SECTION 013300 – CONTRACTOR SUBMITTALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals. The Contractor shall coordinate the submittal requirements in this section with those given in the Request for Proposals (RFP). Where discrepancies exist, the requirements of the RFP shall govern.

B. Related Requirements:

1. Section 013200 “Construction Progress Documentation” for submitting schedules and reports, including Contractor's construction schedule.
2. Section 017823 "Operation and Maintenance Data" for submitting operation and maintenance manuals.
3. Section 017839 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.

1.2 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Engineer's responsive action.

B. Informational Submittals: Written and graphic information and physical samples that do not require Engineer's responsive action. Submittals may be rejected for not complying with requirements.

1.3 ACTION SUBMITTALS

A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Engineer and additional time for handling and reviewing submittals required by those corrections.

B. Construction Schedule: Within fourteen (14) days after the date of Notice to Proceed, the Contractor shall submit a construction schedule providing the starting and completion dates of the various stages of the Work. The Contractor shall be prepared to discuss its construction schedule at the pre-construction conference.

C. Schedule of Values or lump sum price breakdown: Within fourteen (14) days after the date of Notice to Proceed, the Contractor shall submit a schedule of values or lump sum price breakdown for progress payment purposes.

1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Engineer's Digital Data Files: Electronic copies of digital data files of the Contract Drawings will be provided by Engineer for Contractor's use in preparing submittals.

1. Engineer will furnish Contractor one set of digital data drawing files of the Contract Drawings for use in preparing Shop Drawings.

a. Engineer makes no representations as to the accuracy or completeness of digital data drawing files as they relate to the Contract Drawings.
b. Contractor shall execute a data licensing agreement in the form of Agreement form acceptable to Owner and Engineer.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.

a. The Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Engineer's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow fifteen (15) days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Engineer will advise Contractor when a submittal being processed must be delayed for coordination.

2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.

3. Resubmittal Review: Allow fifteen (15) days for review of each resubmittal.

4. Submittal Copies: Unless additional copies are required for final submittal, and unless Engineer observes noncompliance with provisions in the Contract Documents, initial submittal may serve as final submittal.

D. Electronic Submittals: Identify and incorporate information in each electronic submittal file as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.

a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., LNHS-061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-061000.01.A). If multiple resubmittals are necessary, subsequent resubmittal naming will follow in alphabetical order after the decimal point.

3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Engineer.
4. Transmittal Form for Electronic Submittals: Use electronic form acceptable to Owner, containing the following information:

   a. Project name.
   b. Date.
   c. Name and address of Engineer.
   d. Name of Construction Manager.
   e. Name of Contractor.
   f. Name of firm or entity that prepared submittal.
   g. Names of subcontractor, manufacturer, and supplier.
   h. Category and type of submittal.
   i. Submittal purpose and description.
   j. Specification Section number and title.
   k. Specification paragraph number or drawing designation and generic name for each of multiple items.
   l. Drawing number and detail references, as appropriate.
   m. Location(s) where product is to be installed, as appropriate.
   n. Related physical samples submitted directly.
   o. Indication of full or partial submittal.
   p. Transmittal number.
   q. Submittal and transmittal distribution record.
   r. Other necessary identification.
   s. Remarks.

5. Metadata: Include the following information as keywords in the electronic submittal file metadata:

   a. Project name.
   b. Number and title of appropriate Specification Section.
   c. Manufacturer name.
   d. Product name and model number, if applicable.

E. Options: Identify options requiring selection by Engineer.

F. Deviations: Identify deviations from the Contract Documents on submittals.

G. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.

1. Note date and content of previous submittal.
2. Note date and content of revision in label or title block and clearly indicate extent of revision.
3. Resubmit submittals until they are marked with approval notation from Engineer's action stamp.

H. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction (AHJs), and others as necessary for performance of construction activities. Show distribution on transmittal forms.

I. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Engineer's action stamp.

PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements:

1. Action Submittals: Submit one (1) electronic copy and/or one (1) hard copy (if requested by the Owner) of each submittal unless otherwise indicated.
2. Informational Submittals: Submit one (1) electronic copy and one (1) hard copy (if hard copy is requested by the Owner) of each submittal unless otherwise indicated. Engineer will not return hard copies.
3. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.

    a. Provide a digital signature with digital certificate on electronically-submitted certificates and certifications where indicated.
    b. Provide a notarized statement on original paper copy certificates and certifications where indicated.

B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:

    a. Manufacturer's catalog cuts.
    b. Manufacturer's product specifications.
    c. Standard color charts.
    d. Statement of compliance with specified and/or referenced standards.
    e. Testing by recognized testing agency.
    f. Application of testing agency labels and seals.
    g. Notation of coordination requirements.
    h. Availability and delivery time information.

4. For equipment, include the following in addition to the above, as applicable:

    a. Wiring diagrams showing factory-installed wiring.
    b. Printed performance curves.

c. Operational range diagrams.
d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

5. Submit Product Data before or concurrent with Samples.

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:

a. Identification of products.
b. Schedules.
c. Compliance with specified standards.
d. Notation of coordination requirements.
e. Notation of dimensions established by field measurement.
f. Relationship and attachment to adjoining construction clearly indicated.
g. Seal and signature of professional engineer if specified.

2. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches, but no larger than 30 by 42 inches.

D. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.

1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
2. Identification: Attach label on unexposed side of Samples that includes the following:

a. Generic description of Sample.
b. Product name and name of manufacturer.
c. Sample source.
d. Number and title of applicable Specification Section.

3. For projects where electronic submittals are required, provide corresponding electronic submittal of Sample transmittal, digital image file illustrating Sample characteristics, and identification information for electronic record.
4. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.

a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in an undamaged condition at time of use.
b. Samples not incorporated into the Work, or otherwise designated as Owner's property, are the property of Contractor.

5. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.

a. Number of Samples: Submit two (2) full set(s) of available choices where color, pattern, texture, or similar characteristics are required for selection from manufacturer's product line. Engineer will return submittal with options selected.

6. Samples for Verification: Submit full-size units or Samples of size indicated, prepared from same material to be used for the Work, cured and finished in manner specified, and physically identical with material or product proposed for use, and showing full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.

a. Number of Samples: Submit two (2) sets of Samples. Engineer will retain one (1) Sample set; remaining Sample will be returned. Mark up and retain one returned Sample set as a project record sample.

1) If variation in color, pattern, texture, or other characteristic is inherent in material or product represented by a Sample, submit at least three sets of paired units that show approximate limits of variations.

E. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:

1. Submit product schedule in the following format:

a. Four (4) paper copies of product schedule or list unless otherwise indicated. Engineer will return three (3) copies.

F. Coordination Drawings Submittals: Comply with requirements specified in Section 013100 "Project Management and Coordination."

G. Contractor's Construction Schedule: Comply with requirements specified in Section 013200 "Construction Progress Documentation."

H. Test and Inspection Reports and Schedule of Tests and Inspections Submittals: Comply with requirements specified in Section 014000 "Quality Requirements."

I. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Section 017700 "Closeout Procedures."

J. Maintenance Data: Comply with requirements specified in Section 017823 "Operation and Maintenance Data."

K. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of engineers and owners, and other information specified.

L. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure

Specification and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.

M. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.

N. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.

O. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

P. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.

Q. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.

R. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

S. Research Reports: Submit written evidence, from a model code organization acceptable to AHJs, that product complies with building code in effect for Project.

T. Schedule of Tests and Inspections: Comply with requirements specified in Section 014000 "Quality Requirements."

U. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.

V. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

W. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.

X. Design Data: Prepare and submit written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.

2.2 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Engineer.

B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit three (3) paper copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Engineer.

B. Project Closeout and Maintenance Material Submittals: See requirements in Section 017700 "Closeout Procedures."

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents. In the case of shop drawings, each sheet shall be so dated, signed and certified.

3.2 ENGINEER'S ACTION

A. General: Engineer will not review submittals that do not bear Contractor's approval stamp and will return them without action.

B. Action Submittals: Engineer will review each submittal, make marks to indicate corrections or revisions required, and return it. Engineer will stamp each submittal with an action stamp to indicate appropriate action, as follows:

1. “NO EXCEPTIONS TAKEN” or “EXCEPTIONS AS NOTED” will require no formal revision and resubmission.

2. "REVISE AND RESUBMIT" or "REJECTED" will require the Contractor to revise said submittal and resubmit the required number of copies of revised submittal to the Engineer.

C. Informational Submittals: Engineer will review each submittal and will not return it, or will return it if it does not comply with requirements. Engineer will forward each submittal to appropriate party.

D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

E. Submittals not required by the Contract Documents may not be reviewed and may be discarded.

F. Fabrication of an item shall commence only after the Engineer has reviewed the submittal, returned copies to the Contractor marked either "NO EXCEPTIONS TAKEN" or "EXCEPTIONS AS NOTED", and Contractor has resolved any exceptions noted and documented their resolution. Corrections indicated on submittals shall be considered as changes necessary to meet the requirements of the Contract Documents and shall not be taken as the basis of claims for extra work.

END OF SECTION 013300

SECTION 016600 – EQUIPMENT TESTING AND PLANT START-UP

PART 1 - GENERAL

1.1 GENERAL

A. Equipment testing and plant start-up are required for satisfactory completion of the contract and shall be scheduled and completed within the contract time.

1.2 EQUIPMENT TESTING

A. The Contractor shall provide the services of an experienced and authorized representative of the manufacturer of each item of equipment indicated in the equipment schedules. The experienced, authorized representative shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The Contractor shall have the manufacturer's representative revisit the Work site as often as necessary until any and all problems (i.e., failures to comply with specifications of Contract Documents) are corrected. The Contractor shall require that each manufacturer's representative furnish to the Engineer a written report addressed to the Owner certifying that the equipment has been properly installed and lubricated, is in accurate alignment, is free from any undue stress imposed by connecting piping or anchor bolts and has been operated satisfactorily under full-load conditions.

B. The Contractor shall be responsible for scheduling all operations testing. The Contractor shall furnish all personnel, power, water, chemicals, fuel, oil, grease and all other necessary equipment, facilities and services required for conducting the tests. The Contractor is advised that the Engineer and the Owner's operating personnel will witness operations testing and that the manufacturer's representative shall be required to instruct the Owner's operating personnel in correct operation and maintenance procedures. This instruction shall be scheduled with the Engineer and the Owner at least ten (10) days in advance and shall be provided while the equipment is fully operational. The Contractor shall have previously furnished the technical manuals required under Section 013300 entitled, "Contractor Submittals".

1.3 PLANT START-UP

A. The start-up of the treatment plant facilities and equipment is a coordinating operation requiring the combined technical expertise of the Contractor, Suppliers, Engineer and Owner. The Contractor shall provide the effective coordination of all parties necessary for successful plant, facilities and equipment start-up.

B. The Contractor shall be required to start up and operate the various pieces of equipment in accordance with requirements of section 17500 “Commissioning”.

C. All defects in materials or workmanship which appear during this test period shall be immediately corrected by the Contractor. The Contractor shall provide the services of authorized representatives of the manufacturer, in addition to those services required under equipment testing, as may be necessary, to correct faulty equipment operation. Time lost for

equipment repairs, wiring corrections, control point settings or other reasons which actually interrupt the start-up may, at the discretion of the Engineer, be justifiable cause for extending the start-up test duration.

END OF SECTION 016600

SECTION 017500 – COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This specification discusses pre-Commissioning and Commissioning activities. Pre-Commissioning activities include all the activities associated with the first-time start-up of all equipment, instruments, electrical gear and/or process. This includes all checks and tests prior to running equipment, including any manufactures inspections. Commissioning activities include but are not limited to the Functional Acceptance Test (FAT) of equipment and facilities with clean water, operator training and manufacturer's start-up services. The final step in Commissioning includes a Reliability Acceptance Test (RAT). This test will require the system to function for an extended period without interruption as listed in Table 2. After the test period is complete, the system will be Substantially Complete and can be turned over to the Owner for beneficial use.

B. For the purpose of this Project, Commissioning will start after Owner's acceptance of Operational Readiness Test (ORT) and the listed requirements in Table 1. Full operational tests that demonstrate functionality and reliability will be done during Commissioning. It may be necessary to include the installation of temporary facilities to support testing and the removal of temporary facilities when testing is complete. It is the Contractor's responsibility to execute proper planning, notification and scheduling. The Commissioning activities will involve the Owner, Engineer, Construction Manager, Contractor and staff responsible for plant operation. The Contractor will provide a Commissioning Coordinator to lead all Commissioning activities.

C. This section identifies the tests and documentation that the Contractor shall be responsible for in order to complete pre-Commissioning and Commissioning. All pre-Commissioning and Commissioning work, as described in this section, shall be performed by the Contractor and witnessed by the Owner.

D. Related Requirements:

1. Section 011000 – Summary of Work
2. Section 016600 – Equipment Testing and Plant Start-up
3. Section 017823 – Operation and Maintenance Data
4. Section 017839 – Project Record Documents
5. Section 260000 – General Electrical Requirements
6. Section 409000 – Instrumentation Control for Process Systems

1.2 DEFINITIONS

A. Functional Acceptance Test (FAT): The FAT is used to test the system prior to placing it into service. The test is to prove the system is operational using clean water in normal operating requirements. The requirements for the FAT are listed in Section 1.4 Commissioning Work.

B. Operational Readiness Test (ORT): This test includes all parts of a system to verify that they are in working order and functioning properly in the system, including but not limited to verification

of proper alignment, pressure tests, rotational checks, control devices, loop checks and other items listed in Table 1. The requirements of the ORT are described in detail in Section 1.3 Pre-Commissioning Work.

C. Reliability Acceptance Test (RAT): The RAT is used to prove the reliability of the system for a duration listed in Table 2. The test is performed under normal plant flows using typical process influent with the assistance of plant operators. The requirements for the RAT are listed in Section 1.4 Commissioning Work. Following successful completion of the RAT and acceptance of the system by the Owner, the Contractor may apply for Substantial Completion of the system.

D. Substantial Completion: The Substantial Completion date is certified by the Engineer when the construction of the Project or a specified part thereof is sufficiently completed, in accordance with the Contract Documents so that the Project or specified part can be utilized for the purposes for which it is intended. The Contractor may apply for Substantial Completion after the Engineer has accepted all RATs in accordance with technical specifications section 017500 – Commissioning, Contractor has submitted all Manufacturers' Certificates of Proper Installation, and all Operation and Maintenance Manuals have been submitted by Contractor and approved by the Engineer.

E. Final Completion: Final completion includes all Work under the Contract as outlined in the contract documents, including any approved change orders.

F. System: A system means the overall process, or a portion thereof, that performs a specific function.

G. Commissioning Coordinator: The Commissioning Coordinator is employed by the Contractor and responsible for all Commissioning activities, scheduling start-up and training sessions, developing and submitting all reports and certificates. The Commissioning Coordinator shall have no other responsibilities during Commissioning and will be on-site during all Commissioning phases. The Commissioning Coordinator shall be a registered engineer in the State of Colorado or a currently licensed Class A wastewater treatment operator in the State of Colorado.

H. Plant Water: Plant Water is fully treated plant effluent and is considered non-potable water.

1.3 PRE-COMMISSIONING WORK

A. Pre-Commissioning is comprised of all the activities that shall be completed before the Contractor is permitted to begin Commissioning. Table 1 illustrates some of the tasks.

B. The primary activities for this are construction, factory testing, documentation, component testing, stand-alone equipment testing, and energization of electrical power distribution equipment. This also includes pipe pressure testing. The intent is to test isolated equipment and components. Pre-Commissioning testing shall conclude with the Owner's acceptance of the ORTs.

C. Once all components have been tested individually, electrical power distribution equipment has been functionally tested and energized, and Owner has accepted all required deliverables, the Contractor may request to proceed to Commissioning. If the Owner agrees that the Contractor has successfully performed all tests and provided all required documentation, the Owner will notify the Contractor in writing that he may begin Commissioning.

1.4 COMMISSIONING WORK

A. Commissioning is composed of two parts, Phase 1 and Phase 2 (note that terms Phase 1 and Phase 2 are not associated with construction phasing and are solely used to describe Commissioning requirements). Table 1 illustrates some of the tasks.

1. Phase 1 Commissioning will include operator training as well as comprehensive testing with clean water. The steps will include approval of ORT(s) and the FAT(s). The purpose of the FAT(s) is to test all equipment, instruments and software as an integrated system using plant water wherever applicable. The successful completion of the Functional Acceptance Test will allow the Contractor to request Operational Acceptance. When all deliverables have been accepted and operator and maintenance training is complete, Owner will notify Contractor in writing that the facility has achieved Operational Acceptance, and Contractor may proceed to the next phase of Commissioning.
2. Phase 2 Commissioning is designed to functionally test the facility as an integrated system under normal operating conditions using wastewater. The testing includes the RAT that will be conducted over a period of time that demonstrates the operational reliability of the system. (See Table 2 for test durations.) After successful completion of the RAT and all Manufacturers' Certificates of Proper Operation have been submitted to Engineer, and after Contractor has submitted all Operation and Maintenance Manuals, Contractor may request the Owner's acceptance that the system is Substantially Complete.

