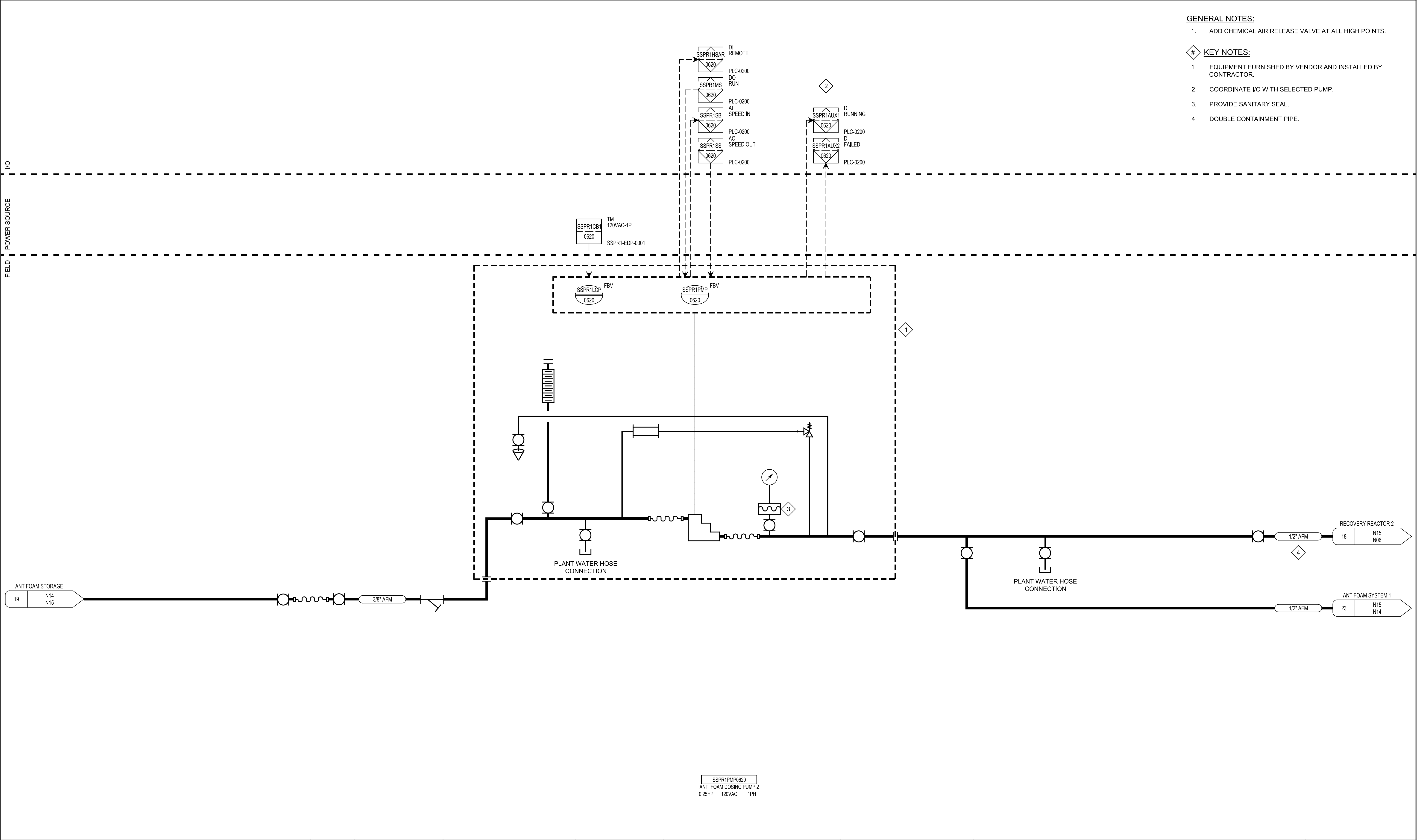
NO.	REVISION	BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL		MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION MAGNESIUM CHLORIDE SYSTEM 1 P&ID	VERIFY SCALE BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
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				CHECKED							DATE	JANUARY 2021
				APPROVED							DRAWING NO.	SHEET NO.
											N12	107



NO.	REVISION	BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL		MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION MAGNESIUM CHLORIDE SYSTEM 2 P&ID	VERIFY SCALE	
				DRAWN KMM							BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
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				APPROVED							DATE JANUARY 2021	
											DRAWING NO.	SHEET NO.
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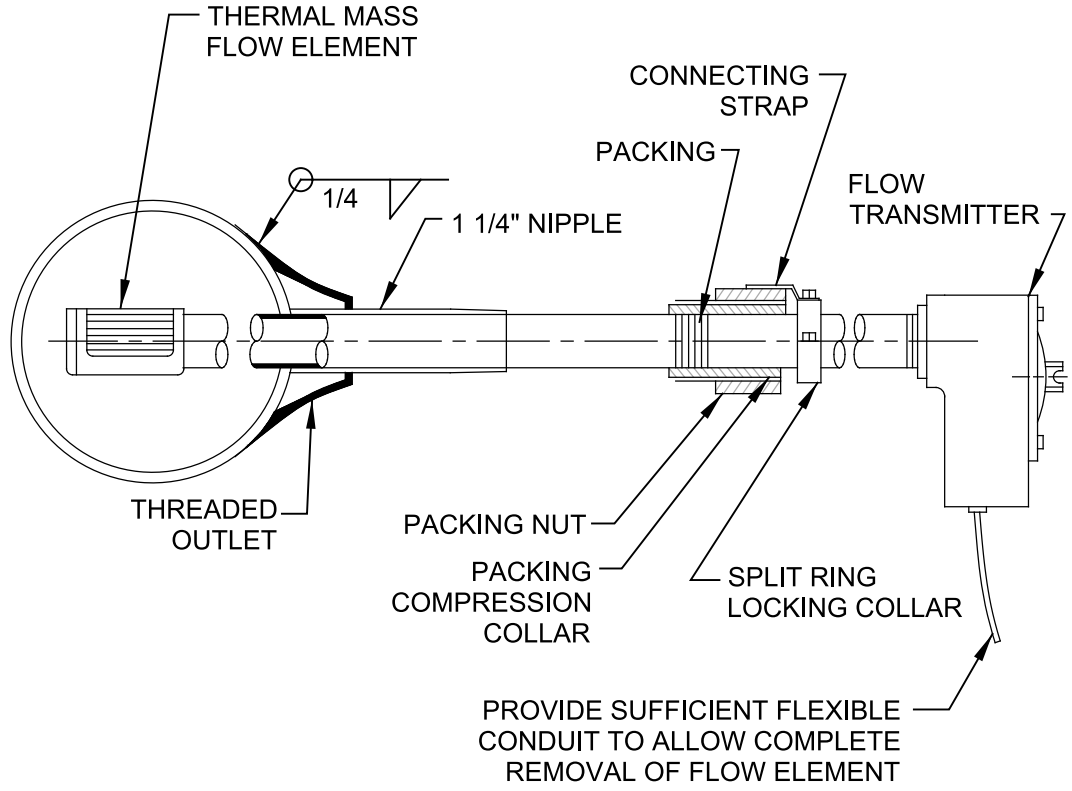


NO.	REVISION	BY	DATE	DESIGN GEB	PRELIMINARY DRAFT NOT FOR CONSTRUCTION			ENGINEERING AND ENVIRONMENTAL SOLUTIONS 1161 W. RIVER ST. SUITE 130 BOISE, IDAHO 83702 208.780.3990 IDAHO OFFICES BOISE · LEWISTON · MCCALL		MERIDIAN WASTEWATER FACILITY MERIDIAN, IDAHO INSTRUMENTATION ANTI FOAM SYSTEM 1 P&ID	VERIFY SCALE BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
				DRAWN KMM							PROJECT	11700A.10
				CHECKED							DATE	JANUARY 2021
				APPROVED							DRAWING NO.	SHEET NO.
											N14	107



- GENERAL NOTES:**
- ADD CHEMICAL AIR RELEASE VALVE AT ALL HIGH POINTS.
- # KEY NOTES:**
- EQUIPMENT FURNISHED BY VENDOR AND INSTALLED BY CONTRACTOR.
 - COORDINATE I/O WITH SELECTED PUMP.
 - PROVIDE SANITARY SEAL.
 - DOUBLE CONTAINMENT PIPE.