1.5 MANUFACTURER'S FIELD SERVICES

A. It is the Contractor's responsibility to provide the services of the manufacturer's representatives required during equipment installation, facilities testing, pre-Commissioning, Commissioning and training of the Owner's personnel. Where manufacturer's services are specified, the Contractor shall furnish an experienced, qualified representative of the manufacturer to provide these services.

B. Definitions: For purposes of furnishing manufacturer's services, the following definitions shall apply:

1. Manufacturer's Representatives: Employee of manufacturer who is factory trained and knowledgeable in technical and operational aspects of their products and systems.
2. Person-Day or Instructor-Day: One person for eight (8) hours straight time, exclusive of Saturdays, Sundays or holidays; does not include travel time.

C. Submittals

1. Submittals shall be in accordance to General Requirements Section 013300 -- Contractor Submittals and the requirements of this section.
2. Qualifications and experience records of proposed manufacturers' representatives who will assist installation and testing of equipment and conduct training sessions.
3. After installation, each manufacturer's representative shall submit to the Owner, via the Construction Manager, a written report (Certificate of Proper Installation) certifying that the all equipment is installed properly, in accordance with documented manufacturer's installation instructions.
4. During Phase 2 of Commissioning and after the RAT, each manufacturer's representative shall submit to the Owner a written report (Certificate of Proper Operation) certifying that

the all equipment has been properly installed and lubricated; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; has been operated under full load conditions; and that it operated per specifications.

D. Scheduling of Manufacturer's Field Services

1. The manufacturer's representative shall be an experienced, competent, and authorized representative of the manufacturer of each item of equipment for which field services are indicated in the individual sections of the Contract Specifications. The representative shall visit the site of the Work to inspect, check, adjust if necessary, and accept the equipment installation. In each case, the manufacturer's representative shall be present when the equipment is being tested and placed in operation. The manufacturer's representative shall revisit the jobsite as often as necessary until all problems (i.e., nonconformities with equipment specifications) are resolved and resolutions are documented to the satisfaction of Owner.
2. The scheduling of all visits to the site by the manufacturer's field services representative shall be determined by the Contractor and accepted by Owner. It is intended that the manufacturer's representatives' visits be primarily for making equipment inspections and normal adjustments, and for remedying defective work only if approved in writing by Owner.
3. Manufacturer's representatives shall resolve assembly or installation problems attributable to or associated with their products and equipment.
4. During the testing, the manufacturer's representative shall assist, as applicable, to perform initial equipment and system adjustments and calibrations.
5. After all acceptance tests have been completed, but prior to Substantial Completion, the Contractor shall recheck all equipment for proper alignment and adjustment, check oil levels, re-lubricate all bearing and wearing points, and, in general, confirm that all equipment is in proper condition for regular continuous operation.

PART 2 - PRODUCTS

2.1 COMMISSIONING PLAN

A. The Commissioning Coordinator shall be responsible for preparing the Commissioning Plan.

B. As a condition precedent to receiving any progress payment for work 30 days prior to the pre-Commissioning activities, the Commissioning Plan shall be submitted to the Engineer 60 days preceding Commissioning of a system and receive the Owner's comments and acceptance for all Commissioning Plan documents. The Owner requires five (5) hard copies to review the submitted Commissioning Plan.

C. Once the Owner has accepted the Commissioning Plan, the Commissioning Coordinator reproduce the Plan in sufficient number for the Commissioning Coordinator's purposes and an additional five (5) copies of the final Commissioning Plan for delivery to the Owner. No test work shall begin until the Commissioning Coordinator has delivered five (5) hard copies of the final Commissioning Plan to the Owner.

D. Testing

1. The Contractor shall develop and produce the ORTs, FATs and RATs to conduct the testing. Sample templates for ORT, FAT and RAT have been provided in Exhibit 1 – Commissioning Document Samples of this specification to help facilitate this production.
2. The Contractor shall submit an EPSET procedure, as defined in Section 2.2.B.1 entitled EPSET - Electrical Power System Energization Test.
3. The Commissioning Coordinator shall develop test plans detailing the coordinated, sequential testing of each item of equipment and system installed under this Contract. Each test plan shall be specific to the item of equipment or system to be tested. Test plans shall identify by specific equipment or tag number each device or control station to be manipulated or observed during the test procedure. The specific results to be observed or obtained shall be identified in the plan. Test plans shall also be specific as to support systems required to complete the test work, temporary systems required during the test work, Subcontractors' and manufacturers' representatives to be present and expected duration of tests.
4. The Commissioning Coordinator shall prepare written test procedures for submittal to the owner and Engineer for acceptance. The test procedures shall be submitted in hard copy and electronically as required. For each test, the procedure form should clearly define the following:
   a. Test Number
   b. Purpose of the test: Describe what is being verified by this particular test.
   c. Test Method: Describe the setup for the test and the steps required to complete the test.
   d. Criteria: Describe the criteria for passing or failing the test.
   e. Provide space on the form for the Owner's comments and authorized signature(s).
   f. Test on a loop-by-loop basis. Every loop shall be signature-approved individually.
   g. Provide a test schedule.
   h. Provide a list of all test equipment to be available for the tests.
   i. Provide a block diagram showing the test setup arrangement. The diagram shall illustrate the equipment under test, any special test equipment and indicate equipment interconnections.
5. Staffing for each test, identifying roles and responsibilities.
6. For all ORT testing, the Contractor shall use the final project PLC hardware.
7. Instrumentation list with calibration methods and calibration dates.
8. Acceptance criteria required to release equipment and systems for Commissioning.
9. Statement of successful test.
10. Forms for each test.

E. Training

1. Identify each operator and maintenance training class.
2. Provide lesson plan for each class.

F. Schedule: The Commissioning Coordinator shall produce a test and training schedule, clearly setting forth the sequence contemplated for performing the test and training work.

1. The schedule shall detail the equipment and systems to be tested, and the schedule shall be part of the Contractor's Baseline Construction Schedule.
2. The schedule shall show the contemplated start date, duration of the test, and completion of each pre-Commissioning and Commissioning activity.
3. The test schedule shall be submitted, reviewed, and accepted by the Owner with the Baseline Construction Schedule.

4. The test schedule shall be updated weekly, showing actual dates of test work, indicating systems and equipment testing completed satisfactorily and meeting the requirements of the Contract Documents.
5. Daily Schedule for Testing
   a. The Commissioning Coordinator shall begin each day of witnessed testing by meeting with the Owner.
   b. The meeting purpose is to review the test schedule, the test results from the previous day, and where applicable, to coordinate the testing schedule with Plant Operations.
   c. Note that the Commissioning Coordinator must schedule some testing outside normal working hours because of plant operational requirements. The Commissioning Coordinator may be required to rearrange portions of the testing schedule at short notice to accommodate unanticipated plant conditions such as equipment failure or unusually high sewage flows caused by wet weather.
6. Show all tests with beginning and ending dates. At a minimum, the Commissioning Coordinator will show all ORT, FAT and RAT schedules.
7. Show all operations and maintenance training classes.

2.2 PRE-COMMISSIONING AND COMMISSIONING TESTS

A. The following tests are conducted by the Commissioning Coordinator during Pre-Commissioning and Commissioning.

B. Pre-Commissioning: The Contractor shall successfully complete each test and receive written confirmation prior to starting any Commissioning Tests.

1. EPSET - Electrical Power System Energization Test – This test is performed after installation of all electrical switchgear systems and MCCs, after completion of NETA testing of the electrical power distribution system and after receipt of vendor certificate of proper installation. An accepted EPSET procedure shall be used to perform this test. The purpose of EPSET is to confirm that 480V and greater power distribution is functional and ready for energization during Commissioning. Prior to energization, PLC I/O check will not be possible; it will be part of ORTs and FAT testing. The Contractor cannot power any equipment (e.g., lighting panel, PLC panels, etc.) until EPSET is complete. Arc Flash labels shall be placed on electrical equipment prior to start of EPSET.
   a. This test will check and document that all local manual, remote and automatic interlocks, switching scenarios, I/O and controls are functional; any temporary power for testing of breakers, switchgear and battery charger system (125 V dc), if required, shall be provided. The Owner's authorized personnel will witness this test. Qualified Contractor and vendor personnel capable of operating and troubleshooting electrical equipment shall be available during the course of this test. The Contractors' Commissioning Coordinator shall direct test.
   b. The Contractor shall submit an EPSET procedure. The EPSET procedure shall include the following:
      1) Steps to test and check all modes of operation (local, remote, manual, automatic and PLC), verify all required switching scenarios and functions, and verify that precluded switching scenarios do not occur.
      2) Methods and procedures for supplying temporary power, if required.
      3) Steps to coordinate administrative control of project electrical equipment that interfaces with existing electrical equipment so that testing does not negatively affect Plant operations.

c. Prior to commencement of the EPSET, the following documentation shall be submitted and made available to the Owner:
   1) An accepted EPSET procedure
   2) All associated redlined as-built single line and loop drawings
   3) Electrical equipment O&M manuals and schematics
   4) Certificate of Proper Installation
   5) NETA testing reports and required testing outlined in Division 26 – Electrical
d. Prior to commencement of the EPSET, vendor training of personnel for electrical equipment shall be completed.

2. ORT - Operational Readiness Test - This test is performed after installation and calibration of instruments is complete. The test purpose is for the Contractor to check and document the complete control system, including I/O to/from PLC register but excluding that the application software is ready for operation. In addition, the equipment shall be tested in local/manual mode for operation and functionality. This test will be required for all electrical, piping and mechanical equipment, including but not limited to actuated valves and gates, meters, conveyors, blowers, compressors, mixers, screens, motors, boilers, bio-gas handling equipment, pumps and filters. Upon completion of the test, the Contractor shall leave the equipment de-energized.
   a. After the equipment supplier has certified proper installation, Contractor shall submit printouts for VFD, RVSS, relays and similar parameter settings for review by the Owner prior to starting the ORT's. If further tuning is required when equipment is under electrical load, as during FAT or RAT, the Contractor shall arrange to have on site the Supplier to finalize settings. When complete, the Contractor shall provide printouts of parameter settings and submit to the Owner. The final parameter settings shall be included in the Final Vendor Equipment Manual submittal. The Owner shall witness all ORT's. After the ORT's for a system are complete and approved by the Owner, Commissioning can begin.

C. Commissioning

1. Phase 1. FAT – Functional Acceptance Test – The FAT is a combined effort between the Contractor and Owner. The combined software/hardware system is tested from this point forward. This test shall be conducted for LOCAL control; REMOTE MANUAL control; REMOTE AUTO control; REMOTE CASCADE (if applicable) control. The purpose for the test is to confirm that the PLC and Operator Graphics software configuration is working in conjunction with the hardware and plant as intended. This test is accomplished with the system online under normal operating conditions. Equipment will operate with plant water. After acceptance of the FAT by the Owner, the Contractor may request to start with Phase 2.
2. Phase 2. RAT – Reliability Acceptance Test – The Purpose for this test is for the Contractor to demonstrate that all systems are capable of operating continuously in the intended manner for an extended period without failing. During the RAT, the Contractor will be responsible for recording all readings, collecting all samples and conducting laboratory analysis. During the RAT, the system under test will be operated within design parameters reflecting the day-to-day operation of the facilities for an uninterrupted period. The duration for each system is listed in Table 2. Several systems may have to test simultaneously in order to treat the wastewater adequately. Each system will require its own RAT, but all of the above systems must start together. The existing systems must remain operational during the test in case of a problem during the test period.
3. Unless noted otherwise in Table 2 of this section, the RAT will run for 7 continuous days without interruption. During the test, operation of the system will be under the direction of

the Contractors Commissioning Coordinator with assistance from Equipment Manufacturers, Sub-Contractors, Owner and Plant Operators. The test, to the greatest extent possible, will take place at 80% of design flow for each process or piece of equipment. The test may need to be terminated due to above average rainfall, unforeseen conditions at the plant or any malfunction with the equipment causing the plant not to meet its discharge requirements. The Plant must be able to return to normal operation prior to the test if suspension of the test in necessary.

4. If the system test is suspended for a period exceeding four (4) hours due to equipment malfunction or break-down, the entire test will be void and must be restarted at the beginning of the test.

2.3 PRE-COMMISSIONING AND COMMISSIONING DOCUMENTATION

A. Pre-Commissioning: The following documentation shall be up to date and accepted by the Owner prior to starting any Commissioning activities. The Owner will give written notice to the Contractor when all the documents are accepted.

1. Equipment Submittal Process Complete.
2. RFIs and Responses up-to-date.
3. All Electrical Equipment Tests.
4. All Process and Instrumentation Equipment Tests.
5. All Mechanical Equipment Tests.
6. Loop Drawings.
7. P&ID Drawings.
8. Contractor Lock-out Tag-out Procedures.
9. All Vendor and Manufacturer Certificates of Correct Installation.
10. All Pressure Test Reports.
11. All Loop Test Reports.
12. All Conductivity Test Reports.
13. All Instrument Calibration Reports, including parameter settings for magnetic flow meters, ultrasonic level elements, transmitters and similar instruments requiring calibration.
14. All Electrical Breaker Setting Reports.
15. All Mechanical Alignment Reports.
16. Draft Operations and Maintenance Manual.
17. Any and All Operating Permits.
18. Operator Training Plan.
19. Pre-Commissioning Report.

B. Commissioning: The following documents shall be submitted by the Commissioning Coordinator to Owner during Commissioning:

1. Redline As-Built Drawings.
2. Final Maintenance Manuals.
3. Final Punch List.
4. Commissioning – Phase 1 Report.
5. Commissioning – Phase 2 Report.

2.4 DOCUMENTATION

A. The Commissioning Coordinator shall develop a record-keeping system to document compliance with the requirements of this Section. Calibration documentation shall include identification (by make, manufacturer, model, and serial number) of all test equipment, date of original calibration, subsequent calibrations, calibration method, and test laboratory.

B. Equipment and system documentation shall include date of test, equipment number or system name, nature of test, test objectives, test results, test instruments employed for the test, and signature spaces for Owner's witness and the Contractor. A separate file shall be established for each system and item of equipment. For process systems that require Commissioning prior to taking another process system out of service, the documentation shall be provided for each process system to be completed independently. These files shall include the following information as a minimum:

1. Metallurgical tests (if applicable).
2. Factory performance tests.
3. Accelerometer recordings made during shipment.
4. Field calibration tests.
5. Field pressure tests.
6. Field performance tests.
7. Field operational tests.

C. The Commissioning Coordinator shall develop test documentation forms specific to each item of equipment and system installed under this Contract.

D. Once the Owner has reviewed and taken no exceptions to the forms proposed by the Commissioning Coordinator, the Commissioning Coordinator shall produce sufficient forms, at his expense, to provide documentation of all testing work to be conducted as a part of this Contract.

E. Reference Documentation

1. The Commissioning Coordinator shall make two hard copies and a digital file of the following documentation available to the Owner at the test site:
   a. All drawings, specifications, addenda and change orders;
   b. Copy of the accepted test procedure for the specific equipment being tested and record-keeping forms filled out during testing.

2.5 REPORTS

A. The Contractor shall submit several reports to the Owner for acceptance in order to continue with the Commissioning process. For process systems that require Commissioning prior to taking another process system out of service, the reports shall be submitted for each process system as completed. These shall be submitted in hard copy and electronic formats. The reports are described below. One each of these tests is required even if not specifically listed in the detailed specification section.

B. Pre-Commissioning Report: The Pre-Commissioning Report is a collection of all test reports, test data, certificates and Commissioning forms that are produced during the Pre-Commissioning

Stage. The first section of this document will be a summary of the contents certifying that all prescribed tests and procedures have been successfully completed. The Commissioning Coordinator is responsible for producing this document and submitting to Owner in hard copy and electronic formats.

C. Commissioning – Phase 1 Report

1. The Phase 1 Report is a collection of all test reports, test data, certificates and Commissioning forms that are produced during the Phase 1 Stage. The first section of this document will be a summary of the contents certifying that all prescribed tests and procedures have been successfully completed. The Commissioning Coordinator is responsible for producing this document and submitting to Owner in hard copy and electronic formats.

D. Commissioning – Phase 2 Report

1. The Phase 2 Report is a collection of all test reports, test data, certificates and Commissioning forms that are produced during the Phase 2 Stage. The first section of this document will be a summary of the contents certifying that all prescribed tests and procedures have been successfully completed. The Commissioning Coordinator is responsible for producing this document and submitting to Owner in hard copy and electronic formats.
   a. Manufacturer's equipment data.
   b. Field recorded dimensional measurements and clearances.
   c. Pressure, pressure differential, level, flow and other field settings.
   d. All electrical devices field settings.
   e. Operational pressure tests, control system timing tests and settings and other test data specified.
   f. Field wiring changes made, including marked-up drawings.

2.6 SUBMITTALS

A. Contractor shall submit the following information in addition to specific equipment where specified in individual sections and paragraphs:

1. Manufacturer’s Certification of Proper Installation of all equipment.
2. Completed ORT, FAT and RAT forms.

B. Submit design and details of temporary test equipment and facilities.

C. Formal Reports

1. Submit two (2) bound copies and one (1) digital file of all start-up and test reports within thirty days after completion of last test.

PART 3 - EXECUTION

3.1 PRE-COMMISSIONING AND COMMISSIONING ACTIVITIES

A. The following is a partial list of activities that shall be complete during each stage of Commissioning.

B. Pre-Commissioning

1. Electrical Service Tie-ins.
2. Electrical Testing.
3. Electrical Equipment is Clean and Energized.
4. Mechanical Equipment is Clean and Energized.
5. Verify Rotation of Motors.
6. Verify Alignment of Equipment.
7. Perform Local Manual Mode Tests.
8. Piping Equipment is Complete and Pressure Tested.
9. Pipe Supports Complete.
10. Pipe is Clean of Debris (inside and out).
11. Verify Valve Operation and Positions for Commissioning.
12. SCADA System is Complete and Energized.
13. Perform Wiring and Loop Tests.
14. PLC Programming Complete.
15. Perform Electrical Power System Energization Test (EPSET).
16. Perform Operational Readiness Test (ORT).
17. Pre-Commissioning Requirements.

C. Commissioning

1. Operator Training.
2. As-Built Drawings.
3. Functional Acceptance Test (FAT).
4. Reliability Acceptance Test (RAT).
5. Final Maintenance Manuals.
6. Completion of Final Punch List.

TABLE 1
PRE-COMMISSIONING AND COMMISSIONING

PRE-COMMISSIONING	COMMISSIONING	
	PHASE 1	PHASE 2
Equipment Submittal Process Complete	Redlined As-Built Drawings Received Prior to Operator Training	Reliability Acceptance Test (RAT)
RFI's and Responses Up-to-date		
All Electrical Equipment Tests Complete	Operational Readiness Tests Reports Approved	All Manufactures Certificates of Proper Installation and Training
All Process and Instrumentation Tests Complete		
All Mechanical Equipment Tests Complete	Operator Training Completed Prior to Phase 2	Commissioning - Phase 2 Report
Loop Drawings		Substantial Completion of System
P&ID Drawings	Functional Acceptance Test (FAT) Completed	
Contractor Safety Procedures Approved, In Place	Commissioning - Phase 1 Report Completed	Final O&M Manuals
Equipment, Valve and Pipe Labeling Complete	Obtain operational acceptance from the Owner to Proceed to Phase 2	Final Punch List Complete
All Manufactures Certificates of Proper Installation Complete		Final As-Built Drawings
All Pressure Test Reports		Final Completion
All Loop Test Reports		
All Conductivity and Megger Test Reports		
All Instrument Calibration Reports		
All Breaker Setting Reports		
All Mechanical Alignment Reports		
Operator and Maintenance Training Plan		
Commissioning Plan Accepted		
Draft O&M Manuals Submitted and Approved		
Electrical Power System Energization Test		
Operational Readiness Tests (ORT's) Complete		
Pre-Commissioning Report Submitted		
Obtain Owner Approval to Proceed to Commissioning Phase 1		

TABLE 2
RELIABILITY ACCEPTANCE TEST PARAMETERS

SYSTEM	TEST DURATION
Group #1	30 Continuous Days without a problem
Influent Pump Station	
Headworks Area	
Equalization Basin	
Retrofitted Process Basins	
MBR Building	
Dewatering Building	
Emergency Generator	7 Continuous Days without a problem
Non-Potable Water Pump Station	

EXHIBIT 1

COMMISSIONING DOCUMENT SAMPLES

OPERATIONAL READINESS TEST (ORT)

FUNCTIONAL ACCEPTANCE TEST PROCEEDURE (FAT)

SAMPLE RELIABILITY ACCEPTANCE TEST PROCEEDURE (RAT)

OPERATIONAL READINESS TEST
TOWN OF JOHNSTOWN
CENTRAL WWTP PROJECT

Date:_____

Equipment Name:_____ Equipment #:_____

Test Type:_____ System:_____

Step	ok Contractor	ok Sub	Signature or comments for non-acceptance (Owner's Representative) Comment / Sign Off
Verify correct installation			
Verify correct electrical and control wiring (voltage, breaker settings, etc.)			
Verify all lubrication is complete and correct			
Check rotation (uncouple motor from equipment if required)			
Verify all alarms and signals are functioning (simulate signal if needed)			
Verify all H/O/A switches function			
Verify all emergency stops function			
Check clearances and verify all guards are in place			
Verify loop checks are complete and test operation through the PLC			
Verify ready for start-up by manufacturer if applicable			
Equipment is ready for system Functional Acceptance Test (FAT)			

FUNCTIONAL ACCEPTANCE TEST PROCEDURE (FAT)

1.1 OVERVIEW

A. The purpose of the Functional Acceptance Test (FAT) is to demonstrate to the Owner that both the software and hardware installed under this Contract is performing as specified. The test is performed with the equipment in service using plant water. The FAT is a combined effort between Contractor and Owner. The tests will require coordination with Operations so that normal processing is not disrupted. A Plant Operator must be present when any system operated may disrupt normal plant operation. Each individual piece of equipment shall have a completed ORT prior to the system FAT. This schedule will be based on work sequencing as discussed in the Contract Documents.

1.2 TEST PROTOCOL

A. The combined software/hardware system is tested from this point forward. The test is performed with equipment in service under normal operating conditions, and extreme design conditions (max and min), to the extent that test conditions allow. The purpose of the test is to confirm and document that the PLC and Operator Graphics software configuration is working in conjunction with the hardware and plant as intended.

B. Equipment will operate with plant water. Application software problems encountered during the test will be investigated and corrected by the Contractor. Problems with PLC and/or SCADA software programming done by the Owner will be corrected by the Owner. The Contractor shall provide a qualified person familiar with the installation and trouble-shooting of PLC panels, working full time, under the direction of the Commissioning Coordinator, for the duration of the test. Prior to the test, the Contractor shall submit a written FAT procedure, prepared by the Commissioning Coordinator, to the Owner for approval. The Owner's approval of the FAT procedure is required prior to the start of the FAT.

C. Alarms and interlocks are simulated in the field by activating the final element (sensor) or, if this is not possible, by simulating the test condition at field terminals as close as possible to the final element. Calibration checks completed for the ORT will not be repeated.

D. The Owner must be notified at least 48 hours prior to the start of the FAT and must be present during the test.

E. If any sections of the test are found to be unsatisfactory, the Contractor will be required to repeat the test at his expense until the entire test is completed satisfactorily.

1.3 COMPONENTS

A. Each component of a system shall be brought on-line as required to simulate a fully functioning system.

B. Each component shall be tested at normal plant flows. If it is not possible to produce the flow, it may be simulated for this testing purpose.

C. Each component shall be fully functional and compatible with the system at the conclusion of the FAT.

D. Any repair or replacement of system components shall be completed and tested prior to final approval and initiation of the RAT(s).

1.4 TEST PROCEDURE

A. The Commissioning Coordinator shall prepare a written procedure and sign-off sheet for each system. The sheet shall include all necessary components and requirements for the system. The procedure must be submitted to the Owner at least twenty-one (21) working days prior to the test for approval and comments. The Owner must approve the procedure prior to proceeding with the test.

B. Following is a general procedure for conducting the FAT:

1. Schedule test time with the Owner.
2. Set all valves and gates to the required position.
3. Fill channels and basins with plant water to prepare for the start-up.
4. Energize electrical equipment.
5. Check and calibrate all transmitters, sensors, alarms and meters.
6. Simulate high, normal, and low flow conditions.
7. Verify operation and reporting of the system through the SCADA System as well by manual operation.
8. Obtain approval from the Owner prior to terminating the test.

SAMPLE FUNCTIONAL ACCEPTANCE TEST PROCEDURE EXAMPLE PUMP STATION #1			
#	**Test and Setup**	**Required Results**	**Signnature / Comments**
1	Verify all ORT's are complete and accepted by Owner	All ORT's complete (Provide copies of all ORT's).	
2	Notify Owner	All required people notified to observe test.	
3	Verify all local and remote switches are in the off position	No unwanted starting of equipment.	
4	Energize equipment at the MCC and power panel	Equipment is safely energized.	
Example Pumps #1 through #3			
1	Open isolation valves	Pumps should not operate unless the isolation valves are open.	
2	Verify proper operation of level instruments	Verify the level instruments operate as intended.	
4	Verify downstream processes are ready to receive flow.	Pumps should not be operated unless downstream processes are available to receive flow.	
5	Provide utility water to wet well and fill wet well as needed.	Pumps should not operate without water in the wet well.	
6	Turn HOA switch to Hand	Verify the pump operates and run at appropriate flow/head conditions.	
7	Turn HOA switch to Auto	Pump should not operate until water level is at high level setpoint.	
8	Verify pump alarms along with pump on and pump off sequence with HOA in Auto.	Pump should operate as intended in Auto.	
9	De-energize equipment until Reliability Acceptance Test (RAT)	Contractor complete lock—out/tag-out procedure.	

Test Completion Endorsements			
		Signature/Date (Contractor)	Signature/Date(Owners Rep)
1	All components are complete and functioning.		
2	Acceptance to move on to Reliability Acceptance Test (RAT)		

SAMPLE RELIABILITY ACCEPTANCE TEST PROCEDURE (RAT)
EXAMPLE PUMP STATION #1

1.1 OVERVIEW

A. The RAT for the Example Pump Station #1 will involve other areas or systems that must start simultaneously; they are listed in Sequence of Operations in Section 011000, "Summary of Work". Each related area will have its own RAT. The Commissioning Coordinator will be responsible to prepare each RAT and schedule the start-up of the systems with the Owner. The RAT cannot begin until the Functional Acceptance Tests (FAT) is complete and approved by the Owner for all related areas.

1.2 CONSTRAINTS

A. The RAT will run for seven (7) continuous days without interruption or problem (unless a different duration is noted in Table 2 above). During the test, the responsibility for operation of the system and direction for testing falls on the Contractors Commissioning Coordinator with assistance from Equipment Manufacturers, Sub-Contractors, Engineer, Owner and Plant Operators. The test, to the greatest extent possible, will take place at 80% of design flow for each process or piece of equipment. The test may need to be terminated due to above average rainfall, unforeseen conditions at the plant or any malfunction with the equipment causing the plant not to meet its discharge permit requirements. A contingency plan in case the RAT is suspended must be submitted and approved by the Owner.

B. If the system test is suspended for a period exceeding four (4) hours due to equipment malfunction or break down, the entire test will be void and must restart at the beginning of the test.

1. The RAT must be repeated and run for an additional seven (7) continuous days without interruption and or problem following the construction and FAT for the Equalization Basin.

1.3 PROCEDURE

A. Prior to beginning the Influent Pump Station RAT, all of the related systems must be ready for their own RAT. These are identified in the Sequence of Operations in Section 011000, "Summary of Work." The contractor, with the approval of the Owner, may modify this list of related areas.

B. All ORT's and the FAT must be complete and approved prior to beginning the RAT. Documentation requirements will be discussed with the Commissioning Coordinator and Owner. The Commissioning Coordinator will create the logs and record the information. The logs will be submitted to the Owner for acceptance at the conclusion of the test and have the logs available for review during the test.

C. A written procedure will be submitted to the Owner 60 days prior to the test for approval and comment. A sample start-up activity list for an Influent Pump Station is provided below.

EXAMPLE WET WELL #1 START-UP ACTIVITY		
1.	Verify completion of ORT's and FAT.	
2.	Verify the Owner has approved the RAT procedure.	
3.	Verify all downstream systems are ready to accept flow. (See Section 011000 for a list of related systems.)	
4.	Start-up meeting with Owner, Plant Operators, Commissioning Coordinator and Engineer reviewing the start-up plan.	
Influent Pump Station		
	Downstream Process Equipment should be operating	
1.	Open the appropriate pump isolation valves.	
2.	Energize Pumps #1, #2 and #3	
4.	Set the HOA switch for Pumps #1, #2 and #3 to Auto.	
5.	Open the appropriate isolation valves and/or gates to introduce flow to the wet well.	
6.	Verify the operation of the pump station.	
8.	Start the clock for the RAT.	

DOCUMENTATION

A test and issue log will be the only required documentation for the Influent Pump Station RAT. A sample log sheet is provided below.

EXAMPLE PUMP STATION #1 TEST AND ISSUE LOG										
Activity/Equipment	Start Time/Date	Verify Proper Operation Initial Y=Yes N=No							Stop Time/Date	Comments/Issues (Use additional sheet if needed.)
		S	M	T	W	T	F	S		
Pump #1										
Pump #2										
Pump #3										
Level Sensor #1										
Level Alarm Low										
Level Alarm High										
Level Alarm High/High										
Note:										
Contractor Approval:										
Engineer Approval:										
Owner Approval:										

SECTION 017700 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for contract closeout, including but not limited to the following:

1. Substantial Completion procedures.
2. Final completion procedures.
3. Warranties.
4. Final cleaning.
5. Repair of the Work.

B. Related Requirements:

1. Section 017500 “Commissioning” for commissioning requirements.
2. Section 017823 "Operation and Maintenance Data" for operation and maintenance manual requirements.
3. Section 017839 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.

1.2 ACTION SUBMITTALS

A. Product Data: For cleaning agents (submitted by the Contractor).

B. Contractor's List of Incomplete Items: Initial submittal by the Contractor at Substantial Completion.

C. Certified List of Incomplete Items: Final submittal by the Contractor at Final Completion.

1.3 CLOSEOUT SUBMITTALS

A. Certificates of Release: From authorities having jurisdiction (AHJ’s).

B. Certificate of Insurance: For continuing coverage.

1.4 SUBSTANTIAL COMPLETION PROCEDURES

A. Contractor's List of Incomplete Items: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction, including, if necessary, areas disturbed by Contractor that are outside the limits of construction.

1. Organize list of spaces in sequential order.

2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
3. Include comments from the Construction Manager, Owner and Engineer.
4. Submit list of incomplete items in the following format:

    a. MS Excel electronic file. Engineer will return annotated copy.

B. Submittals Prior to Substantial Completion: Complete the following a minimum of 14 days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.

1. Certificates of Release: Obtain and submit releases from AHJ's permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases necessary for Work.
2. Submit closeout submittals specified in other Division 01 Sections, including project record documents, operation and maintenance manuals, final completion construction photographic documentation, damage or settlement surveys, property surveys, and similar final record information.
3. Submit closeout submittals specified in individual Sections, including specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
4. Submit maintenance material submittals specified in individual Sections, including tools, spare parts, extra materials, and similar items, and deliver to location designated by Engineer. Label with manufacturer's name and model number where applicable.

    a. Schedule of Maintenance Material Items: Prepare and submit schedule of maintenance material submittal items, including name and quantity of each item and name and number of related Specification Section. Obtain Engineer's signature for receipt of submittals.

5. Submit test; adjust/balance records.
6. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.

C. Procedures Prior to Substantial Completion: Complete the following a minimum of 14 days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.

1. Advise Owner of pending insurance changeover requirements.
2. Make final changeover of permanent locks and deliver keys to Owner. Advise Owner's personnel of changeover in security provisions.
3. Complete start-up and testing of systems and equipment.
4. Perform preventive maintenance on equipment used prior to Substantial Completion.
5. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Submit demonstration and training video as required.
6. Advise Owner of changeover in heat and other utilities.
7. Participate with Owner in conducting inspection and walkthrough with local emergency responders.
8. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
9. Complete final cleaning requirements, including touchup painting.

10. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.

D. Inspection: Submit a written request for inspection to determine Substantial Completion a minimum of 14 days prior to date the work will be completed and ready for final inspection and tests. On receipt of request, Engineer and Construction Manager will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by Engineer, that must be completed or corrected before certificate will be issued.

1. Re-inspection: Request re-inspection when the Work identified in previous inspections as incomplete is completed or corrected.
2. Results of completed inspection will form the basis of requirements for final completion.

1.5 FINAL COMPLETION PROCEDURES

A. Preliminary Procedures: Before requesting final inspection for determining final completion, complete the following:
1. Certified List of Incomplete Items: Submit certified copy of Engineer's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Engineer. Certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
2. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems.

B. Inspection: Submit a written request for final inspection to determine acceptance. On receipt of request, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.

1. Re-inspection: Request re-inspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.6 SUBMITTAL OF PROJECT WARRANTIES

A. Time of Submittal: Submit written warranties on request of Engineer for designated portions of the Work for which commencement of warranties other than date of Substantial Completion is indicated, or when delay in submittal of warranties might limit Owner's rights under warranty.

B. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.

1. Bind warranties and bonds in heavy-duty, three-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.
2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or

installation, including the name of the product and the name, address, and telephone number of Installer.

3. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, and name of Contractor.
4. Warranty Electronic File: Scan warranties and bonds and assemble complete warranty and bond submittal package into a single indexed electronic PDF file with links enabling non-expiring navigation to each item. Provide bookmarked table of contents at beginning of document.

C. Provide additional copies of each warranty to include in operation and maintenance manuals.

D. Operating manuals, technical manuals and instructions. The Contractor's attention is directed to the condition that one percent (1%) of the contract price will be deducted from any monies due the Contractor as progress payments if at the seventy-five percent (75%) construction completion point the approved technical manuals have not been submitted in accordance with Section 013300 entitled, "Contractor Submittals". The aforementioned amount will be retained by the Owner as the agreed estimated value of the approved technical manuals. Any such retention of money for failure to submit the approved technical manuals on or before the seventy-five percent (75%) construction completion point shall be in addition to the retention of any payments due to the Contractor as specified in Article 4 of the Contract.

E. Releases from all parties who are entitled to claims against the subject project, property or improvement pursuant to the provisions of law.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to human health, property, or finished surfaces.