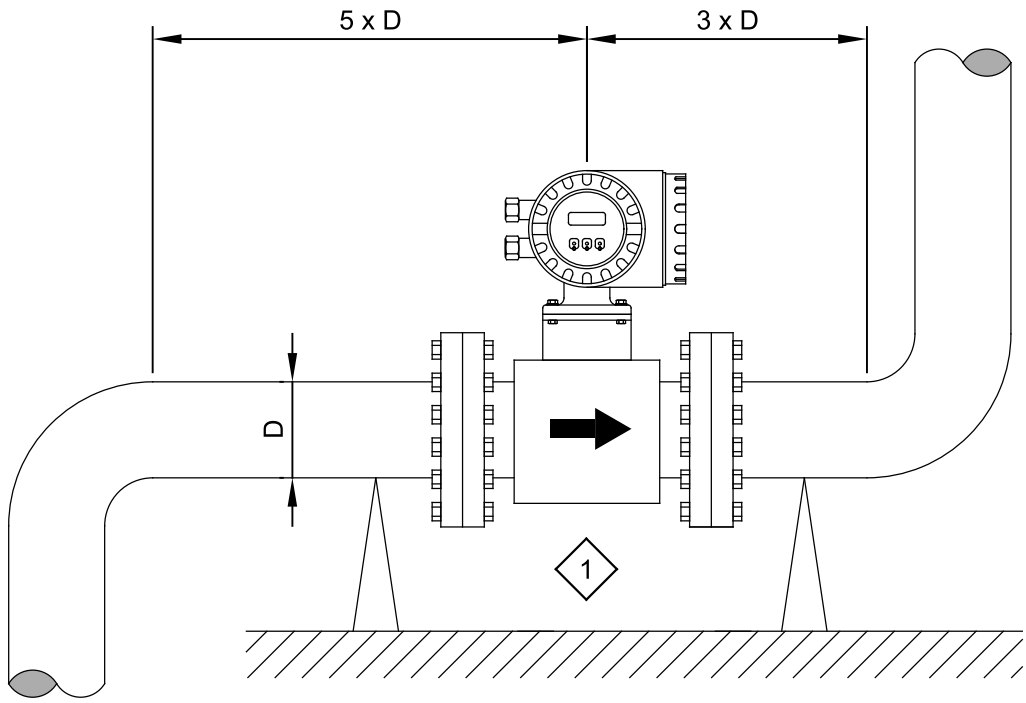
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				DRAWN KMM							BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"
				CHECKED							PROJECT 11700A.10
				APPROVED							DATE JANUARY 2021
											DRAWING NO. N15 SHEET NO. 107



NOTES:

- 1. LENGTH OF PROBE TO BE DETERMINED BY MFG.

NF112 TYP S THERMAL MASS FLOWMETER INSTALLATION DETAIL



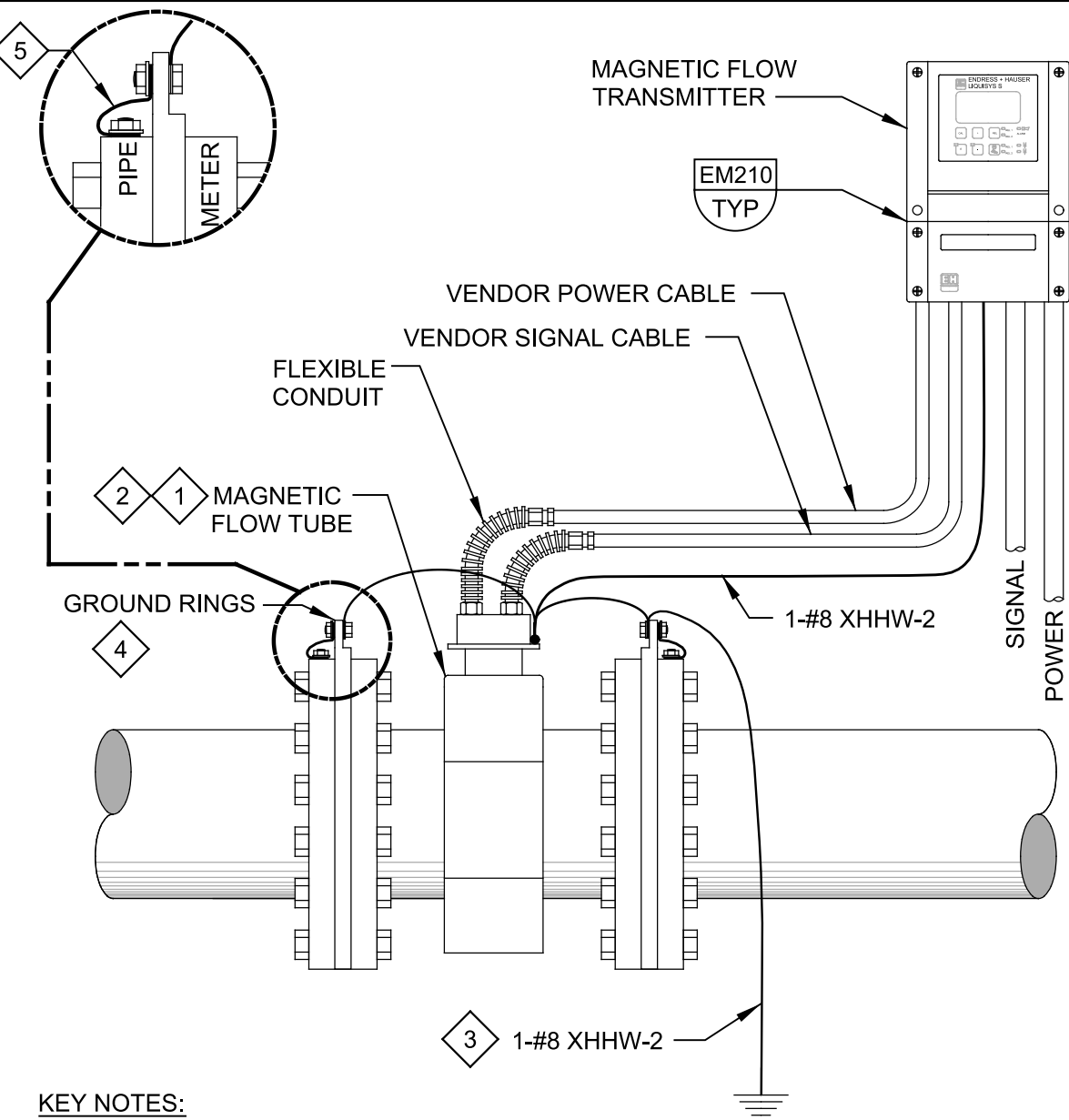
NOTES:

- 1. FOLLOW MANUFACTURER'S RECOMMENDED MAXIMUM TORQUE SETTINGS. DO NOT OVER-TORQUE FLANGE BOLTS. OVERTIGHTENING THE FASTENERS WILL DEFORM SEALING FACES OR DAMAGE THE LINE.
- 2. ALWAYS TIGHTEN FLANGE BOLTS UNIFORMLY AND IN DIAGONALLY OPPOSITE SEQUENCE.
- 3. MOUNT METER SO THAT IT REMAINS FULLY FLOODED.
- 4. INSTALL METER SUCH THAT THERE ARE NO PIPE BENDS FOR 5 PIPE DIAMETERS UPSTREAM AND 3 PIPE DIAMETERS DOWNSTREAM OF THE METER.

KEY NOTES:

- 1. PIPE SUPPORTS BY MECHANICAL CONTRACTOR. NO SUPPORTS SHALL BE INSTALLED AT THE METER HOUSING.