1. Use cleaning products that comply with Green Seal's GS-37; if GS-37 is not applicable, use products that comply with the Colorado Code of Regulations maximum allowable VOC levels.

PART 3 - EXECUTION

3.1 FINAL CLEANING

A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:

    a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
    b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
    c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
    d. Remove tools, construction equipment, machinery, and surplus material from Project site.
    e. Remove snow and ice to provide safe access to buildings and equipment.
    f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
    g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
    h. Sweep concrete floors broom clean in unoccupied spaces.
    i. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.
    j. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.
    k. Remove labels that are not permanent.
    l. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
    m. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
    n. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
    o. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.
    p. Leave Project clean and ready for occupancy.

C. Pest Control: Comply with pest control requirements in Section 015000 "Temporary Facilities and Controls." Prepare written report.

3.2 REPAIR OF THE WORK

A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.

B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired.

Restore damaged construction and permanent facilities used during construction to specified condition.

1. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.
2. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that that already show evidence of repair or restoration.

    a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.

3. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.
4. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

END OF SECTION 017700

SECTION 017823 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:

1. Operation and maintenance documentation directory.
2. Emergency manuals.
3. Operation manuals for systems, subsystems, and equipment.
4. Product maintenance manuals.
5. Systems and equipment maintenance manuals.

1.2 CLOSEOUT SUBMITTALS

A. Manual Content: Operations and maintenance manual content is specified in individual Specification Sections to be reviewed at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.

1. Engineer will comment on whether content of operations and maintenance submittals is acceptable.
2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.

B. Format: Submit operations and maintenance manuals in the following format:

1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to Engineer.

   a. Name each indexed document file in composite electronic index with applicable item name. Include a complete, non-expiring, electronically-linked operation and maintenance directory.
   b. Enable inserted reviewer comments on draft submittals.

2. Four (4) paper copies. Include a complete operation and maintenance directory. Enclose title pages and directories in clear plastic sleeves. One set will be provided to the Engineer and three sets to the Owner.

C. Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 15 days before commencing demonstration and training. Engineer will return copy with comments for revision and finalization.

1. Correct or revise each manual to comply with Engineer's comments. Submit copies of each corrected manual within 15 days of receipt of Engineer's comments and prior to commencing demonstration and training.

PART 2 - PRODUCTS

2.1 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Directory: Prepare a single, comprehensive directory of emergency, operation, and maintenance data and materials, listing items and their locations to facilitate ready access to desired information.

B. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment that is not part of a system. Each manual shall contain the following materials, in the order listed:

1. Title page.
2. Table of contents.
3. Manual contents.

C. Title Page: Include the following information:

1. Subject matter included in manual.
2. Name and address of Project.
3. Name and address of Owner.
4. Date of submittal.
5. Name and contact information for Contractor.
6. Name and contact information for Construction Manager.
7. Name and contact information for Engineer.
8. Name and contact information for Commissioning Authority.
9. Names and contact information for major consultants to the Engineer that designed the systems contained in the manuals.
10. Cross-reference to related systems in other operation and maintenance manuals.

D. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

E. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

F. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.

1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
2. File Names and Bookmarks: Enable bookmarking of individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily

navigated file tree. Configure electronic manual to display bookmark panel on opening file.

G. Manuals, Paper Copy: Submit manuals in the form of hard copy, bound and labeled volumes.

1. Binders: Heavy-duty, three-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

   a. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, subject matter of contents. Indicate volume number for multiple-volume sets.

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.
4. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

   a. If oversized drawings are necessary, neatly fold drawings to same size as text pages and use as foldouts.
   b. If drawings are too large to be used as foldouts, carefully fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.2 OPERATION MANUALS

A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:

1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
2. Performance and design criteria.
3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

1. Product name and model number. Use designations for products indicated on Contract Documents.

2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.
6. Limiting conditions.
7. Performance curves.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

C. Operating Procedures: Include the following, as applicable:

1. Start-up procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.
4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

E. Piped Systems: Diagram piping as installed and identify color-coding where required for identification.

2.3 PRODUCT MAINTENANCE MANUALS

A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Product Information: Include the following, as applicable:

1. Product name and model number.
2. Manufacturer's name.
3. Color, pattern, and texture.
4. Material and chemical composition.
5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.

3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

2.4 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:

1. Standard maintenance instructions and bulletins.
2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:

1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
5. Aligning, adjusting, and checking instructions.
6. Demonstration and training video recording, if available.

E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

G. Maintenance Service Contracts: Include copies of maintenance agreements with names and telephone numbers of service agents.

H. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

A. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

B. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

C. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

D. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

E. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to confirm correct illustration of completed installation.

1. Do not use original project record documents as part of operation and maintenance manuals.

F. Comply with Section 017700 "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 017823

SECTION 098000 - PROTECTIVE COATINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Section includes the surface preparation and application requirements of paint systems as specified herein.

B. The coating system schedule included in the drawings, and the specifications herein identify the surfaces to be coated with the designated coating system number including the required surface preparation, and the products to be applied. If used, coating notes on the Drawings are to show or extend the limits of coating schedules, to show exceptions to the schedules, or to clarify or show details for application of the coating systems.

C. Scope of Work

1. The Contractor shall furnish all materials, labor, equipment, and incidentals required to provide a protective coating system for the surfaces listed herein and not otherwise excluded.
2. The work includes surface preparation and cleaning, painting and finishing of interior and exterior exposed items and surfaces such as ceilings, walls, floors, miscellaneous metal, doors, frames, construction signs, guardrails, posts, pipes, fittings, valves, equipment, and all other work obviously required to be painted unless otherwise specified herein or on the Drawings. The omission of minor items in the schedule of work shall not relieve the Contractor of his obligation to include such items where they come within the general intent of the Specifications as stated herein.

1.2 REFERENCES

A. American National Standards Institute:

1. ANSI/NSF Standard 61 Listing of Certified Drinking Water System Components - Health Effects.
2. ANSI Z53.1, Safety Color Code for Marking Physical Hazards.

B. ASTM International (ASTM):

1. ASTM D4263 – Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
2. ASTM D4414 – Standard Practice for Measurement of Wet Film Thickness by Notch Gages
3. ASTM D4417 – Standard Test Method for Field Measurement of Surface Profile of Blast Cleaned Steel.
4. ASTM D6386 – Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting.
5. ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.

6. ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes.

C. International Concrete Repair Institute (ICRI):

1. Guideline No. 310.1 – Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion
2. Guideline No. 310.2 – Selecting and Specifying Concrete Surface Preparation for Sealer, Linings, and Polymer Overlays

D. NACE International, (NACE)

1. NACE RP0287 – Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape
2. NACE SP0188 – Standard Practice for Discontinuity (Holiday) Testing of Protective Linings
3. NACE No. 1/SSPC-SP 5 - White Metal Blast Cleaning.
4. NACE No. 2/SSPC-SP 10 - Near-White Metal Blast Cleaning.
5. NACE No. 3/SSPC-SP 6 Commercial Blast Cleaning
6. NACE No. 6/SSPC-SP13 – Surface Preparation of Concrete

E. National Association of Pipe Fabricators (NAPF)

1. NAPF 500-03 – Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings

F. Occupational Safety and Health Act (OSHA):

1. OSHA 1910.144, Safety Color Code for Marking Physical Hazards.
2. OSHA 1910.145, Specifications for accident prevention signs and tags.

G. SSPC: The Society for Protective Coatings, (SSPC)

1. SSPC PA1 - Shop, Field, and Maintenance Painting of Steel
2. SSPC-PA2 – Paint Application Specification No. 2: Measurement of Dry Coating Thickness with Magnetic Gages.
3. SSPC-PA11 - Protecting Edges, Crevices, and Irregular Steel Surfaces by Stripe Coating
4. SSPC-SP1 Solvent Cleaning
5. SSPC-SP2 Hand Tool Cleaning
6. SSPC-SP3 Power Tool Cleaning
7. SSPC-SP5/NACE No. 1 – White Metal Blast Cleaning
8. SSPC-SP 6/NACE No. 3 - Commercial Blast Cleaning.
9. SSPC-SP 10/NACE No. 2 - Near-White Metal Blast Cleaning.
10. SSPC-SP 13/NACE No. 6 – Surface Preparation of Concrete
11. SSPC-SP16 Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals
12. SSPC-VIS 1 - Guide to Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

H. Unless otherwise specified, references to documents shall mean the documents in effect at the time of receipt of proposals. If referenced documents have been discontinued by the issuing organization

references to those documents shall mean the replacement documents or the last version of the document before it was discontinued.

1.3 DEFINITIONS

A. "Paint" as used herein means all coating systems, materials, including primers, emulsions, enamels, sealers and fillers, and other applied materials whether used as prime, intermediate or finish coats.

B. Dry Film Thickness (DFT): Thickness of fully cured coating, measured in mils.

C. Volatile Organic Compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter per pounds per gallon, as determined by EPA Method 24.

D. The term “exposed” as used in this Section shall mean all items not covered with concrete, masonry, or similar material.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include preparation requirements and application instructions.

1. Submit to the Engineer as provided in the General Conditions and Section 013300: Contractor Submittals, Working Drawings, and Samples; shop drawings, manufacturer's specifications and data on the proposed paint systems and detailed surface preparation, application procedures and dry film thickness (DFT).
2. Submit material manufacturer's technical information, including paint label analysis and application instructions for each material proposed

    a. List each material and cross-reference to specific paint and finish system and application. Identify by manufacturer's catalog number and general classification.
    b. Submit copies of manufacturer's complete color charts for each coating system.
    c. Provide certifications from manufacturers verifying that factory applied prime coats are compatible with specified finish coatings.
    d. Pipe Markers and Safety Signs: Submit copies of manufacturer's technical brochure, including color chart and list of standard signs. Owner will set titles on pipe markers and safety signs.

B. Safety Data Sheets: Copies of current Safety Data Sheets (SDS) for materials.

C. Qualification Data: Submit proof of acceptability of Applicator by manufacturer to Engineer.

D. Jobsite Reports: Submit at the completion of Work
1. Daily Reports: Include surface preparation, ambient conditions, application methods, material applied, material quantities, material batch number, and description of items completed.
2. Applicator shall maintain a copy of records until the expiration of the specified warranty period.

E. Schedule:

1. The Contractor shall submit for approval to the Construction Manager, a complete typewritten Schedule of Painting Operations within 90 days after the Notice to Proceed. This Schedule is

imperative so that the various fabricators or suppliers may be notified of the proper shop prime coat to apply. It shall be the Contractor's responsibility to properly notify and coordinate the fabricator's or suppliers' surface preparation and painting operations with these specifications. Record of notification shall be transmitted to the Construction Manager or be available for review. This Schedule shall include for each surface to be painted, the brand name, generic type, solids by volume, application method, the coverage and the number of coats in order to achieve the specified dry film thickness, and color charts. When the Schedule has been approved, the Contractor shall apply all material in strict accordance with the approved Schedule and the manufacturer's instructions. Wet and dry paint film gauges may be utilized by the Owner to verify the proper application while work is in progress.

2. It is the intent of this section that as much as possible all equipment and piping utilize coating systems specified herein supplied by a single manufacturer. All exceptions must be noted on the Schedule. For each coating system, only one (1) manufacturer's product shall be used.
3. Contractor is responsible for the compatibility of all shop primed and field painted items in this Contract. Furnish information on the characteristics of the finish materials proposed to use, so that compatible prime coats are used. As directed by the Engineer, provide barrier coats over incompatible primers or remove and re-prime. Notify the Engineer in writing of anticipated problems using the coating systems as specified with substrates primed by others.

F. Color Samples: Manufacturer's standard color charts for color selection by Owner.

G. Samples – Painting:

1. Paint colors will be selected by Owner unless other standards are noted. Compliance with all other requirements is the exclusive responsibility of the Contractor.

H. Applicator Qualifications: Submit qualifications as specified under Quality Assurance article.

I. Closeout Submittals:

1. Submit certificate stating Work was properly prepared and painted in accordance with Specifications.
2. Submit manufacturer's certificate stating quantity of paint furnished was sufficient to properly coat all surfaces.
3. Maintenance Manual: Upon completion of work, furnish copies of a detailed maintenance manual including following information:

   a. Product name and number.
   b. Name, address and telephone number of manufacturer and local distributor.
   c. Detailed procedures for routine maintenance and cleaning.
   d. Detailed procedures for light repairs such as dents, scratches and staining.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Coatings: 5 percent, but not less than 1 gal. of each material and color applied.

1.6 QUALITY ASSURANCE

A. Provide the best quality grade of the various types of coatings suitable for use in corrosive water and wastewater treatment and pumping environments as regularly manufactured by approved paint materials manufacturers. Materials not displaying the manufacturer's identification as a standard, best grade product will not be acceptable.

B. Provide undercoat paint produced by the same manufacturer as the finish coats. Undercoat and finish coat paints shall be compatible. Use only thinners approved by the paint manufacturer, list the manufacturer, and use only within recommended limits as listed on the manufacturer's product data sheets.

C. Painting shall be accomplished by experienced painters specializing in industrial painting familiar with all aspects of surface preparations and applications required for this project. Work shall be done in a safe and workmanlike manner.

D. Applicator Qualifications:

1. Successfully painted water and wastewater utility installations for at least five (5) years. Submit name and experience record of painting applicator to Engineer. A list of at least five (5) utility installations painted within the last five (5) years, along with responsible officials, architects or engineers involved with the project, and the approximate contract price may be requested by the Owner or Engineer.
2. Painting applicators whose submissions indicate a lack of experience required to perform the work, or have performed work in an unsatisfactory manner, will not be approved.

E. Pre-Installation Conference:

1. Before start of Work – General Contractor, Applicator, and Manufacturer's Technical Representative shall meet on-site with Engineer to discuss approved products and workmanship for proper surface preparation and application of the coatings.
2. Review foreseeable methods and procedures related to the coating Work, including but not necessarily limited to the following:

   a. Review Project requirements and the Contract Documents.
   b. Review required submittals.
   c. Review requirements of on-site quality control inspection and testing.
   d. Review the requirements for preparing the quality control report as specified herein.
   e. Review availability of materials, tradesmen, equipment and facilities needed to make progress and avoid delays.
   f. Review material storage and staging.
   g. Review equipment storage and staging.
   h. Review waste management and disposal.
   i. Review environmental conditions, other Project conditions, and procedures for coping with unfavorable conditions.
   j. Review regulations concerning code compliance, environmental protection, health, safety, fire and similar considerations.
   k. Review procedures required for the protection of the completed work during the remainder of the construction period.

F. Single-Source Responsibility:

1. Materials shall be products of a single manufacturer or items standard with manufacturer of specified coating materials.
2. Provide secondary materials which are produced or are specifically recommended by coating system manufacturer for compatibility of system.

G. Regulatory Requirements: Conform to applicable codes and ordinances for flame, fuel, smoke and volatile organic compounds (VOC) ratings requirements for finishes at time of application.

H. Acceptable Manufacturers:

1. Tnemec Co. (Where noted otherwise in the coating specification use specified product or equal).
2. Sherwin Williams, subject to meeting the requirements of individual coating systems requirements and the requirements of an "or equal" product as described below.
3. Or Equal. No substitutions will be considered that decrease film thickness, number of coats, surface preparation or generic type of coating specified. Furnish same color selection of substituted manufacturers as manufacturer specified, including accent colors in coating systems. Substitutions must meet the performance requirements of the materials selected.

1.7 DELIVERY, HANDLING AND STORAGE

A. Deliver, store and handle paint in accordance with manufacturer's recommendations, and as supplemented below.

B. Delivery of Materials:

1. Deliver materials to job site in original, new, and unopened packages and containers bearing manufacturer's name and label with following information:

a. Name or title of material.
b. Manufacturer's stock number, batch number and date of manufacture (shelf life).
c. Manufacturer's name.
d. Contents by volume, for major pigment and vehicle constituents.
e. Thinning instructions where recommended.
f. Application instructions.
g. Color name and number.

C. Storage of Materials:

1. Store only acceptable project materials on project site.
2. Store in a suitable location approved by Owner. Keep area clean and accessible.
3. Restrict storage to paint materials and related equipment.
4. Comply with health and fire regulations including the Occupational Safety and Health Act of 1970. Flammable materials shall be separated and stored in a suitable area as required.
5. Keep temperature of storage area above 50° F or manufacturer's recommended storage temperature, whichever is higher. Consult the manufacturer's written literature for storage condition requirements.
6. Containers shall be clearly marked to indicate any hazards connected with the use of the paint and steps which should be taken to prevent injury to those handling the product.

1.8 JOB CONDITIONS

A. Environmental Requirements:

1. Proceed with coating Work only when temperature of substrate, air temperature, relative humidity, dew point and other conditions comply with the manufacturer's written recommendations and when no damaging environmental conditions are forecasted for the time when the material will be vulnerable to such environmental damage. Record such conditions and include in Daily Report.
2. Maintain substrate temperature and ambient temperature before, during and after installation in accordance with manufacturer's instructions.
3. Provide adequate ventilation during installation and full curing periods of the coating.
4. Coatings shall not be applied when ambient air temperature is within 5°F of the dew point and falling.

B. Dust and Contaminants: Protect work and adjacent areas from excessive dust and airborne contaminates during coating application and curing. Schedule Work to avoid excessive dust and airborne contaminants.