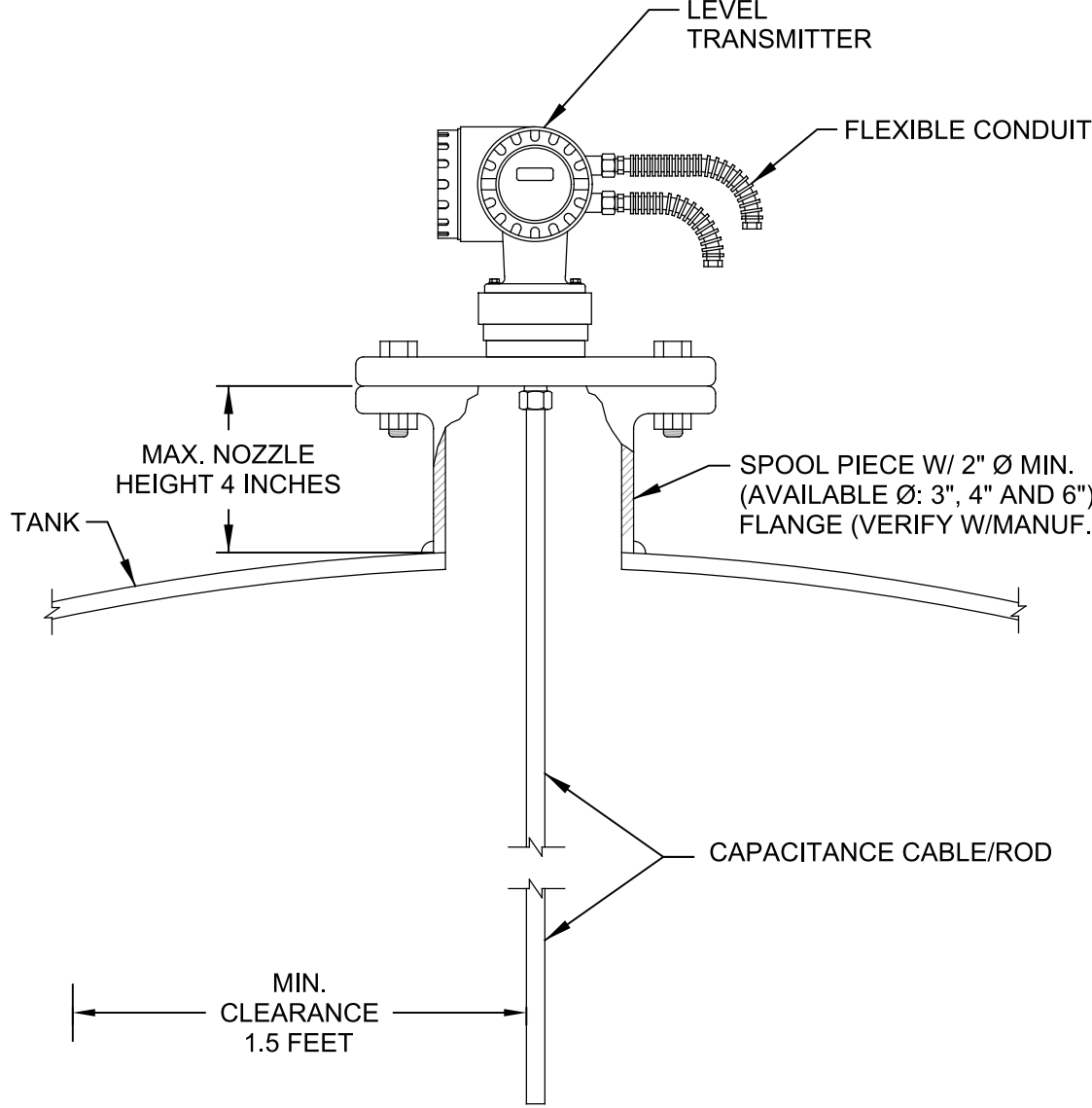
NF130 TYP S MAGNETIC FLOW MOUNTING DETAIL



KEY NOTES:

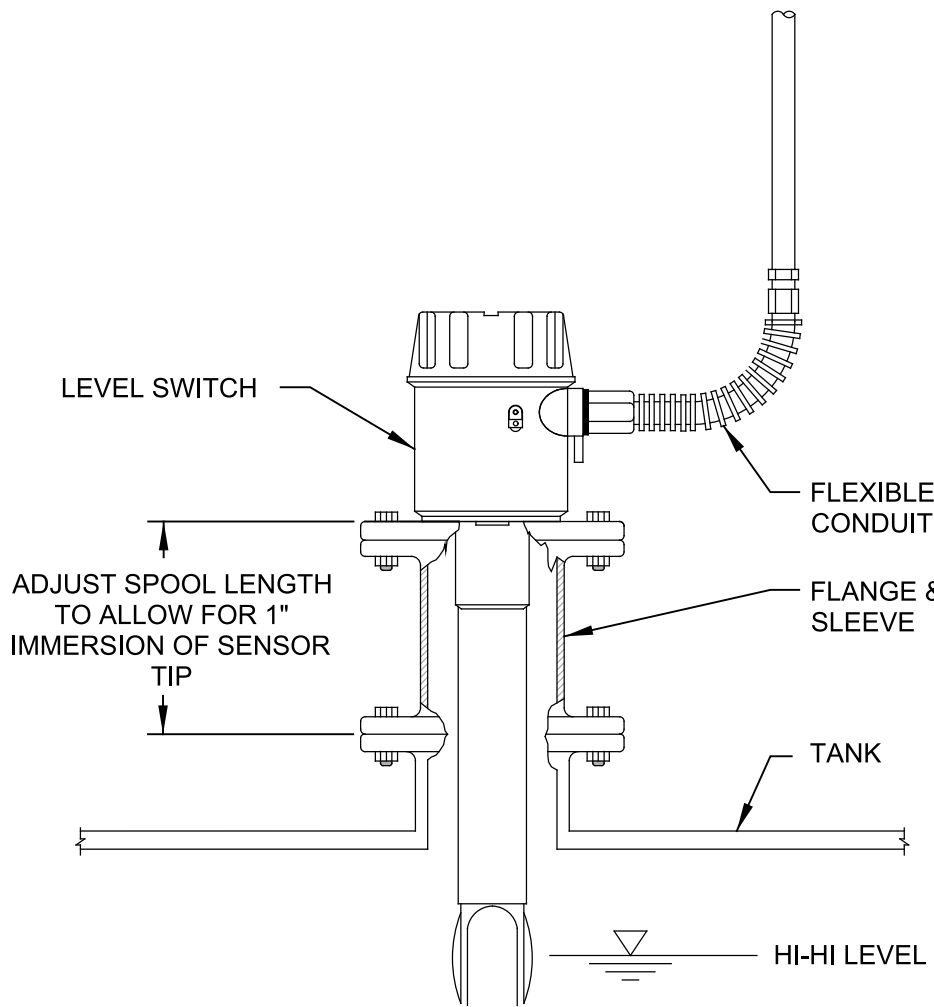
- 1. CONTRACTOR SHALL VERIFY ZERO POTENTIAL BETWEEN FLOW TUBE, EARTH GROUND AND TRANSMITTER GROUND TERMINAL.
- 2. CONNECT TRANSMITTER GROUND TERMINAL TO GROUND RINGS.
- 3. CONNECT METER BODY TO EARTH GROUND POTENTIAL.
- 4. EQUALIZE POTENTIAL VIA GROUND RINGS BETWEEN FLUID AND MAGMETER.
- 5. PROVIDE BONDING JUMPER ON CONDUCTIVE PIPES.

NF135 TYP S REMOTE TRANSMITTER MAGNETIC FLOWMETER GROUNDING DETAIL



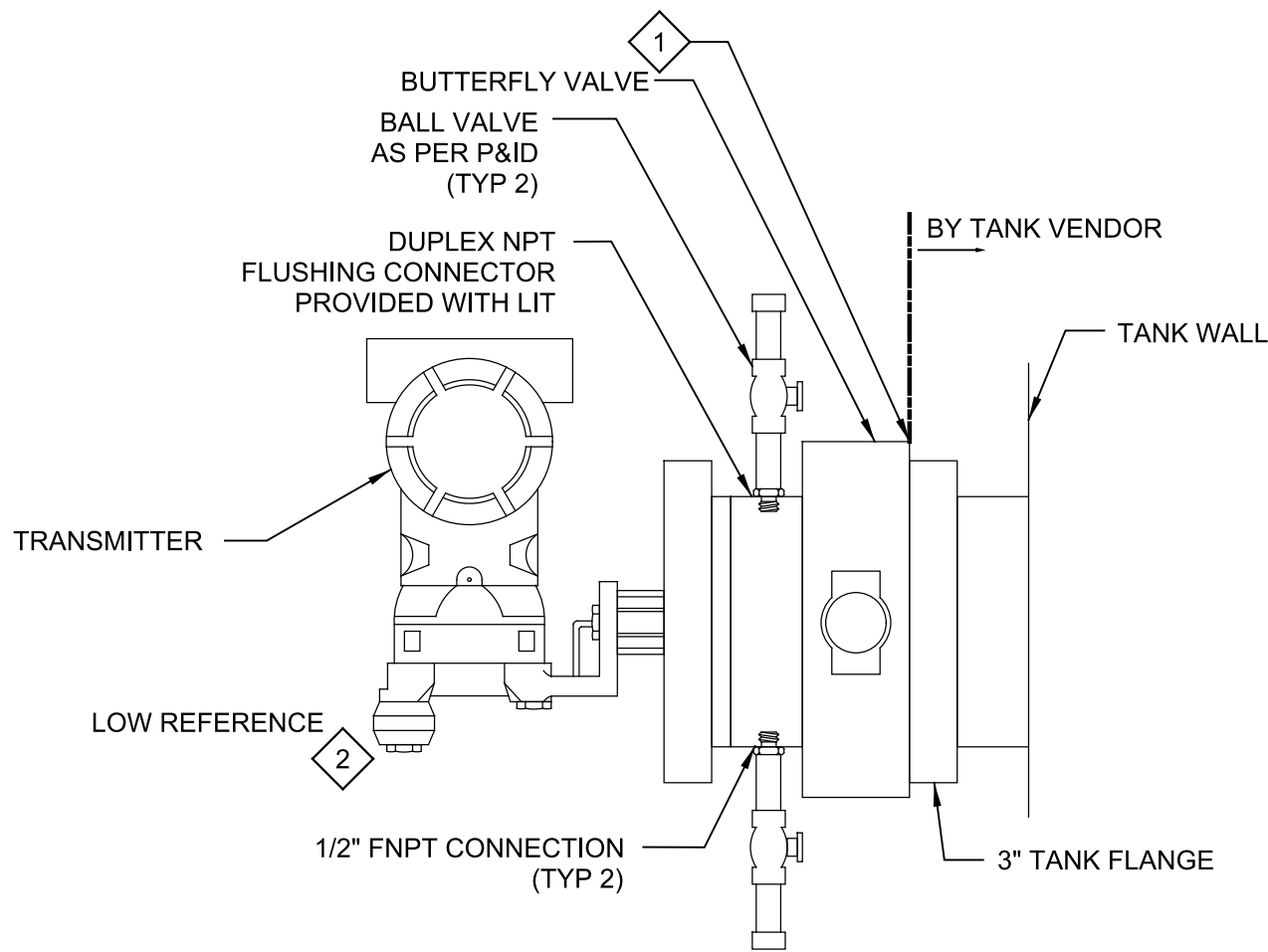
NL900 TYP J TANK MOUNT CAPACITANCE TRANSMITTER MOUNTING DETAIL

02/10/21



NL901 TYP J TUNING FORK LEVEL SWITCH MOUNTING DETAIL

02/10/21

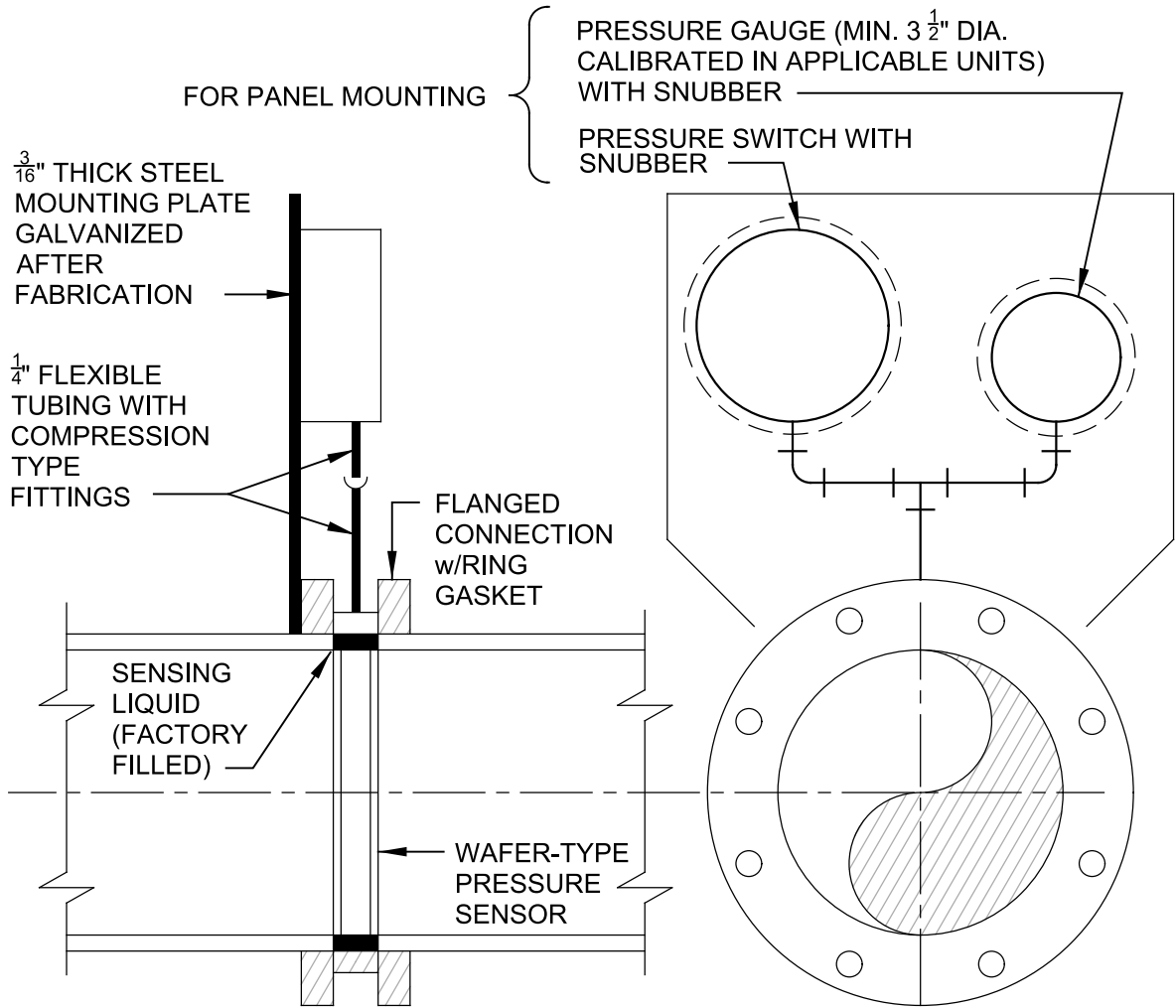


KEY NOTES:

- 1. PROVIDE GASKETS, GASKET MATERIAL TO MATCH ASSOCIATED PIPING GASKET SPECIFICATION.
- 2. CONNECT TO TANK BLANKET IF REQUIRED.