1.9 WARRANTY AND GUARANTEES

A. All paint and coatings work performed under these specifications shall be guaranteed by the coatings applicator for 100 percent of the total coated area for both materials and labor against failures during the warranty period.

B. Failure under this warranty shall include flaking, peeling, or delaminating of the coating due to aging, chemical attack, or poor workmanship; but it shall not include areas which have been damaged by unusual chemical, thermal, or mechanical abuse.

1.10 SURFACES TO BE COATED

A. Design Requirements:

1. Confirm that surfaces are properly prepared, proper primer applied to correct mil thickness, and finish coat is compatible with primer coat and applied to correct mil thickness. This requirement applies to all equipment and material, whether the total process is done in the shop, in the field, or partially in shop and partially in field.
2. Provide paint products supplied by one manufacturer unless otherwise approved by the Engineer.

B. Paint all exposed surfaces, except where natural finish of material is specifically noted as a surface not to be painted.

C. Where items or surfaces are not specifically mentioned, paint these the same as adjacent similar materials or areas.

D. The following items will not be painted unless otherwise noted.

1. Any code-requiring labels, such as Underwriters' Laboratories and Factory Mutual, or any equipment identification, performance rating, name or nomenclature plates.

2. Any moving parts of operating units, mechanical and electrical parts, such as valve and damper operators, linkages, sensing devices, motor and fan shafts, unless otherwise indicated.
3. Aluminum except where in contact with dissimilar metals.
4. Fiberglass items including but not limited to handrails, walkways, toeboards, windows, louvers, fans, grating, and tanks.
5. Stainless steel, chromium plate/polished chrome, anodized aluminum, nickel and similar finished products.
6. Brass and bronze other than exposed utility tubing.
7. Flexible couplings, lubricated bearing surfaces, insulation and plastic pipe or duct interiors.
8. Plastic switch plates and receptacle plates.
9. Signs and nameplates.
10. Finish hardware.
11. Packing glands and other adjustable parts, unless otherwise indicated.
12. Portions of metal, other than aluminum, embedded in concrete. This does not apply to the back face of items mounted to concrete or masonry surfaces which shall be painted before erection. This also does not apply to concrete encased piping which shall be coated as specified in the Coating Schedule included in the drawings. Aluminum to be embedded in, or in contact with, concrete shall be coated to prevent electrolysis.
13. Galvanized metals unless specifically noted otherwise.
14. Prefinished Items.

    a. Unless otherwise shown or specified, factory finishing such as baked-on factory porcelain, polyvinyl fluoride or other similar finish is specified for such items as, but not limited to, mechanical and electrical equipment such as instruments, light fixtures and distribution cabinets. Touch up factory finished items with paint supplied by the item manufacturer. As directed by Engineer, field paint damaged prefinished items or return them to the factory for repair and repainting.
    b. Any prefinished item not having generic type of paint or proper mil thickness to withstand corrosive atmosphere of water treatment plants, wastewater treatment plants and/or pumping stations shall be returned to the factory for painting or shall have additional coats applied in the field.

PART 2 - PRODUCTS

2.1 MATERIALS

A. The following coating systems list a product by name to establish a standard of quality; other products of the same generic types may be submitted to the Engineer for approval as described in Paragraph 1.6 H., herein. When other than the specified coating system is proposed, the Contractor shall submit on a typewritten list giving the proposed coatings, brand, trade name, generic type and catalog number of the proposed system and the requested test results for the Engineer's approval.

B. Paint used in successive field coats shall be produced by the same manufacturer. Paint used in the first field coat over shop painted or previously painted surfaces shall cause no wrinkling, lifting, or other damage to underlying paint. Shop paint shall be of the same type and manufacturer as used for field painting by the Contractor.

C. Provide paints, pipe marker and safety signs of durable and washable quality. Use materials which will withstand normal washing as required to remove grease, oil, chemicals, etc., without showing discoloration, loss of gloss, staining, or other damage.

2.2 COLORS AND FINISHES

A. Provide surface treatments and finishes as specified in paragraph 2.4 of this Section.

B. Color Schedule: Colors for painted surfaces will be selected by Owner or as shown on Drawings.

C. Piping Color Code: Colors for piping will be in accordance with Section 220553 "Identification for Plumbing Piping and Equipment".

D. Use representative colors when preparing samples for Engineer's review. Final acceptance of colors will be from samples applied on the job.

E. Color Pigments: Pure, nonfading, applicable types to suit substrates and service indicated.

F. Paints specified for application on submerged metal in contact with potable water shall meet NSF 61 and be approved by the governing health and safety codes.

2.3 MANUFACTURERS

A. Products of Tnemec Company, Inc., Kansas City, Missouri are listed to establish a standard of performance and quality.

B. Materials specified are those that have been evaluated for the specific service. Request for material substitutions shall be in accordance with requirements of the project specifications. Equivalent materials of other manufacturers may be submitted on written approval of the Engineer. No request for substitution shall be considered that would decrease film thickness or offer a change in the generic type of coating specified. In no case, will the request be considered unless information is received, in writing, ten (10) days prior to the bid opening date.

C. Requests for substitution shall include:
   1. Manufacturer's literature for each product giving name, product number, generic type, descriptive information, laboratory testing showing results equal to the performance criteria of the products specified herein.
   2. Side by side comparison of the performance attributes of the proposed materials as compared to the specified coating system.
   3. List of ten (10) projects in which each product has been used and rendered satisfactory service.
   4. The sum which will be added to or deducted from the base bid should alternate materials be accepted.

2.4 MATERIALS

A. STEEL – STRUCTURAL, TANKS, PIPE AND EQUIPMENT

1. SYSTEM 101 - EXTERIOR EXPOSED – STRUCTURAL, TANKS, AND EQUIPMENT

a. Surface Preparation: SSPC-SP6 Commercial Blast Cleaning with a minimum angular anchor profile of 1.5 mils
b. Primer: Hydro-Zinc Series 94-H20 2.5 – 3.5 mils dft
c. Intermediate: Hi-Build Epoxoline II Series L69 at 3.0 – 5.0 mils dft
d. Finish: Finish: Endura-Shield Series 1095 2.0 to 3.0 mils dft

2. SYSTEM 102 - EXTERIOR EXPOSED – PIPE

a. Surface Preparation: SSPC-SP6 Commercial Blast Cleaning with a minimum angular anchor profile of 1.5 mils
b. Primer: Hi-Build Epoxoline II Series L69 at 3.0 – 5.0 mils dft
c. Intermediate: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Finish: Endura-Shield Series 1095 2.0 to 3.0 mils dft

3. SYSTEM 103- INTERIOR EXPOSED

a. Surface Preparation: SSPC-SP6 Commercial Blast Cleaning with a minimum angular anchor profile of 1.5 mils
b. Primer: Hi-Build Epoxoline II Series L69 at 3.0 – 5.0 mils dft
c. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

4. SYSTEM 104 - IMMERSION – TYPICAL MUNICIPAL WASTEWATER

a. Surface Preparation: SSPC-SP10 Near White Blast Cleaning with a minimum angular anchor profile of 1.5 mils
b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
c. Intermediate: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

5. SYSTEM 105 - IMMERSION – POTABLE WATER REQUIRING NSF 61 CERTIFICATION
a. N/A

6. SYSTEM 106 - IMMERSION – MODERATE TO SEVERE CHEMICAL EXPOSURE INCLUDING H_2S VAPOR EXPOSURE – SMALL STRUCTURES - MECHANISMS

a. Surface Preparation: SSPC-SP10 Near-White Blast Cleaning with a minimum angular anchor profile of 2.0 mils
b. Primer: Tneme-Liner Series 61 at 10.0 – 12.0 mils dft
c. Finish: Tneme-Liner Series 61 at 10.0 – 12.0 mils dft

7. SEVERE WASTEWATER H_2S VAPOR EXPOSURE – LARGE STRUCTURES

a. N/A

8. SYSTEM 107 - BELOW GRADE

a. Steel Surface Preparation: SSPC-SP10 Near White Blast Cleaning
b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
c. Intermediate: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

9. SYSTEM 108 – MARGINALLY PREPARED SURFACES (MAINTENANCE) (NON-IMMERSION) INTERIOR/EXTERIOR

   a. Surface Preparation: SSPC-SP2/SP3 Hand and Power Tool Cleaning, feather all rough edges, remove loose rust, dirt, and other surface contaminants with sandpaper, scotch brite, etc.
   b. Primer: Chem-Build Series 135 3.0 to 5.0 mils dft
   c. Interior Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
   d. Exterior Finish: Endura-Shield Series 1095 2.0 to 3.0 mils dft

B. FACTORY PRIMED STEEL – DOORS, FRAMES & EQUIPMENT

1. SYSTEM 121 - CHEMICAL EXPOSURE

   a. Surface Preparation: SSPC-SP2/SP3 Hand and Power Tool Cleaning, feather all rough edges, remove loose rust, dirt, and other surface contaminants with sandpaper, scotch brite, etc.
   b. Primer: Chem-Build Series 135 3.0 to 5.0 mils dft
   c. Finish: Endura-Shield Series 1095 2.0 to 3.0 mils dft

2. SYSTEM 122 - NON-CHEMICAL EXPOSURE

   a. Surface Preparation: Clean & Dry
   b. Primer: Enduratone Series 1028 at 2.0 – 3.0 mils dft
   c. Finish: Enduratone Series 1028 at 2.0 – 3.0 mils dft

C. GALVANIZED STEEL, STAINLESS STEELS, & NON- FERROUS METALS

1. SYSTEM 201 – INTERIOR/EXTERIOR EXPOSED PIPE & MISC. FABRICATIONS

   a. Surface Preparation: SSPC-SP16 Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals to achieve a uniform anchor profile of 1.0 – 2.0 mils
   b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
   c. Interior Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
   d. Exterior Finish: Endura-Shield Series 1095 2.0 to 3.0 mils dft

2. SYSTEM 202 –IMMERSION PIPE & MISC. FABRICATIONS

   a. Surface Preparation: SSPC-SP16 Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals to achieve a uniform anchor profile of 1.0 – 2.0 mils
   b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
   c. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

3. SYSTEM 203 –DISSIMILAR METAL INSULATION – ALUMINUM IN CONTACT WITH CONCRETE, STAINLESS IN CONTACT WITH CARBON STEEL.

   a. Surface Preparation: SSPC-SP16 Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals to achieve a uniform anchor profile of 2.0 – 3.0 mils

b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
c. Intermediate: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

4. SYSTEM 204 – INTERIOR DRY EXPOSED – OVERHEAD DECKING AND DUCT WORK

a. Surface Preparation: Clean and Dry
b. Prime: Uni-Bond DF Series V115 at 2.0 – 4.0 dft mils
c. Finish: Uni-Bond DF Series V115 at 2.0 – 4.0 dft mils

D. DUCTILE OR CAST IRON – PIPE, PUMPS & VALVES

1. SYSTEM 211 - BELOW GRADE

a. Ductile Iron Surface Preparation: Prepare all surfaces as per NAPF 500-03 - Uniformly abrasive blast the entire exterior surface using abrasive to an NAPF 500-03-04 with a minimum angular anchor profile of 1.5 mils.
b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
c. Intermediate: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

2. SYSTEM 212 –EXTERIOR EXPOSED (OUTSIDE DIAMETER)

a. Surface Preparation of Ductile Iron: Prepare all surfaces as per NAPF 500-03 - Uniformly abrasive blast the entire exterior surface using abrasive to an NAPF 500-03-04 with a minimum angular anchor profile of 1.5 mils.
b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
c. Intermediate: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Endura-Shield Series 1095 2.0 to 3.0 mils dft

3. SYSTEM 213 – INTERIOR EXPOSED AND/OR IMMERSION (OUTSIDE DIAMETER)

a. Surface Preparation of Ductile Iron: Prepare all surfaces as per NAPF 500-03 - Uniformly abrasive blast the entire exterior surface using abrasive to an NAPF 500-03-04 with a minimum angular anchor profile of 1.5 mils.
b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
c. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

4. INTERIOR EXPOSED AND/OR IMMERSION, H_2S VAPOR EXPOSURE (INSIDE DIAMETER)

a. N/A

E. PVC

1. SYSTEM 221 - EXTERIOR EXPOSED

a. Surface Preparation: Scarify, Clean and Dry
b. Primer: Hi-Build Epoxoline II Series L69 at 2.0 – 4.0 mils dft
c. Finish: Endura-Shield Series 1095 2.0 to 3.0 mils dft

2. SYSTEM 222- INTERIOR EXPOSED

a. Surface Preparation: Scarify, Clean and Dry
b. Primer: Hi-Build Epoxoline II Series L69 at 2.0 – 4.0 mils dft
c. Finish: Hi-Build Epoxoline II Series L69 at 2.0 – 4.0 mils dft

F. CONCRETE & MASONRY –PRECAST, POURED-IN-PLACE, CAST-IN-PLACE AND CMU

1. SYSTEM 301 – INTERIOR WALLS NON-CHEMICAL EXPOSED

a. Surface Preparation: SSPC-SP13/NACE 6 – Clean & Dry
b. Filler for Porous Surfaces: Epoxoblock WB Series 1254 at 75 – 150 sq. ft./gal
c. Primer: Enduratone Series 1028 at 2.0 – 3.0 mils dft
d. Finish Enduratone Series 1028 at 2.0 – 3.0 mils dft

2. SYSTEM 302 - INTERIOR WALLS CHEMICAL EXPOSED

a. Surface Preparation: SSPC-SP13/NACE 6 – Clean & Dry
b. Filler (if needed): Epoxoblock WB Series 1254 at 75 – 150 sq. ft./gal
c. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

3. ULTRAFILTRATION TANKS – MEMBRANE BASINS – NSF61 POTABLE WATER

a. N/A

4. SYSTEM 306 – BELOW GRADE OR IMMERSION

a. Surface Preparation: SSPC-SP13/NACE 6, ICRI CSP 3
b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
c. Intermediate: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

5. SYSTEM 307 – IMMERSION - MODERATE CHEMICAL AND H_2S EXPOSURE

a. Surface Preparation: SSPC-SP13/NACE 6, ICRI CSP 2-3
b. Primer: Tneme-Liner Series 61 at 10.0 – 12.0 mils dft
c. Finish: Tneme-Liner Series 61 at 10.0 – 12.0 mils dft

6. SYSTEM 308 - WASTEWATER H_2S VAPOR EXPOSURE

a. Surface Preparation: Abrasive Blast to remove laitance, form release agents, curing compounds, sealers, and other contaminants and to provide surface profile in accordance with SSPC-SP13/NACE6, ICRI CSP5.
b. Filler: MortarClad Series 218 - parge coat of entire surface at a minimum thickness of 1/16" inch.
c. Finish: Perma-Glaze Series 435 at 30 - 40 mils DFT applied in multiple coats

G. CONCRETE FLOORS

1. SYSTEM 311– LIGHT TRAFFIC, MILD CHEMICAL EXPOSURE

a. Surface Preparation: SSPC-SP13/NACE 6, Minimum ICRI CSP-2
b. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
c. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

2. SYSTEM 312– MODERATE TO SEVERE ABUSE, CHEMICAL EXPOSURE
a. Surface Preparation: SSPC-SP13/NACE 6, Minimum ICRI CSP-3
b. Primer: Epoxoprime Series 201 at 6.0 – 8.0 mils dft
c. Intermediate: Tneme-Glaze Series 282 at 6.0 – 8.0 mil dft
d. Finish: Tneme-Glaze Series 282 at 6.0 – 8.0 mil dft

3. SYSTEM 313– DRY AREAS – WAREHOUSE STORAGE

a. Surface Preparation: Clean and Dry – as per product data sheet
b. Finish: CT Densifyer Series 629 at 300 – 350 square feet per gallon

4. RESINOUS FLOORING

a. N/A

H. CONCRETE – SECONDARY CONTAINMENT

1. N/A

I. WALLS

1. SYSTEM 401 - GYPSUM WALL BOARD - INTERIOR

a. Prime: Uni-Bond DF Series V115 at 2.0 – 4.0 mils dft
b. Intermediate: Enduratone Series 1028 at 2.0 – 3.0 mils dft
c. Finish: Enduratone Series 1028 at 2.0 – 3.0 mils dft

2. SYSTEM 402 - WALL BOARD – WATER RESISTANT – INTERIOR WALLS CHEMICAL EXPOSURE

a. Surface Preparation: Clean & Dry
b. Surfacer/Filler for joints and screw holes: Surfacing Epoxy Series 215 and Series 273 Part D fiberglass tape
c. Primer: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft
d. Finish: Hi-Build Epoxoline II Series L69 at 4.0 – 6.0 mils dft

J. WOOD

1. SYSTEM 411 - INTERIOR

a. Surface Preparation: Sand rough areas. Clean and dry.
b. Prime: Uni-Bond DF Series V115 at 2.0 – 4.0 mils dft
c. Intermediate: Enduratone Series 1028 at 2.0 – 3.0 mils dft
d. Finish: Enduratone Series 1028 at 2.0 – 3.0 mils dft

K. MISCELLAENOUS

1. SYSTEM – 601- EXPOSED SAWCUT CONCRETE FACE AND EXPOSED REINFORCEMENT

a. Surface Preparation: According to manufacturer's recommendations.
b. Coating: Sika Armatec 110 EpoCem, or equal (Coverage per manufacturer's recommendations. Minimum 20 mil. thickness).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which coating systems are to be applied. Notify Engineer of areas or conditions not acceptable. Do not begin surface preparation or application until unacceptable areas or conditions have been corrected.

B. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions otherwise detrimental to formation of a durable paint film.

C. Remove by blast cleaning to SSPC-SP 10 Near White Blast Cleaning any bitumastic coating or improper primer on any material or equipment which is to be painted and arrives at the construction site with a bitumastic coating or a priming system not specified in paragraph 2.4 Coating Systems.

3.2 PROTECTION OF SURFACES NOT SCHEDULED TO BE COATED

A. Protect surrounding areas and surfaces not scheduled to be coated from damage during surface preparation and application of coatings.

B. Immediately remove coatings that fall on surrounding areas and surfaces not scheduled to be coated.

C. Remove mask, or otherwise protect hardware, lighting fixtures, switchplates, machines, surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not intended to be painted. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting. Mask openings in motors and equipment to prevent abrasives, paint and other materials from entering.

D. Exercise care not to damage adjacent work during sandblasting operations. Conduct spray painting under controlled conditions. Promptly repair any damage to adjacent work or adjoining property occurring from sandblasting or spray-painting operations.

3.3 SURFACE PREPARATION

A. Surfaces shall be prepared in accordance with manufacturer's written instructions as outlined in the product data sheet and application guides.

1. Surface preparation shall be as specified in the designated coating system.

B. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce coating systems indicated.

C. Steel – Structural, Tanks, Pipe and Equipment:
1. Grind smooth to a rounded contour sharp edges and welds, and remove weld splatter.
2. Prior to the specified surface preparation SSPC-SP1 Solvent Cleaning shall be performed to all surfaces.
3. SSPC-SP2 Hand Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by hand chipping, scraping, sanding, and wire brushing.
4. SSPC-SP3 Power Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by power tool chipping, descaling, sanding, wire brushing, and grinding.
5. SSPC-SP5/NACE 1 White Metal Blast Cleaning: Removal of all visible rust, oil, grease, soil, dust, mill scale, paint, oxides, corrosion products and foreign matter by blast cleaning.
6. SSPC-SP6/NACE 3 Commercial Blast Cleaning: Removal of all visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining shall be limited to no more than 33 percent of each 9-square inch of surface area.
7. SSPC-SP10/NACE 2 Near-White Blast Cleaning: Removal of all visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining shall be limited to no more than 5 percent of each 9-square inch of surface area.
8. Apply prime coat before rust bloom forms or within 24-hours, whichever is earlier.
9. Do not allow blast cleaned or bare surfaces to stand overnight before coating.

D. Ductile or Cast Iron – Pipe, Pumps, Valves and Fittings

1. Ductile iron pipe and fittings shall be delivered without asphalt, cement lining, or any other lining.
2. All oils, small deposits of asphalt paint, grease, and soluble deposits shall be removed in accordance with NAPF 500-03-01 Solvent Cleaning prior to abrasive blasting.
3. Exterior Preparation: Uniformly abrasive blast the entire exterior surface using angular abrasive to an NAPF 500-03-04: "External Pipe Surface Condition". When viewed without magnification, the exterior surfaces shall be free of all visible dirt, dust, loose annealing oxide, loose mold coating, rust and other foreign matter. Tightly adherent annealing oxide, mold coating and rust staining may remain on the surface provided they cannot be removed by lifting with a dull putty knife. Any area where rust reappears before application shall be re-blasted. The surface shall contain a minimum angular anchor profile of 1.5 mils in accordance with ASTM D 4417, Method C.

E. Galvanized Steel, Aluminum, Stainless Steel, and Non-Ferrous Metal Substrates:

1. SSPC-SP16 Brush-off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals: Not for carbon steel. Requires sweep blasting of the entire surface to remove all foreign matter. Dense and uniform surface profile is required.
2. The type and size of abrasive shall be selected to produce a surface profile that meets the coating manufacturer's recommendation for the particular coating and service conditions.

F. Wood Substrates:

1. Wood surfaces to be painted shall be cleaned of dirt, oil or other foreign substances with mineral spirits, scrapers, sandpaper or wire brush. Seal knots and pitch pockets with shellac reduced with equal parts of shellac thinner (denatured alcohol) before sandpaper finishing with fine grit and

remove sanding dust. After the prime coat is dry, fill cracks and holes with putty or spackling compound. When filler is hard, sand flush with the surface using fine grit sandpaper. Sand lightly between coats with fine grit, open-coated sandpaper.

G. PVC Substrates:

1. PVC surfaces to be painted shall be clean, dry and free of oil, grease, and other contaminants and lightly sanded to create a surface for coating to adhere to.

H. Concrete and Masonry Substrates:

1. All surfaces must be clean, dry and free of oil, grease and other contaminants, prior to preparation in accordance with NACE No. 6/SSPC-SP13. Concrete surfaces must be sound and capable of supporting the coating system.
2. Prepare concrete surfaces in accordance with NACE No. 6/SSPC-SP13 Joint Surface Preparation Standards and ICRI Technical Guidelines. Shot-blast or mechanically abrade concrete surfaces to remove laitance, curing compounds, hardeners, sealers, existing coatings, and other contaminants and to provide the recommended ICRI-CSP Profile.
3. Cracks, voids and other surface imperfections should be filled with the recommended filler or surfacer prior to the installation of the materials.
4. Treat control joints and other nonmoving substrate cracks to prevent cracks from reflecting through the coating system according to manufacturer's written recommendations.
5. Level or grind concrete substrates to produce a uniform and smooth surface, including removal of sharp edges, ridges, form fins, and other concrete protrusions.
6. All surfaces to be painted or repainted, shall be repaired, cleaned and finished to the standards as specified herein and in Division 3 for new concrete.

I. Gypsum Drywall:

1. Sand joint compound with fine grit, open-coated sandpaper to provide a smooth flat surface. Avoid heavy sanding of the adjacent wall board surfaces, which will raise the nap of the paper covering. Remove dust from the surface by wiping with clean rags or other means. If additional joint finishing is required to provide a smooth surface, the same joint compound of a ready-mixed spackling compound should be used. Putty, patching pencils, caulking or masking tape should not be applied to dry wall surfaces to be painted. Finish level 4 or 5 must be achieved prior to beginning to paint. Level shall be suitable for coating system to be applied.
2. Lightly scuff-sand tape joints after priming to remove raised paper nap. Take care not to sand through the prime coat and remove dust by wiping with clean rags.

3.4 APPLICATION

A. Apply coatings in accordance with manufacturer's written instructions as outlined in the product data sheet, application guides and technical bulletins.

B. The application of coatings to steel substrates shall be in accordance with SSPC PA1 - Shop, Field, and Maintenance Painting of Steel.

C. All painting shall be done by skilled and experienced craftsmen and shall be of highest quality workmanship. Coating systems shall be as specified herein.

D. Use application equipment, tools, pressure settings, and techniques in accordance with manufacturer's instructions.

E. Uniformly apply coatings at spreading rate required to achieve specified Dry Film Thickness (DFT).

F. Apply coatings to be free of film characteristics or defects that would adversely affect performance or appearance of coating systems

G. Paint back sides of access panels and removable or hinged covers to match the exposed surfaces.

H. Equipment manufacturer or supplier shall provide touch-up paint for items with shop applied finish coats.

I. Where specified in the individual sections, primer coat(s) shall be applied in the shop by the equipment manufacturer. The shop coats shall be as specified and shall be compatible with the field coat or coats.

J. Certification: The Contractor shall obtain from the equipment manufacturer or supplier, prior to shipment of equipment, a written certification that surface preparation, coating brand, material, DFT and application method complied with this section.

K. If the shop applied coating is in good condition, as determined by the Engineer, the field application may consist of touching up the shop primer coat to achieve the specified film thickness in accordance with the product data sheet.

   1. The Owner/Engineer reserves the option, however, to require that badly damaged and poorly applied shop coatings be removed and the surfaces recoated in accordance with the specified system requirements.

L. Shop applied coatings of unknown composition shall be completely removed before the indicated coatings are applied.

   1. Valves, castings, ductile or cast-iron pipe, and fabricated pipe or equipment shall be examined for the presence of shop-applied temporary coatings. If present, this coating shall be removed.

M. Shop primed equipment shall be prepared as per manufacturer's recommendations in the field before finish coats are applied.

N. Shop Applied Bituminous Paint or Asphalt Varnish: Abrasive blast clean shop applied bituminous paint or asphalt varnish from surfaces scheduled to receive non-bituminous coatings.

O. In accordance with SSPC-PA11 Protecting Edges, Crevices, and Irregular Steel Surfaces by Stripe Coating shall be applied to edges, angles, weld seams, flanges, nuts and bolts, and other places where insufficient film thicknesses are likely to be present.

P. Each coat of paint shall be of a slightly different shade, to facilitate inspection of surface coverage of each coat.

Q. Sprayed Finishes: Spray paint finish doors, frames and windows, where required. Brush or roller finishes will not be acceptable.

R. Install piping markers and safety signs only after painting and finish work is completed.

3.5 FIELD QUALITY CONTROL, INSPECTION AND TESTING

A. The Applicator shall perform the quality control procedures listed below in conjunction with the requirements of this section.

B. Inspect materials upon receipt to confirm that products are supplied by the approved Manufacturer.

C. Surface Profile and Degree of Surface Cleanliness: Inspect and record substrate profile (anchor pattern) and degree of cleanliness. Surfaces shall meet the manufacturer's recommended anchor profile and degree of blast cleaning.

1. Visually confirm the specified degree of surface cleanliness of the ferrous metal surface in accordance with SSPC-VIS 1.
2. The specified surface profile of the prepared substrate shall be verified in accordance with ASTM D4417 – Method C Replica Tape or NACE RP0287.

D. Concrete Surface Profile: Inspect and record substrate profile. Surface profile shall be equal to the manufacturer's recommendation in accordance with ICRI Guideline 310.2 and SSPC-SP13/NACE No. 6.

1. Compare the substrate profile once every 50 square feet with the Concrete Surface Profile (CSP) comparators in accordance with ICRI Guideline No. 310.2.

E. Concrete Moisture Testing: After surface preparation verify concrete dryness in accordance with one or more of the following moisture tests.

1. ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.

   a. Moisture vapor transmission not to exceed three pounds per 1,000 square feet in a 24-hour period.

2. ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes.

   a. Relative humidity not to exceed 80 percent.

3. ASTM D4263— Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

   a. No moisture present.

4. Consult manufacturer regarding questions and or recommendations in reference to moisture problems or questions.

F. Surface Cleanliness: Prepared surfaces shall be inspected for surface cleanliness after cleaning and drying, prior to the coating application.

G. Measure and record ambient air temperature, relative humidity and dew point temperature once every two hours of each work shift to confirm that the products are being applied within the manufacturer's recommendations.

H. Measure and record substrate temperature once every two hours using an infrared or other surface thermometer to confirm that the products are being applied within the manufacturer's recommendations.

I. Film Thickness:

1. Wet-Film Thickness shall be taken in accordance with ASTM D4414 or other agreed-upon method.
2. The Dry-Film Thickness (DFT) shall be measured in accordance with SSPC-PA2 Measurement of Dry Coating Thickness. Verify DFT of each coat and total DFT of each coating system are as specified.

J. Holiday (Spark) Testing: Upon full cure of coating system numbers 104, 105, and 106 the coating system shall be checked by spark detection in accordance with NACE SP0188 and the Manufacturer's instructions to verify a pinhole-free surface. Areas which do not pass the spark detection test shall be corrected at no cost to the Owner.

1. Submit written reports of the test results and actions taken to correct non-conforming work.

K. The Applicator is responsible for keeping the Engineer informed of progress so that Engineer may provide additional quality control at his discretion.

L. Inspection by the Engineer or others does not absolve the applicator from his responsibilities for quality control inspection and testing as specified herein or as required by the Manufacturer's instructions.

3.6 MANUFACTURER'S FIELD SERVICES

A. Manufacturer's technical representative shall provide technical assistance and guidance for surface preparation and application of coating systems.

3.7 ACCEPTANCE CRITERIA

A. Surfaces shall be prepared, applied, and tested in accordance with the specification and referenced standards herein.

3.8 REPAIR

A. Damaged Materials: Repair or replace damaged materials and surfaces not scheduled to be coated.

B. Damaged Coatings: Touch-up or repair damaged coatings. Touch-up of minor damage shall be acceptable where result is not visibly different from adjacent surfaces. Recoat entire surface where touch-up result is visibly different, either in sheen, texture, or color.

C. Coating Defects: Repair in accordance with manufacturer's instructions coatings that exhibit film characteristics or defects that would adversely affect performance or appearance of coating systems.

3.9 PROTECTION AND CLEANING

A. Protect the completed Work from traffic, physical abuse, immersion and chemical exposure until the complete system has thoroughly cured as per manufacturer's written instructions.

B. At the completion of the Work, Applicator shall remove materials and debris associated with the Work of this Section.

C. Clean surfaces not designated to receive coating. Restore designated areas in a manner acceptable to Engineer.

D. Protect the completed Work from damage until Final Acceptance. Coating damaged in any manner shall be repaired or replaced at the discretion of Engineer, at no additional cost to Owner.

3.10 COATING/FINISH SCHEDULE

A. As shown in Drawings.

END OF SECTION

SECTION 220513 – COMMON MOTOR REQUIREMENTS FOR EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section includes AC induction electric motors to be provided with associated driven equipment. Motor voltage, speed and enclosures are specified in the equipment specifications. Unless otherwise specified, motors shall be provided by the manufacturer of the driven equipment under the provisions of the individual equipment specification.

1.2 MOTOR RATING

A. Motor horsepower ratings as shown on the drawings and noted on the specifications are estimates only and it is the responsibility of the CONTRACTOR and/or VENDOR to furnish motors, electric circuits, power feeds and other equipment whose ratings meet the requirements for the submitted horsepower and amperage.

B. This section applies to electric motors rated 480 V and below.

1.3 CODE AND STANDARDS

A. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction and NEC Articles 220, 250, and 430, as applicable to installation, and construction of motor controllers.

B. AFBMA Compliance: Comply with applicable requirements of AFBMA 9 & 11, "Load Rating and Fatigue Life for Ball and Roller Bearings."

C. UL Compliance: Comply with applicable requirements of UL 674, “Electric Motors and Generators, for Use in Division 1 Hazardous (Classified) Locations” and UL 1004, “Electric Motors”.

D. IEEE Compliance: Comply with recommended practices contained in IEEE Standard 112, "Standard Test Procedures for Polyphase Induction Motors and Generators," and IEEE Standard 841, “Standard for Petroleum and Chemical Industry – Totally Enclosed Fan Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 500 HP”.

E. NEMA Compliance: Comply with applicable requirements of NEMA Standard ICS 2, "Industrial Control Devices, Controllers and Assemblies", NEMA Standard ICS 6, “Enclosures for Industrial Controls and Systems, ”Pub No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)" and NEMA MG 1, “Motors and Generators”.

1.4 MAINTENANCE DATA

A. Submit maintenance data and parts list for each motor and auxiliary component; including troubleshooting maintenance guide. Also, provide product data and shop drawings in a maintenance manual, in accordance with requirements of the Contract Documents.

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's data and installation instructions for each motor in accordance with the individual equipment specification. As a minimum, the following information shall be provided:

1. Manufacturer name, type and model number
2. Motor outline, dimensions and weight
3. Manufacturer’s general descriptive information relative to motor features
4. Type of bearing and method of lubrication
5. Rated size of motor and service factor
6. Temperature rise and insulation rating
7. Full-load rotative speed
8. Efficiency at full, ¾ and ½ load
9. Full load current
10. Locked-rotor current
11. Space heater wattage and voltage, if applicable
12. If a winding overtemperature device is required, provide a response curve for the temperature device, wiring diagram and specifications
13. If a moisture detection system is required, provide a typical wiring diagram and a moisture detection relay to be installed by the CONTRACTOR or VENDOR in the associated motor controller.

B. Shop Drawings: Submit shop drawings of electric motors showing accurately scaled equipment locations and spatial relationships to associated drive equipment.

C. Wiring Diagrams: Submit power and control wiring diagrams for electric motors showing connections to electrical power panels, feeders, and equipment.

D. Operations and Maintenance Data: Submit operation and maintenance information.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide electric motors and ancillary components that comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for a complete installation.

2.2 SERVICE CONDITIONS

A. Unless specified otherwise, motors shall be suitable for continuous operation at an elevation of 0 to 3000 feet above mean sea level.

B. Unless specified otherwise, motors located outdoors shall be suitable for continuous operation from -25 to 50°C; motors located indoors shall be suitable for continuous operation from 0 to 50°C.

C. All motors shall be able to operate under power supply variations in accordance with NEMA MG 1 – 14.30.

2.3 NAMEPLATES

A. Motor nameplates shall be engraved or stamped stainless steel. Information shall include those items as enumerated in NEMA Standard MG 1, as applicable. Nameplates shall be permanently fastened to the motor frame and shall be visibly positioned for inspection.