NL902 TYP J TANK LEVEL TRANSMITTER

02/10/21



NP123 TYP S ANNULAR SEAL WITH PRESSURE GAUGE AND PRESSURE SWITCH MOUNTING DETAIL

NO.	REVISION	BY	DATE	DESIGN GEB
				DRAWN KMM
				CHECKED
				APPROVED

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Mountain
WATERWORKS

ENGINEERING AND ENVIRONMENTAL SOLUTIONS
1161 W. RIVER ST. SUITE 130
BOISE, IDAHO 83702
208.780.3990

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BOISE · LEWISTON · MCCALL

MERIDIAN
IDAHO

MERIDIAN WASTEWATER FACILITY
MERIDIAN, IDAHO

INSTRUMENTATION
INSTRUMENTATION TYPICAL DETAILS

VERIFY SCALE BAR IS ONE INCH ON FULL SIZE DRAWING 0 1"	
PROJECT	11700A.10
DATE	JANUARY 2021
DRAWING NO.	SHEET NO.
TN01	



NUMBER: 06638

TO: City of Meridian
33 E. Broadway Ave.
Meridian, Idaho 83642

DATE: 06/18/2021

REF: CAROLLO PROJECT
NO. 11700A.10

Proposal
Prepared For:
Meridian, ID
CNP MagPrex™ System



CNP Contact

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Regional Sales Manager
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Ph: (262) 654 6006
Direct: (612) 401 2006
Email: Jerod.swanson@centrisys.us

Local Representative

Chris McCalib
Treatment Equipment Company
249 Main Ave S, Ste 107 #322
North Bend, WA 98045
Ph: (206) 909-1546
Email: chris@tec-nw.com

MAGPREX™ WITH SEQUESTRATION PROCESS (NO HARVESTING)

ITEM 1 DESIGN PARAMETERS

Our design calculations are based on the following parameters:

SEQUESTRATION PARAMETERS	VALUE	UNITS
Digested sludge flow rate to MagPrex™ reactors 2020 - Design flow:	76	gpm
Digested sludge flow rate to MagPrex™ reactors 2040 - Design flow:	145	gpm
Ortho-P in digested sludge, max	377	mg-P/L (as PO ₄ -P)

ITEM 2 O&M REQUIREMENTS

ITEM	VALUE	UNITS
Estimated MgCl ₂ Consumption at 30% w/w solution – 2020 Design Flow, max	495	gallon/day
Estimated MgCl ₂ Consumption at 30% w/w solution – 2040 Design Flow, max	942	gallon/day
Total installed power	59	HP
O&M Labor requirements	<1	hours/day

ITEM 3 SCOPE OF SUPPLY

ITEM	QUANTITY	DESCRIPTION
1	2	MagPrex™ MAP reactors - 14 ft. diameter x 34 ft. high - Minimum Volume: 20,000 gallons per reactor - MOC: 316 SS - Includes galvanized reactor platforms as per drawings
2	2	Blower and air distribution system - VKM diffusers and air distribution for each reactor - One (1) Aerzen Generation 5 Delta Blower Model GM10S per reactor - Brake Horsepower (max) : 15 bHp - Installed Power: 20 HP per blower
3	1	MgCl ₂ storage tank (10,000 gallons) Manufacturer: Snyder - MOC: HDLPE (High Density Linear Polyethylene) - Dimensions: 142" diameter x 226" overall height, flat-bottom, domed-top
4	1	Prominent MgCl ₂ dosing system (1 diaphragm pump per reactor system, sigma controls and panel, no VFD) - Includes two (2) dosing pumps per skid (one (1) pump per reactor system) - Each pump rated up to 35.9 GPH - Includes one (1) Dual Pump H/O/A Scada Interface Panel 4X 316SS Enclosure per skid
5	1	Prominent Defoamer dosing system (1 diaphragm pump per reactor system, sigma controls and panel, no VFD) - Includes two (2) dosing pumps per skid (one (1) pump per reactor system) - Each pump rated up to 35.9 GPH - Includes one (1) Dual Pump H/O/A Scada Interface Panel NEMA 4X FRP Enclosure per skid
6	2	Struvite discharge pumps (1 per each Reactor) Flow Rate: 100 gpm Pump Operating speed: 122 RPM

		Power requirement: 3ph, 60hz, 230/460V Installed Power: 7.5 HP per pump Manufacturer: Netzsch
7	2	Internal piping system for air distribution, chemical supply and sludge handling
8	1	Valves provided per Appendix A attached
9	1	Set of Instrumentation provided per Appendix B attached
10	2	Control Panel for independent control of each system (PanelView Plus 7 10" screen, NEMA 12, VFDs in MCC, no panel cooling)
11	1	Anchor Bolt sizing
12	1	Start-up and commissioning services
13	1	Payment and Performance Bonds

*Note that there is a trade-off between polymer and cake solids improvement, depending on the needs of the plant, one or the other can be maximized or both can be improved simultaneously but to a lesser extent.

ITEM 4 SERVICES

CNP will furnish one factory representative for 20 days during 3 trips to assist in installation inspection, start-up supervision, and operator training. Dates of service to be scheduled upon Buyer's written request.

ITEM 5 PRICING

EQUIPMENT	PRICE PER THE ABOVE SCOPE
MagPrex™ Sequestration System Base Price Reactor Material of Construction: 316SS	\$2,139,000.00
Deduct for using Painted Carbon Steel as Reactors Material of Construction	-\$331,000.00

Note: Taxes are excluded (This is a tax-exempt project)

Due to the current fluctuating material prices –CNP reserves the right to review quote with possible re-calculation of price at time of issuance of Purchase Order. CNP reserves the right to adjust the tank pricing and staircase pricing according to the steel index such as MEPS - NORTH AMERICAN STAINLESS-STEEL PURCHASING PRICE INDEX (SPPI)

ITEM 6 LEADTIME

EQUIPMENT	SUBMITTAL PREPARATION TIME	DELIVERY TIME AFTER APPROVED SUBMITTALS
MagPrex™ Sequestration System	10 weeks	40 weeks

ITEM 7 PAYMENT TERMS

Price Validity: 30 days from the quoted date.

Payment target: 30 days net

Delivery terms: FOB, Jobsite

Payment Item

- 1.0 10% for Contract Approval & Signing
- 2.0 Receipt of Submittals - 70 days per proposal
- 2.0 10% for Approved Shop Drawing Submittals
- 2.0 10% for Approved Operation & Maintenance Manuals
- 3.0 60% for Delivery of Equipment
- 4.0 10% for Start Up & Commissioning (as broken down below)
 - 4.1 Demonstration and Training (25% of 10%)
 - 4.2 Functional Acceptance Testing (25% of 10%)
 - 4.3 Operational Acceptance Testing (25% of 10%)
 - 4.4 Performance Testing (25% of 10%)

ITEM 8 Liquidated Damages

Limited to \$500/day starting 40 weeks after final submittal approval

ITEM 9 TERMS & CONDITIONS

All sales are subject to CNP and the Purchaser's mutually agreed upon Terms & Conditions of sale. CNP's standard Terms & Conditions of sale are found at the end of this document.

ITEM 10 Performance Guarantee

Provided the design criteria is met as defined in specification 46_63_83.01-2 section 1.03 A, the below performance guarantee from 46_63_83.01-2 section 1.03 B shall be satisfied.

The guaranteed system performance shall be:

1. The content of free (dissolved) ortho-phosphate between inlet and outlet of the reactor is reduced by 90 percent.
2. The dose of magnesium required to achieve the above phosphorus removal performance shall be no greater than 1.5 moles of magnesium added per 1.0 moles of free ortho-phosphate fed to the reactor.
3. Struvite particle size:
 - a. The minimum size of struvite particles produced in the system should be sufficiently large and dense to achieve a minimum of 80 percent of struvite mass removal during digested sludge dewatering.

ITEM 11 Warranty

Warranty: 24 months after date of startup or 30 months after **delivery**, whichever comes first. Components that are subject to usual wear, as well as damages caused by inadequate attendance or faulty operation shall not be covered by this warranty.

Five (5) year warranty from delivery on Magnesium Chloride Storage tank as described.



ITEM 12 CLARIFICATIONS AND EXCEPTIONS:

- Spec 43_33_20.01-1 1.04A MgCl₂ and Antifoam Dosing pump skids shall be duplex (i.e. Two (2) dosing pumps per skid) with dual discharges. Includes one (1) Dual Pump H/O/A Scada Interface Local Control Panel per skid.
- Spec 43_33_20.01-7 2.05E 3A Antifoam Dosing pumps local control panel shall be a NEMA 4X FRP enclosure
- Spec 46 63 83-9 Section 3.01A Pre-inspection of the Reactors at the fabrication facility for One (1) person over Two (2) days shall be provided to the purchaser at their request at additional cost. Reactor's must be signed off by the purchaser as meeting specifications before Reactor's can be shipped to site from the fabrication facility. Tanks shall only be inspected at the fabrication facility.
- Spec 46 63 83-10 Sec 3.02A & 3.05B Hydrostatic Pressure testing shall be performed at the job site. Hydrostatic Pressure testing is not able to be performed at Fabrication site. Water for Hydrostatic testing is supplied by others.
- Spec 46 63 83-9 Section 3.05A Additional onsite time outside what is specified shall be provided and billed at CNP's daily rate.
- All Spec sections Instrumentation shall be provided as detailed in Appendix B attached to this proposal.

ITEM 13 SCOPE EXCLUSIONS

- Stairwell & stairs
- Any site preparation work including surveying and soil sampling
- Building and building plans; Civil works such as the foundation plate for the system or the building
- Structural and Civil engineering labor
- Pipes and piping (except from the outside flange of the reactor the aeration ring inside the reactor)
- Sludge holding or storage tanks for sludge equalization.
- Blowers do not include MCC Starter, VFD, External Controls, Isolation, Valves, Anchor Bolts and Installation Hardware.
- Anchor bolts
- Supply lines (water and electricity) as well as building services (lighting, water supply / sink) in the office building
- Concrete work and core drill holes
- Permits
- Readiness of the Equipment before requesting start-up service. Non-readiness may incur additional charges.
- Any other auxiliary equipment or service not detailed above.

Issued by
Josh Benoit
Applications Engineer
Date: 06/18/2021

Appendix A: Valves Supplied

Item	Quantity	Description
1	2 (one per system)	6" DeZurik KGC Knife Gate Valve, 316SS body/gate, flanged ends, teflon packing, metal seat, handwheel actuator with 304SS yoke. Model KGC, 6, ES, F1, S2, SMP, S2-M*MN-HD12-S1.
2	4 (two per system)	6" DeZurik KGC Knife Gate Valve, 316SS body/gate, flanged ends, teflon packing, metal seat, electric actuator with 304SS yoke. Model KGC, 6, ES, F1, S2, SMP, S2-M*Rotork IQ10.
3	1	Set of spare parts per spec section 40 05 57.23, 1.06 including stem nut, worm shaft subassembly, drive sleeve subassembly, complete actuator seal kit, actuator gearbox oil to fill 4 gearboxes, encoder, control module
4	1	Special warranty per spec section 01 78 36, 1.06

Appendix B: Instrumentation Supplied

Instrument Tag	Service Description	Instrument Type	Manufacturer
SSPR1-FIT-0003	Reactor 1 Sludge Feed Flow Meter	Magnetic Flow Meter	Endress & Hauser
SSPR1-FIT-0010	Reactor 1 Blower Thermal Mass Flow Meter	Thermal Mass Flow Meter	Sierra Instruments
SSPR1-AIT-0102	Reactor 1 pH/Temp Transmitter	pH Transmitter	Hach
SSPR1-AE-0102	Reactor 1 pH/Temp Probe	pH Probe	Hach
SSPR1-LE-0103	Reactor 1 Foam Level	Capacitive Rod	Magnetrol
SSPR1-LIT-0104	Reactor 1 Level Pressure	Pressure Transmitter	Endress & Hauser
SSPR1-LSH-0105	Reactor 1 High Level Switch	Tuning Fork Switch	Endress & Hauser
SSPR1-FIT-0004	Reactor 2 Sludge Feed Flow Meter	Magnetic Flow Meter	Endress & Hauser
SSPR1-FIT-0020	Reactor 2 Blower Thermal Mass Flow Meter	Thermal Mass Flow Meter	Sierra Instruments
SSPR1-AIT-0102	Reactor 2 pH/Temp Transmitter	pH Transmitter	Hach
SSPR1-AE-0202	Reactor 2 pH/Temp Probe	pH Probe	Hach
SSPR1-LIT-0203	Reactor 2 Foam Level	Capacitive Rod	Magnetrol
SSPR1-LIT-0204	Reactor 2 Level Pressure	Pressure Transmitter	Endress & Hauser
SSPR1-LSH-0205	Reactor 2 High Level Switch	Tuning Fork Switch	Endress & Hauser
SSPR1-TSH-0120	Struvite Pump 1 Stator Temperature Switch	Stator Temp Switch	By Netzsch
SSPR1-PSH-0120	Struvite Pump 1 Discharge Pressure Switch	Pressure Switch	Ashcroft
SSPR1-PI-0120	Struvite Pump 1 Discharge Pressure Gauge	Pressure Gauge	Ashcroft

SSPR1-TSH-0220	Struvite Pump 2 Stator Temperature Switch	Stator Temp Switch	By Netzsch
SSPR1-PSH-0220	Struvite Pump 2 Discharge Pressure Switch	Pressure Switch	Ashcroft
SSPR1-P1-0220	Struvite Pump 2 Discharge Pressure Gauge	Pressure Gauge	Ashcroft
SSPR1-TSH-0300	Blower 1 Motor Temperature Switch		By Aerzen
SSPR1-PI-0301	Blower 1 Inlet Filter Pressure Gauge		By Aerzen
SSPR1-PI-0302	Blower 1 Discharge Pressure Gauge		By Aerzen
SSPR1-TI-0303	Blower 1 Discharge Temperature Gauge		By Aerzen
SSPR1-TSH-0304	Blower 1 Discharge Temperature Switch		By Aerzen
SSPR1-TSH-0400	Blower 2 Motor Temperature Switch		By Aerzen
SSPR1-PI-0401	Blower 2 Inlet Filter Pressure Indicator		By Aerzen
SSPR1-PI-0402	Blower 2 Discharge Pressure Indicator		By Aerzen
SSPR1-TI-0403	Blower 2 Discharge Temperature Indicator		By Aerzen
SSPR1-TSH-0404	Blower 2 Discharge Temperature Switch		By Aerzen
SSPR1-LSH-0500	MgCl ₂ Storage Tank Leak Detection Switch	Capacitive Switch	By Environmental Solutions
SSPR1-LIT-0501	MgCl ₂ Storage Tank Level Transmitter	Radar	Endress & Hauser
SSPR1-LSH-0502	MgCl ₂ Storage Tank High Level Switch	Float Switch	
SSPR1-FIT-0501	Reactor 2 MgCl ₂ Dosing Pump Flow Meter	Magnetic Flow Meter	By Skid Vendor

SSPR1-FIT-0502	Reactor 1 MgCl ₂ Dosing Pump Flow Meter	Magnetic Flow Meter	By Skid Vendor
SSPR1-PI-N/A	MgCl ₂ Dosing Pump 1 Pressure Indicator		By Skid Vendor
SSPR1-PI-N/A	MgCl ₂ Dosing Pump 1 Pulsation Dampener		By Skid Vendor
SSPR1-PI-N/A	MgCl ₂ Dosing Pump 2 Pressure Indicator		By Skid Vendor
SSPR1-PI-N/A	MgCl ₂ Dosing Pump 2 Pulsation Dampener		By Skid Vendor
SSPR1-PI-N/A	Antifoam Dosing Pump 1 Pressure Indicator		By Skid Vendor
	Antifoam Dosing Pump 1 Pulsation Dampener		By Skid Vendor
SSPR1-PI-N/A	Antifoam Dosing Pump 2 Pressure Indicator		By Skid Vendor
	Antifoam Dosing Pump 2 Pulsation Dampener		By Skid Vendor



TERMS AND CONDITIONS OF PURCHASE

These terms and conditions apply to all quotations, proposals, orders acknowledgements or confirmations and contracts of CNP Corp. (hereinafter "Equipment"). As used in these terms and conditions of sale, the word "Equipment" includes all hardware, parts, components, software and options.