2.4 CONSTRUCTION

A. All motors provided under this specification shall have the following features of construction:

1. Frames shall be steel for motors smaller than ½ horsepower and cast iron for motors ½ horsepower and larger.
2. Cast metal shrouds and covers for non-sparking fan blades.
3. Non-hygroscopic motor leads.
4. NEMA Design-B as standard design. Other designs if required must be submitted and approved in writing by the ENGINEER.
5. Motor Service Factor of 1.15 for Sine-Wave and 1.0 for Inverter Duty.
6. Grounding terminal
7. Windings shall be copper
8. Rotor cages shall be die cast aluminum or fabricated copper
9. Shafts shall be made from carbon steel.

2.5 MOTORS LESS THAN ½ HORSEPOWER

A. General:

1. Unless specified otherwise, motors less than ½ horsepower shall be squirrel cage, single phase, capacitor start, induction run type.
2. Single phase motors shall have class B insulation as a minimum.
3. Motors for fans less than 1/8 horsepower may be split-phase or shaded pole type.
4. Winding shall be copper.

B. Rating:

1. Unless specified otherwise, motors less than ½ horsepower shall be rated for operation at 115 volts, single phase, 60 Hz, and shall be continuous-time rated in conformance with NEMA Standard MG 1 – 10.35.
2. Dual voltage (115/230) rated motors are acceptable if all leads are brought out to the conduit box.
3. Motors shall be non-overloading at all points of the equipment operation.

2.6 MOTORS ½ HORSEPOWER AND LARGER

A. General:

1. Unless specified otherwise, motors ½ horsepower and larger shall be 3 phase, squirrel cage, full voltage start induction type.
2. Unless otherwise specified, motors shall have a NEMA MG 1-1.16 design letter B or C torque characteristic as required by the driven equipment's starting torque requirement.
3. Winding shall be copper.
4. Motors shall be equipped with a set of thermal overload switches with dry contacts available at the motor terminal box:

B. Rating:

1. Unless specified otherwise, motors ½ horsepower and larger shall be rated for operation at 460 volts, 3 phase, 60 Hz, and shall be continuous-time rated in conformance with NEMA Standard MG 1 – 10.35.
2. Dual voltage (230/460) rated motors are acceptable if all leads are brought out to the conduit box.
3. Motors for variable frequency systems shall not be required to deliver more than 80% of the motor's service factor rating by any load imposed by the driven machine at any specified operating condition or any condition imposed by the driven machine's performance curve at maximum operating speed.

C. Enclosures and Insulation:

1. Motors shall be classified as Type 1 (Process) or Type 2 (Explosion proof) based upon the location of the motor and the associated area classification.
2. Temperature rise for all motors shall not exceed that permitted by Note II, Paragraph 12.42 of NEMA MG 1.
3. Motor Insulation shall be non-hygroscopic.
4. Type 1 motors (Process):

    a. Type 1 motors shall be premium energy-efficient motors, totally enclosed, fan cooled (TEFC)
    b. All motors shall have Class F insulation with Class B temperature rise.
    c. All internal surfaces shall be coated with an epoxy paint.
    d. Motors shall be rated for corrosive atmosphere duty.

5. Type 2 Motors (Explosion Proof):

   a. Explosion proof motors shall be UL listed in accordance with UL 674 for Class I, Group D hazardous atmospheres.
   b. The motor shall have Class F insulation.
   c. A UL-approved Type 316 stainless steel breather/drain device shall be provided in the motor drain hole.
   d. The motor shall be provided with a frame temperature thermostat which meets the UL frame temperature limit code T2A (280°C). The thermostat shall contain an automatically reset, normally closed contact rated 2 amperes at 230 VAC.

2.7 MOTORS FOR VARIABLE FREQUENCY DRIVES

A. Motors intended for use with variable frequency drives shall be compatible with the characteristics of the intended variable frequency inverter.

B. Motors shall be Type 1 or Type 2 as specified in 2.06C.

C. Motors shall withstand a pulse voltage of at least 1750 volts with a rate of rise up to 750V per microsecond.

D. Motors shall be certified by the manufacturer as suitable for inverter duty and shall have as a minimum a 10:1 turndown ratio (6-60Hz).

E. Motors shall be capable of running above the rated RPM up to 70 Hz (116.67% of rated RPM) so long as the load current does not exceed the full load amps of the motor.

2.8 MOTOR EFFICIENCIES

A. Type 1 and Type 2 motors in accordance with NEMA MG 1 Table 12-11 and 12-12 and Type 2 in accordance with IEEE 841 Table 2 motor minimum nameplate efficiency for 900, 1200 and 1800 rpm motors, when operating on a sinusoidal power source shall conform to the following (in accordance with IEEE 112B testing procedures):

Motor Horsepower	Guaranteed Minimum Efficiency (%)		
	900 RPM	1200 RPM	1800 RPM
1	70.0%	78.5%	81.5%
1.5	72.0%	81.5%	82.5%
2	80.0%	81.5%	82.5%
3	81.5%	86.5%	84.0%
5	82.5%	86.5%	84.0%
7.5	82.5%	88.5%	88.5%
10	86.5%	88.5%	88.5%
15	86.5%	89.5%	89.5%
20	87.5%	90.2%	91.7%
25	87.5%	91.0%	91.7%
30	89.5%	91.0%	91.7%

40	89.5%	92.4%	92.4%
50	90.2%	92.4%	92.4%
60	90.2%	93.0%	93.0%
75	91.7%	93.0%	93.6%
100	91.7%	93.6%	94.1%
125	92.4%	93.6%	94.1%
150	92.4%	94.5%	94.5%
200	92.4%	94.5%	94.5%
250	93.6%	94.1%	94.1%

2.9 CONDUIT BOXES

A. Conduit boxes shall be sized based on the conduit number and conduit size indicated on the drawings. Provide over-sized boxes with the number of openings as required to accommodate the conduits required.

B. Conduit boxes shall be split construction with threaded hubs and shall conform to IEEE 841 for Type 1 and Type 2 motors. Motors shall be furnished with petroleum-resistant gaskets at the base of the conduit box and between the halves of the conduit box.

C. Conduit boxes shall be designed to rotate in order to permit installation in any of four positions 90 degrees apart.

2.10 BEARINGS

A. Bearings may be oil or grease lubricated ball or angle contact roller bearing rated for a minimum L-10 life of 100,000 hours in accordance with ABMA 9 or 100 at the ambient temperature specified. Motor designs employing cartridge type bearings will not be accepted. Bearings shall be fitted with lubricant fill and drain or relief fittings. Belt loads shall not exceed forces calculated from NEMA MG 1 Table 14-1.

2.11 LIFTING EYES

A. Motors weighing more than 50 pounds shall be fitted with at least one lifting eye and motors weighing over 150 pounds shall be fitted with two lifting eyes.

2.12 SPACE HEATERS

A. Motors that are located outdoors shall be equipped with Space Heaters to prevent condensation inside the motor enclosure after motor shutdown and maintain the temperature of the windings at not less than 5°C above outside ambient temperature.

B. Heaters shall be flexible wraparound type rated 120 volts, single phase, 60 Hz unless otherwise noted. The space heater rating in watts and volts shall be noted on the motor nameplate or on a

second nameplate. Space heater leads H1 and H2 shall be brought to a separate terminal block or pigtails in the motor conduit box or separate conduit box with a threaded conduit opening.

PART 3 - EXECUTION

A. Install electric in accordance with equipment manufacturer's written instructions, and with recognized industry practices. Comply with applicable requirements of NEC, UL, and NEMA standards, to insure that products fulfill requirements.

B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

C. Ensure that the motor is properly grounded from the incoming motor leads and that the frame is bonded to the grounding electrode system.

D. Verify breather/drain fittings have been installed as specified.

E. Prior to energizing, check circuitry for electrical continuity, and for short-circuits. Winding insulation resistance for motors shall not be less than 10-megohms measured with a 1000-VAC megohmeter at 1-minute at or corrected to 40°C.

F. Check rotation of each motor for proper direction.

G. Upon completion of installation of motor controller equipment and electrical circuitry, energize controller circuitry and demonstrate functioning of equipment in accordance with requirements.

END OF SECTION 220513

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SECTION 262923 - VARIABLE-FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, pre-assembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. See Section 26 24 19 "Motor-Control Centers" for VFDs installed in motor-control centers.

1.2 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).
B. CPT: Control power transformer.
C. EMI: Electromagnetic interference.
D. IGBT: Insulated-gate bipolar transistor.
E. LAN: Local area network.
F. LED: Light-emitting diode.
G. MCP: Motor-circuit protector.
H. NC: Normally closed.
I. NO: Normally open.
J. OCPD: Overcurrent protective device.
K. PCC: Point of Common Coupling
L. PID: Control action, proportional plus integral plus derivative.
M. PWM: Pulse-width modulated.
N. P&ID: Process & Instrumentation Diagram
O. RFI: Radio-frequency interference.
P. SCADA: Supervisory control and data acquisition.
Q. TDD: Total Demand Distortion
R. THD: Total Harmonic Distortion
S. VFD: Variable-frequency drive.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated.

B. System Harmonics Analysis: For each VFD and for the distribution system as a whole.

C. Shop Drawings: For each VFD indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings.
2. Schematic and Connection Wiring Diagrams: For power, signal, communications, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFDs. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Seismic Qualification Certificates: For VFDs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

C. Product certificates.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test VFD according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Rockwell Automation, Inc.; Allen-Bradley PowerFlex 700 series drives.
2. Schneider Electric, Inc.; Altivar Process 630 series drives.
3. Eaton SVX/SPX9000 series drives.

B. General Requirements for VFDs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. Application: Constant torque and variable torque.

D. VFD Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

F. Output Rating: Three-phase; 10 to 200 (60 as programmed default) Hz, programmable as voltage proportional to frequency throughout voltage range or with sensorless vector control; maximum voltage equals input voltage.

G. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFD input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.

4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: Equal to the rating of the gear feeding the drive. If not listed, 65 kA.
7. Ambient Temperature Rating: Not less than 14 deg F (minus 10 deg C) and not exceeding 122 deg F (50 deg C). This is specifically the requirement for the VFD unit itself and not the overall panel assembly. The overall assembly shall meet the requirements of 260000-1.4-A-8 which requires the overall assembly to operate at an ambient temperature of up to 104°F. Electrical equipment not rated for operation at that temperature shall be provided with air conditioning. The majority of the MCC's for the project are located indoors in air-conditioned rooms which satisfies this requirement. VFD assemblies shall have appropriately designed ventilation and or air conditioning so as to protect the internal components and to keep internal panel temperatures below the internal components' rated temperatures.
8. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F (70 deg C)
9. Humidity Rating: Less than 95 percent (noncondensing).
10. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
11. Vibration Withstand: Comply with IEC 60068-2-6.
12. Overload Capability: VFD system shall be rated for continuous operation at a minimum of 110% of motor load full load amps (FLA) times the motor service factor. Variable torque inverters shall be capable of delivering 110% of continuous rating for a minimum of 60 seconds. Constant torque inverters shall be capable of delivering 150% of continuous rating for a minimum of 60 seconds.
13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
14. Speed Regulation: Plus or minus 0.6 Hz.
15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
16. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

H. Inverter Logic: Microprocessor based, VFD isolated from all power circuits.

I. Isolated Control Interface: Allows VFDs to follow remote-control electrical signal over a minimum 100:1 speed range.

J. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

K. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.

3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFD and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor overtemperature fault.

L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

M. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

N. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

O. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to provide high-starting torque and increased torque at slow speeds.

P. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

Q. Integral Input Disconnecting Means and OCPD: NEMA AB 1, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFD input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.

2.2 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. VFD Fault.
4. All other lights as shown on the design drawings

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

C. Historical Logging Information and Displays:

1. Running log of total power versus time.
2. Total run time.
3. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFD door and connected to display VFD parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. Speed Reference: The VFD drive shall be capable of being controlled locally by a speed potentiometer or remotely by a 4- to 20-mA dc signal. The 4- to 20-mA signal shall be galvanically isolated and input resistance shall not exceed 250 ohms.

b. A minimum of two programmable analog inputs shall be provided and would be typically used for PID process variable and set point. These signals shall be setup to accept a 4- to 20-mA dc signal. The 4- to 20-mA signal shall be galvanically isolated and input resistance shall not exceed 250 ohms.

c. A minimum of six multifunction programmable digital inputs. The drive shall be expandable to handle additional digital inputs if required. The digital inputs shall be programmable to perform functions including, but not limited to:

1) VFD Start/Stop Control (2 or 3 wire)
2) Forward/Reverse/Stop Control
3) Local/Remote. The VFD shall be programmable so that “Local” control may either be the keypad or by hard-wired start/stop and potentiometer. The VFD shall be programmable so that “Remote” control may either be hard-wired start/stop and 4- to 20mA speed control or via the communications network.
4) VFD Interlock/Enable. This input when de-energized will not allow the VFD to run the motor under any circumstance.

5) VFD External Fault. This input will trip the VFD and require a reset before allowing the motor to run again.
6) Preset Frequencies. The VFD shall be programmable to run at pre-programmed frequencies with up to 6 different steps.

2. Output Signal Interface:

a. A minimum of two programmable analog output signals 4- to 20-mA dc, which can be configured for any of the following:

1) Output frequency (Hz).
2) Output current (load).
3) DC-link voltage (V dc).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set point frequency (Hz).
7) Motor power (kW)

b. A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following (the drive shall be expandable to handle additional digital outputs if required):

1) Motor running.
2) VFD ready.
3) Set point speed reached.
4) Fault and warning indication (overtemperature or overcurrent).
5) PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: One.

G. SCADA Interface: Factory-installed hardware and software to enable the SCADA to monitor, control, and display VFD status and alarms and energy usage. Allows VFD to be used with an external system within a multidrop LAN configuration; settings retained within VFD's nonvolatile memory.

1. Network Communications Ports: Ethernet
2. SCADA Protocols for Network Communications: Ethernet/IP protocol accessible via the communications ports.

2.3 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: All new power distribution systems supplied shall be required to meet the requirements of IEEE 519-1992. Specifically, the system shall adhere to the TDD requirements of Table 10-3 of IEEE 519-1992. If the power distribution system is equipped with an Active Harmonic System, each VFD shall be equipped with a line reactor whose impedance is as recommended by the Active Harmonic System manufacturer (typically 3%). If no Active Harmonic System is part of the

power distribution system, the following rules as a minimum shall define the input line conditioning for each VFD (unless further conditioning is required to meet the IEEE 519-1992 limits). With the Engineer's approval, the contractor may decide to supply an Active Harmonic System even if not shown on the drawings, with corresponding reactors and chokes (this would typically occur if it is more cost effective to meet IEEE 519 with a single system then multiple harmonic filters).

1. All VFD's sized for motors 50HP or larger shall be equipped with DC-link chokes.
2. All VFD's sized for motors 40HP and less shall be equipped with 5% line reactors unless specifically called out as otherwise on the drawings.
3. All VFD's sized for 50HP to 200HP motors shall be equipped with passive harmonic filters with DC Link Chokes.
4. All VFD's greater than 200HP shall be setup to have less than 5% THD for both voltage and current. This would typically require that the drive is setup with an 18-pulse front end or with an active harmonic filter. The VFD assembly shall accept a single 3-phase input and shall contain all of the harmonic mitigation equipment as part of the assembly.

B. EMI/RFI Filtering: VFD's shall be CE marked and certify compliance with IEC 61800-3 for Category C2.

2.4 LOAD CONDITIONING

A. Load Conditioning: For VFD driven loads with conductor lengths between 200 and 1,000 feet, output dV/dt filters shall be provided as part of the VFD assembly. It is strongly recommended that VFD motor leads not be longer than 500 feet and alternative VFD locations should be considered. If absolutely necessary, loads with conductor lengths greater than 1,000 feet shall have output sine wave filters shall be provided as part of the VFD assembly. Voltage drop considerations shall be taken into account when selecting the motor's nameplate voltage.

2.5 LINE AND LOAD CONDITIONING EQUIPMENT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. MTE Corporation.
2. Transcoil International (TCI).
3. Or approved equal.

B. Line Reactors: Reactors shall be part of the VFD assembly. They shall be sized based upon the VFD input power requirements. They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The reactor shall meet the following criteria:

1. The reactor shall be UL 508 listed.
2. Continuous current rating: 100% RMS.
3. Intermittent current ratings: 150% for 60 seconds; 200% for 10 seconds.
4. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
5. All wiring shall be copper.

C. Passive Harmonic Filters: Filters shall be part of the VFD assembly. They shall be sized based upon the VFD input power requirements. They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. The filter shall filter harmonics generated by the nonlinear VFD to satisfy the requirements of IEEE 519-1992 for individual and total harmonic voltage and current distortion at the input terminals of the filter.
3. The TDD of the current at the input terminals of the filter shall not exceed the limits defined in Table 10-3 of IEEE 519-1992.
4. Full load efficiency: 97% or greater
5. The filter shall not resonate with the power distribution system nor attract harmonics from other sources.
6. The harmonic filter shall be a passive series connected low pass filter consisting of an inductor capacitor network. Active electronic components shall not be used.
7. The harmonic filter shall be equipped with a contactor that will connect the capacitor(s) only when the motor is running, avoiding nuisance VFD over-voltage tripping.
8. All wiring shall be copper.