1. **ACCEPTANCE:** Our sale to you is limited to and expressly made conditional on your assent to the terms and conditions of sale herein and, if applicable, on the attendant quotation, both of which form a part of this order and which supersede and reject all prior agreements, representations, discussions or negotiations, whether written or oral, with respect hereto and any conflicting or additional terms and conditions of yours, or any statement therein, whether or not signed by you. We will furnish only the quantities and Equipment specifically listed on our quotations, proposals, or order acknowledgements or confirmations. We assume no responsibility for the terms or conditions of, or for furnishing other equipment or material shown in, any plans and/or specifications for a project to which the equipment quoted or ordered herein pertain or refer.
2. **PRICES:** Unless otherwise specified in writing, all quoted prices are firm for thirty (30) days from the date of offer. Stenographic, clerical and mathematical errors are subject to correction.
3. **DELIVERY:** Dates for the furnishing of services and/or delivery or shipment of equipment are subject to change. Quoted lead times are figured from the date of receipt of complete technical data and approved drawings as such may be necessary. We shall not be liable, directly or indirectly, for any delay in or failure to deliver caused by carriers or delays from labor difficulties, shortages, strikes or stoppages of any sort failure or delay in obtaining materials from ordinary sources, fires, floods, storms, accidents, or other acts of God or force majeure, by any statute, regulation, administrative order or decree or order or judgment of a court of law or other causes beyond our reasonable control. Unless otherwise agreed to in writing by us, in no event shall we be liable for any damages or penalties whatsoever, or however designated, resulting from our failure to perform or delay in performing due to any of the causes specified in this paragraph 3.
4. **SHIPMENT, RISK OF LOSS, TAXES:** Prices are in US Dollars, F.O.B. Jobsite, unless otherwise noted. Our prices do not include federal, state, municipal or other government excise, sales, use, occupational, processing, transportation or like taxes now in force or enacted in the future. You shall pay any taxes we may be required to collect or pay now or at any time in the future (including interest and penalties imposed by any governmental authority), or any taxes you may be required to pay, that are imposed on the sale, delivery or support of equipment purchased or licensed as a part of this order, or you shall provide us with a tax exemption certificate acceptable to the appropriate taxing authority.
5. **CREDIT AND PAYMENT:** Unless otherwise noted on our quotation, proposal, or order acknowledgement or confirmation payment for equipment shall be thirty (30) days net. Any discount period which may be granted by us begins on the invoice date and all payments are due thirty (30) days after the invoice date. All payments should be made without deduction, deferment, set-off, lien, or counterclaim of any nature. ~~All amounts due not paid within the thirty (30) days after the date such amounts are due and payable shall bear interest at the lesser of 1.5 percent per month or the maximum rate of interest allowed by law.~~ We reserve the right at any time to suspend credit or to change credit terms provided herein, when, in our sole opinion, your financial condition so warrants. Failure to pay invoices when such invoices are due and payable, at our election, shall make all subsequent invoices immediately due and payable irrespective of terms, and we may withhold all subsequent deliveries until the full account is settled. We shall not, in such event, be liable for delay of the performance or nonperformance of contract in whole or in part subsequent to such event.
6. **CANCELLATIONS AND CHANGES:** Orders which have been accepted by us are not subject to cancellation or changes in specification except upon prior written agreement by us and upon terms that will indemnify us against all losses resulting from or arising out of such cancellation or change in specifications. In the absence of such indemnification, we shall be entitled to recover all damages and costs of whatever nature permitted by the Uniform Commercial Code.
7. **DEFERRED SHIPMENT:** If shipment is deferred at your request, payment of the contract price shall become due when you are notified that the equipment is ready for shipment. If you fail to make payment or furnish shipping instructions we may either extend the time for doing so or cancel the contract. In case of deferred shipment at your request, storage and other reasonable expenses attributable to such delay shall be payable by you.
8. **EQUIPMENT WARRANTY AND REMEDY**
 - a. For new equipment only, we warrant to you that the equipment that is the subject of this sale is free from defects in design (provided that we have design responsibility), material and workmanship. The duration of this warranty is **twenty-four (24) months from startup or thirty (30) months from equipment delivery to Idaho**

("Warranty Period"). If you discover within the Warranty Period a defect in design, material or workmanship, you must promptly notify us in writing, preserving the equipment for our inspection. Within a reasonable time after such notification we will correct any such defect with either new or **used** replacement parts, at our option. Such repair, including both parts and labor, is at our expense.

- b. For repairs, parts and service provided by us, we warrant to you that the repairs, parts and service we provide to you will be free from defects in material and workmanship. The duration of this warranty is ninety (90) days from as applicable (i) the date which the machine required the repairs, parts or service is returned to you by us, (ii) the date of your receipt of the part, (iii) the date of repair, if performed at your facility. If during this ninety (90) day period you discover a defect in the repairs, parts or service you must promptly notify us in writing.
 - c. All warranty service is subject to our prior examination and approval and will be performed by us at your facility or at one of our service centers designated by us. All transportation to and from the designated service center will be at our expense. If we are unable to repair the equipment to conform to the warranty after a reasonable number of attempts, we will provide at our option, one of the following: (i) a replacement for such equipment, or (ii) a full refund of the purchase price. These remedies are your exclusive remedies for breach of warranty. Unless otherwise agreed in writing by us, our warranty extends only to you and is not assignable to or assumable by any subsequent purchaser, in whole or in part, and any such attempted transfer shall render all warranties provided hereunder null and void and of no other further force or effect.
 - d. We will use all reasonable efforts to obtain for you any manufacturer's guarantees or warranties for any sub-assemblies included in the equipment. To the extent such warranties are assignable; we hereby assign to you all warranties that are granted to us by our suppliers of any sub-assemblies contained in the equipment.
 - e. The warranties set forth above are inapplicable to and exclude (i) any product, components or parts not manufactured by us or covered by the warranty of another manufacturer, (ii) damage caused by accident or the negligence of you or any third party, normal wear and tear, erosion, corrosion or by disasters such as fire, flood, wind and lightning, (iii) damage caused by your failure to follow all installation and operation instructions or manuals or to provide normal maintenance, (iv) damage caused by unauthorized or improper installation of attachments, repairs or modifications, (v) damages caused by a product or component part which we did not design, manufacture, supply or repair, or (vi) any other abuse or misuse by you or any third party.
 - f. EXCEPT AS SET FORTH IN SUBPARAGRAPHS (a) THROUGH (e) ABOVE, WE DISCLAIM ALL EXPRESS AND IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.
9. **OWNERSHIP:** All drawings, designs, and specifications supplied by us have been prepared or assembled by us and is solely our property. Such drawings, designs and specifications have been furnished in order to provide full documentation and on the condition that they shall not be reproduced or copied in any manner whatsoever, in whole or in part, except for your internal use as necessary, and upon further condition that, as our sole property, they shall not be used, in whole or in part, for furnishing information to others or for any purpose not specifically authorized in writing signed by one of our corporate officers. These ownership provisions shall not be superseded by any printed form used in connection with or arising out of a sale induced by a proposal or otherwise.
10. **PATENT INFRINGEMENT:**
- (a) We warrant that the equipment in the condition sold to you is free of the rightful claim of infringement of any apparatus claims of any third party U.S. patent issued as of the date of our acknowledgement and acceptance of your order, and we will defend, indemnify and hold you harmless from such claims, provided, however, we make no express or implied warranties of non-infringement and undertake no indemnification in respect to third party rights where the alleged patent infringement is based upon or related to (i) any method, process or product claims in third party U.S. patent, (ii) any combination of the equipment with other equipment not supplied by us, (iii) any modifications of the equipment made by you and not approved by us.
 - (b) You shall notify us within thirty (30) days of receipt of notice of an alleged third party patent infringement claim that would entitle you to patent infringement indemnification pursuant to paragraph 11(a), and we shall thereupon assume defense of the claim at our expense. We shall have the sole right to settle or otherwise compromise a third party claim, including but not limited to the right to either (i) modify the equipment to avoid infringement if you are agreeable to the modification, (ii) repurchase the equipment from you at a price equal to the then current fair market value of the equipment, (iii) secure rights by the assignment or license to permit continued use of the equipment.
 - (c) If a third party charges us with patent infringement relating to equipment sold by us to you, we shall have the right to either (i) modify the equipment to avoid infringement if you are agreeable to the modification,

- (ii) repurchase the equipment from you at a price equal to the then current fair market value of the equipment, (iii) secure rights by the assignment or license to permit continued use of the equipment. If a third party charges us with patent infringement on the basis set forth in paragraph 11 (a)(i), (ii) or (iii), you shall hold us harmless for all expenses and awards of damage against us, and we shall also have the right to modify or repurchase the equipment or to secure rights for continued use by way of assignment or license set forth in this paragraph.
11. **SAFETY AND HEALTH STANDARDS:** The equipment described herein (or on specifications provided herewith) complies with applicable safety and health standards issued pursuant to the Occupational Safety and Health Act of 1970 (the Act) and in effect on this date as such standards are interpreted and understood by us. These standards may be amended and/or their meaning may be clarified prior to shipment or performance, and if such changes or clarification requires changes in the equipment described herein, we shall make the necessary changes available to you. You shall pay for any and all changes at our prices therefore in effect at time of shipment or performance, as the case may be. Because actual compliance by employers with the Act is beyond our control, we cannot and do not represent that the use of the equipment described herein, nor the location, installation or maintenance thereof, will comply with the Act or regulations and standards issued pursuant thereto. We make no representation of compliance with safety and health standards contained in any statute, regulations or ordinance of any state or political subdivision thereof applicable to the equipment described herein unless you have notified us of the existence and contents of such standards and we have agreed in writing to the incorporation of such standards in the specifications relating to such equipment. Nothing in this provision shall operate to modify or affect in any manner whatsoever our disclaimer of any liability for consequential damages contained elsewhere in these terms and conditions of sale.
 12. **INSPECTION:** Upon prior written notice, you may make reasonable inspections of equipment at our facility. We reserve the right to determine the reasonableness of the request and to select an appropriate time and location for such inspection. You agree to execute appropriate confidentiality provisions upon our request prior to visiting our facility. All costs of inspection shall be solely determined by us and shall be payable by you. No inspection or expediting by you at the facilities of our suppliers is authorized.
 13. **SOFTWARE PROVISIONS:** If software is provided hereunder, you are granted a nonexclusive, royalty free license only for your use of the software provided with our equipment. Under this license you may: (i) use our software in machine readable code only and only with the equipment provided, (ii) copy our software into any machine readable object code form for backup purposes in support of your use of our software on the equipment provided, and (iii) create one additional copy of the software for archival purposes only. This license may not be assigned, sublicensed or otherwise transferred by you with our prior written consent. You hereby recognize and acknowledge that the software provided to you hereunder comprises valuable trade secret and/or copyright property of CNP (or its licensor) and you covenant that you will take adequate precautions against access to the software by, or disclosure of the software to, anyone not authorized hereunder to use or have access to the software.
 14. **TIME LIMIT FOR BRINGING SUIT:** Any action you file against us, whether for breach of contract, including but not limited to breach of warranty, or for negligence or strict tort, must be commenced within ninety (90) days following the expiration of the Warranty Period.
 15. **MODIFICATION OF TERMS:** The terms and conditions set forth herein are an integral part of our quotation, proposal and/or order acknowledgement or confirmation. These terms shall not be deemed altered, modified or added to by printed or other "standard" terms in the purchase order, acceptance or similar document. Our confirmation or acknowledgement of any order is with the express understanding that all printed or other "standard" language on any such documents submitted by you will be entirely disregarded to the extent that it varies from the terms and conditions of this proposal/offer which may be modified only by typed or handwritten language in the body of your order, acceptance or similar document, together with a written acknowledgement and acceptance of such modification by us.
 16. **LIMITATION ON WARRANTIES:** THE WARRANTIES SET FORTH HEREIN ARE IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING AN IMPLIED WARRANTY OF MERCHANTABILITY, AN IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND AN IMPLIED WARRANTY OF NON-INFRINGEMENT. WE HERBY EXPRESSLY EXCLUDE FROM THIS CONTRACT THE IMPLIED WARRANTY OF MERCHANTABILITY, THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND THE IMPLIED WARRANTY OF NON-INFRINGEMENT, OUR WARRANTIES AND LIABILITIES HEREUNDER ARE LIMITED AS STATED HEREIN.
 17. **APPLICABLE LAW:** Any controversy or claim arising out of the contract or the breach thereof shall be finally decided with binding effect on both parties by the courts of Idaho and in accordance with the laws of the State of Idaho, without giving effect to the provisions thereof relating to conflict of laws. THE EQUIPMENT AND PARTS DESCRIBED IN THESE TERMS AND CONDITIONS OF SALE MAY CAUSE INJURY IF NOT OPERATED PROPERLY AND FOR



THIS REASON ALL OPERATORS SHOULD BECOME THOROUGHLY FAMILIAR WITH THE OPERATING INSTRUCTIONS BEFORE OPERATING THE EQUIPMENT.

18. Indemnification and Insurance:

- 7.1 SUPPLIER shall indemnify and save and hold harmless CITY from and for any and all losses, claims, actions, judgments for damages, or injury to persons or property and losses and expenses and other costs including litigation costs and attorney's fees, arising out of, resulting from, or in connection with the performance of this Agreement by the SUPPLIER, its servants, agents, officers, employees, guests, and business invitees, and not caused by or arising out of the tortuous conduct of CITY or its employees. SUPPLIER shall maintain, and specifically agrees that it will maintain, throughout the term of this Agreement, liability insurance, in which the CITY shall be named an additional insured in the minimum amounts as follow: General Liability One Million Dollars (\$1,000,000) per incident or occurrence, Professional Liability One Million Dollars (\$1,000,000) per incident or occurrence, Automobile Liability Insurance One Million Dollars (\$1,000,000) per incident or occurrence and Workers' Compensation Insurance, in the statutory limits as required by law.. The limits of insurance shall not be deemed a limitation of the covenants to indemnify and save and hold harmless CITY; and if CITY becomes liable for an amount in excess of the insurance limits, herein provided, SUPPLIER covenants and agrees to indemnify and save and hold harmless CITY from and for all such losses, claims, actions, or judgments for damages or injury to persons or property and other costs, including litigation costs and attorneys' fees, arising out of, resulting from , or in connection with the performance of this Agreement by the SUPPLIER or SUPPLIER's officers, employs, agents, representatives or sub-SUPPLIERS and resulting in or attributable to personal injury, death, or damage or destruction to tangible or intangible property, including use of. SUPPLIER shall provide CITY with a Certificate of Insurance, or other proof of insurance evidencing SUPPLIER'S compliance with the requirements of this paragraph and file such proof of insurance with the CITY at least ten (10) days prior to the date SUPPLIER begins performance of its obligations under this Agreement. In the event the insurance minimums are changed, SUPPLIER shall immediately submit proof of compliance with the changed limits. Evidence of all insurance shall be submitted to the City Purchasing Agent with a copy to Meridian City Accounting, 33 East Broadway Avenue, Meridian, Idaho 83642
- 7.2 Any deductibles, self-insured retention, or named insureds must be declared in writing and approved by the City. At the option of the City, either: the insurer shall reduce or eliminate such deductibles, self-insured retentions or named insureds; or the SUPPLIER shall provide a bond, cash or letter of credit guaranteeing payment of losses and related investigations, claim administration and defense expenses.
- 7.3 To the extent of the indemnity in this contract, SUPPLIER's Insurance coverage shall be primary insurance regarding the City's elected officers, officials, employees and volunteers. Any insurance or self-insurance maintained by the City or the City's elected officers, officials, employees and volunteers shall be excess of the SUPPLIER's insurance and shall not contribute with SUPPLIER's insurance except as to the extent of City's negligence.
- 7.4 The SUPPLIER's insurance shall apply separately to each insured against whom claim is made or suit is brought, except with respect to the limits of the insurer's liability.
- 7.5 All insurance coverages for Suppliers subs shall be subject to all of the insurance and indemnity requirements stated herein.
- 7.6 The limits of insurance described herein shall not limit the liability of the Supplier and Supplier's agents, representatives, employees, or subcontractors.
- 7.7 The limits of insurance described herein shall not limit the liability of the Contractor and Contractor's agents, representatives, employees, or subcontractors.