D. dV/dt Filters: Filters shall be part of the VFD assembly. They shall be sized based upon motor horsepower and required full-load current (including service factor). They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. Maximum peak motor terminal voltage with 500 feet of cable: 15% of bus voltage.
3. Maximum dV/dt: 200 Volts per microsecond.
4. The dV/dt Filter shall reduce common mode voltages by a minimum of 40%.
5. Continuous current rating: 100% RMS.
6. Intermittent current ratings: 150% for 60 seconds; 200% for 10 seconds.
7. Allowed inverter switching frequencies: 1kHz to 8 kHz.
8. Nominal inverter operating frequency: 60Hz; Minimum – 6 Hz; Maximum with de-rating: 120Hz.
9. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
10. Insertion loss: 3% of rated voltage maximum.
11. All wiring shall be copper.

E. Sine Wave Filters: Filters shall be part of the VFD assembly. They shall be sized based upon motor horsepower and required full-load current (including service factor). They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. Harmonic Voltage Distortion: 10% maximum
3. Continuous current rating: 100% RMS.
4. Intermittent current rating: 150% for 60 seconds.
5. Allowed inverter switching frequencies: 2kHz to 8 kHz.
6. Nominal inverter operating frequency: 60Hz; Minimum – 0 Hz; Maximum with de-rating: 90Hz.

7. The Sine Wave Filter shall reduce common mode voltages by a minimum of 40%.
8. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
9. Insertion loss: 6% of rated voltage maximum.
10. All wiring shall be copper.

2.6 BYPASS SYSTEMS

A. Provide Bypass Systems only if indicated on the drawings.

B. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

C. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.

D. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: Load-break, NEMA-rated contactor.
2. Output Isolating Contactor: Non-load-break, NEMA-rated contactor.
3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

E. Bypass Contactor Configuration: Full-voltage (across-the-line) or reduced voltage soft-starter as shown on the drawings.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFD while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
   b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

a. CPT Spare Capacity: 100 VA.

6. Overload Relays: NEMA ICS 2.

2.7 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry, Clean and Non-corrosive Indoor Locations: Type 1.
2. Outdoor or Corrosive Locations: Type 4X, stainless steel.
3. Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.8 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFD enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

a. Push Buttons: Maintained and/or momentary as required.
b. Pilot Lights: LED types; colors as shown on P&ID's; push to test.
c. Selector Switches: Rotary type.

B. Bypass contactor auxiliary contact(s) as required.

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Analog Meters:

1. Elapsed time meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4, 4X, and 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4, 4X, 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Cooling Fan and Exhaust System: For NEMA 250, maintaining enclosure NEMA rating; UL 508 component recognized: Supply fan, with non-corrosive intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

I. Air Conditioning System: For NEMA 250, maintaining enclosure NEMA rating; UL 508 component recognized; sized to maintain internal temperatures at or below 100°F.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.

1. Test each VFD while connected to its specified motor.
2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounting Controllers: Install VFDs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Seismic Bracing: Comply with requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFD.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFD with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
5. Test each motor for proper phase rotation.

6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
9. Perform voltage and current harmonic test with each VFD running at minimum and maximum speed. Submit test results for each VFD. Testing shall be witnessed by the Owner and the Engineer.

E. VFDs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs. A minimum of 4 hours of training shall be provided. The training shall cover VFD theory of operation, features and functions available, normal operation, troubleshooting, and routine maintenance. The Contractor shall submit a syllabus for the training session for approval, within 3 weeks of conducting the class. Provide each attendee with a class syllabus detailing each topic to be discussed.

3.7 SPARE PARTS

A. The following spare parts shall be supplied with each type, or frame size, of VFD:

1. 3 sets of all replaceable fuses
2. 3 spare air conditioner or fan filters

END OF SECTION

SECTION 400557 – ACTUATORS FOR PROCESS VALVES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide valve and gate actuators and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to valves and gates except where otherwise indicated in the Contract Documents.

C. Unit Responsibility: The valve or gate manufacturer shall be made responsible for coordination of design, assembly, testing, and installation of actuators on the valves and gates; however, the Contractor shall be responsible to the Owner for compliance of the valves, gates, and actuators with the Contract Documents.

D. Single Manufacturer: Where 2 or more valve or gate actuators of the same type or size are required, the actuators shall be produced by the same manufacturer.

E. The requirements of Section 260000 - Electrical General Provisions apply to the Work of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300 – Contractor Submittals.

B. Shop Drawings: Shop Drawing information for actuators shall be submitted together with the valve and gate submittals as a complete package.

C. Calculations: Selection calculations showing dynamic seating and unseating torques versus output torque of actuator.

D. Technical Manuals: The Contractor shall furnish technical manuals for the butterfly valves, butterfly valve manual actuators, and butterfly valve electric motor actuators under one cover and in accordance with the requirements of Section 013300 – Contractor Submittals.

PART 2 - PRODUCTS

2.1 GENERAL

A. Unless otherwise indicated, shut-off and throttling valves and externally actuated valves and gates shall be provided with manual or power actuators. The Contractor shall furnish actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, handwheels, levers, chains, and extensions, as applicable. Actuators shall have the torque ratings equal to or greater than required for valve seating and dynamic torques, whichever is greater, and shall be capable of holding the valve in any intermediate position between fully-open and fully-closed without creeping or fluttering. Actuator torque ratings for butterfly valves shall be determined in

accordance with AWWA C504 - Rubber-Seated Butterfly Valves. Wires of motor-driven actuators shall be identified by unique numbers.

B. Manufacturers: Where indicated, certain valves and gates may be provided with actuators manufactured by the valve or gate manufacturer. Where actuators are furnished by different manufacturers, the Contractor shall coordinate selection to have the fewest number of manufacturers possible.

C. Materials: Actuators shall be current models of the best commercial quality materials and be liberally-sized for the required torque. Materials shall be suitable for the environment in which the valve or gate is to be installed.

D. Actuator Mounting and Position Indicators: Actuators shall be securely mounted by means of brackets or hardware specially designed and sized for this purpose and be of ample strength. The word "open" shall be cast on each valve or actuator with an arrow indicating the direction to open in the counter-clockwise direction. Gear and power actuators shall be equipped with position indicators. Where possible, manual actuators shall be located between 48- and 60-inches above the floor or the permanent working platform.

E. Standard: Unless otherwise indicated and where applicable, actuators shall be in accordance with AWWA C 540 - Power-Actuating Devices for Valves and Slide Gates.

F. Functionality: Electric, pneumatic, and hydraulic actuators shall be coordinated with the power requirements of Division 26.

G. Fasteners: Fasteners shall be in accordance with Section 055000 – Metal Fabrications.

H. Protective Coatings: Protective coatings shall be in accordance with Section 098000 – Protective Coatings.

2.2 MANUAL ACTUATORS

A. General: Unless otherwise indicated, valves and gates shall be furnished with manual actuators. Valves in sizes up to and including 4-inches shall have direct acting lever or handwheel actuators of the manufacturer's best standard design. Larger valves and gates shall have gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the handwheel. Buried and submerged gear-assisted valves, gates, gear-assisted valves for pressures higher than 250 psig, valves 30-inches in diameter and larger, and where so indicated, shall have worm gear actuators, hermetically-sealed water-tight and grease-packed. Other valves 6-inches to 24-inches in diameter may have traveling nut actuators, worm gear actuators, spur or bevel gear actuators, as appropriate for each valve.

B. Buried Valves: Unless otherwise indicated, buried valves shall have extension stems to grade, with square nuts or floor stands, position indicators, and cast-iron or steel pipe extensions with valve boxes, covers, and operating keys. Where so indicated, buried valves shall be in cast-iron, concrete, or similar valve boxes with covers of ample size to allow operation of the valve actuators. Covers of valve boxes shall be permanently labeled as required by the local Utility Company or the Engineer. Wrench nuts shall comply with AWWA C 500 - Metal - Seated Gate Valves for Water Supply Service.

C. Chain Actuator: Manually-activated valves with the stem located more than 7-feet above the floor or operating level shall be provided with chain drives consisting of sprocket-rim chain wheels, chain guides, and operating chains provided by the valve manufacturer. The wheel and guide shall be of ductile iron, cast iron, or steel, and the chain shall be hot-dip galvanized steel or stainless steel, extending to 5-feet 6-inches above the operating floor level. The valve stem of chain-actuated valves shall be extra strong to allow for the extra weight and chain pull. Hooks shall be provided for chain storage where chains interfere with pedestrian traffic.

D. Floor Stands: Valve actuator floor stands shall be cast iron or fabricated steel pedestals. The centerline of the actuator shall be approximately 42 to 48 inches above the base of the pedestal.

E. Floor Boxes: Hot dip galvanized cast iron or steel floor boxes and covers to fit the slab thickness shall be provided for operating nuts in or below concrete slabs. For operating nuts in the concrete slab, the cover shall be bronze-bushed.

F. Tee Wrenches: Buried valves with floor boxes shall be furnished with 2 operating keys or 1 key per 10 valves, whichever is greater. Tee wrenches sized so that the tee handle will be 2 to 4 feet above ground, shall fit the operating nuts.

G. Manual Worm Gear Actuator: The actuator shall consist of a single or double reduction gear unit contained in a weather-proof cast iron or steel body with cover and minimum 12-inch diameter handwheel. The actuator shall be capable of 90 degree rotation and shall be equipped with travel stops capable of limiting the valve opening and closing. The actuator shall consist of spur or helical gears or worm gearing. The gear ratio shall be self-locking to prevent "back-driving." The spur or helical gears shall be of hardened alloy steel and the worm gear shall be alloy bronze. The worm gear shaft and the handwheel shaft shall be of 17-4 PH or similar stainless steel. Gearing shall be accurately cut with hobbing machines. Ball or roller bearings shall be used throughout. Output shaft end shall be provided with spline to allow adjustable alignment. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator. Gearing shall be designed for a 100 percent overload. The entire gear assembly shall be sealed weatherproof. Manual worm gear actuators shall be Auma GS Series, Limitorque HBC Series, no “Or-Equals”.

H. Traveling-Nut Actuator: The actuator shall consist of a traveling-nut with screw (Scotch yoke) contained in a weatherproof cast iron or steel housing with spur gear and minimum 12-inch diameter handwheel. The screw shall run in 2 end bearings, and the actuator shall be self-locking to maintain the valve position under any flow condition. The screw and gear shall be of hardened alloy steel or stainless steel, and the nut and bushings shall be of alloy bronze. The bearings and gear shall be grease-lubricated by means of nipples. Gearing shall be designed for a 100 percent overload.

I. Schedule for Manual Actuator Types: For a complete schedule of manual actuators required on project valves (4” diameter and larger), see Valve Schedule Drawings.

2.3 ELECTRIC MOTOR ACTUATORS

A. General

1. Equipment Requirements: Where electric motor actuators are indicated, an electric motor-actuated valve control unit shall be attached to the actuating mechanism housing by means of a flanged motor adapter piece.

2. Gearing: The motor actuator shall include the motor, reduction gearing, reversing starter, torque switches, and limit switches in a weather-proof NEMA 4X assembly. The actuator shall be a single or double reduction unit consisting of spur or helical gears and worm gearing. The spur or helical gears shall be of hardened alloy steel, and the worm gear shall be alloy bronze. Gearing shall be accurately cut with hobbing machines. Power gearing shall be grease- or oil-lubricated in a sealed housing. Ball or roller bearings shall be used throughout. Actuator output speed changes shall be mechanically possible by simply removing the motor and changing the exposed or helical gearset ratio without further disassembly of the actuator.
3. Starting Device: Except for modulating valves, the unit shall be so designed that a hammer blow is imparted to the stem nut when opening a closed valve or closing an open valve. The device should allow free movement at the stem nut before imparting the hammer blow. The actuator motor must attain full speed before stem load is encountered.
4. Switches
    a. Electronic Type Switches: Limit switches or valve position shall be sensed by a 15 bit, optical, absolute position encoder. The open and closed positions shall be stored in a permanent, non-volatile memory. The encoder shall measure valve position continuously, including both motor and hand wheel operation, with or without use of battery. An electronic torque sensor shall be furnished. The torque limit may be adjusted from 40 to 100 percent of rating in 1 percent increments. The motor shall be de-energized if the torque limit is exceeded. A boost function shall be included to prevent torque trip during initial valve unseating, and a "jammed valve" protection feature with automatic retry sequence shall be incorporated to de-energize the motor if no movement occurs. Valve actuators with electronic type switches shall be as manufactured by Limitorque or Auma Actuators, Inc.
    b. The actuator shall be wired in accordance with the schematic diagram. Wiring for external connections shall be connected to marked terminals. One of 1-inch and one of 1.25-inch conduit connection shall be provided in the enclosing case. A calibration tag shall be mounted near each switch correlating the dial setting to the unit output torque. Switches shall not be subject to breakage or slippages due to over-travel. Traveling-nuts, cams, or micro switch tripping mechanisms shall not be used. Limit switches shall be of the heavy-duty open contact type with rotary wiping action.
5. Handwheel Operation: A permanently attached handwheel shall be provided for emergency manual operation. The handwheel shall not rotate during electrical operation. The maximum torque required on the handwheel under the most adverse conditions shall not exceed 60 lb.ft, and the maximum force required on the rim of the handwheel shall not exceed 60 lb. An arrow and either the word "open" or "close" shall be cast or permanently affixed on the handwheel to indicate the appropriate direction to turn the handwheel. A clutch lever shall be provided to put actuator into handwheel operation. Valves with electric motor actuators having stems more than 7-feet above the floor shall be provided with chain activator handwheels. The clutch lever shall be provided with a cable secured to the chain to allow disengagement for manual operation.
6. Motor: The motor shall be of the totally enclosed, non-ventilated, high-starting torque, low-starting current type for full voltage starting. It shall be suitable for operation on 480 volt, 3-phase 60 Hz current or 120 volt, 1-phase 60 Hz current as indicated on drawings, and have Class H insulation and a motor frame with dimensions in accordance with the latest revised NEMA MG Standards. The observed temperature rise by thermometer shall not exceed 55 degrees C above an ambient temperature of 55 degrees C when operating continuously for 15 minutes under full rated load. With a line voltage ranging between 10

percent above to 10 percent below the rated voltage, the motor shall develop full rated torque continuously for 15 minutes without causing the thermal contact protective devices imbedded in the motor windings to trip or the starter overloads to drop-out. Bearings shall be of the ball type, and thrust bearings shall be provided where necessary. Bearings shall be provided with suitable seals to confine the lubricant and prevent the entrance of dirt and dust. Motor conduit connections shall be watertight. Motor construction shall incorporate the use of stator and rotor as independent components from the valve operation such that the failure of either item shall not require actuator disassembly or gearing replacement. Two Class B thermal contacts or solid state thermistors imbedded within the motor windings shall be provided to protect against over-temperature damage. The motor shall be provided with a space heater unless the entire actuator is a hermetically sealed, non-breathing design with a separately sealed terminal compartment which prevents moisture intrusion. Each electric motor actuator shall be provided with a local disconnect switch or circuit breaker to isolate power from the motor and controller during maintenance activities.

7. Open/Close Operating Speed: Unless otherwise indicated, electric actuators shall provide a full close to full open or full open to full close operating time range from [30 to 60 seconds].
8. Schedule for Electric AC Actuator Type: For a complete schedule of electric actuators required on project valves (4" diameter and larger), see Mechanical Schedule Drawings.
   a. All electric actuators identified as "OPEN/CLOSE ELECTRIC" in Schedules, shall have AC Reversing type actuators with an open to close and close to open speed times of 60 seconds and 60 seconds, respectively.
   b. All electric actuators identified as "MODULATING ELECTRIC" in Schedules, shall have AC Modulating type actuators with an open to close and close to open speed times of 60 seconds and 60 seconds, respectively.
9. Remote Actuator Control Station. Valves with electric motor actuators where the valve centerline is located at a height greater than 6.5-feet above the floor shall provide a remote actuator control station at a location no higher than 4-feet above the floor. The Contractor shall provide conduit and wiring between the actuator controls and the valve actuator for these applications. The actuator controls shall be wall-mounted beneath the valve at a location approved by the Design Engineer.

B. Electric Motor Actuators (AC Reversing (Open / Close) Control Type)
1. General: Where indicated, electric motor actuators shall be the AC reversing type complete with local control station with open / stop / close and local/off/remote selector switches on the actuator local control station.
2. Actuator Appurtenances: The actuator for each valve shall be provided with a padlockable disconnect switch, open and closed status lights, open, close and lockout stop pushbuttons, a local/off/remote selector switch, and other devices indicated. The disconnect switches in certain applications are required to be located remotely from the actuator body itself, as shown on the Contract Drawings. The local control station may also be provided as an integral part of the actuator or remotely as otherwise indicated or required to permit operation by a person at floor elevation and within sight of the valve actuator. The Contractor shall provide conduit and wiring between the actuator controls and the valve actuator for these applications.
3. Starter: The starter shall be a suitably sized amperage rated reversing starter with its coils rated for operation on 480 volt, 3-phase, 60 Hz current or 120 volt, 1-phase, 60 Hz current as indicated on the drawings. A control power transformer shall be included to provide a 120 volt source, unless otherwise indicated. The starter shall be equipped with 3 overload relays of the automatic reset type. Its control circuit shall be wired as indicated. The

integral weatherproof compartment shall contain a suitably sized 120 volt ac, single phase, 60 Hz space heater to prevent moisture condensation on electrical components. A local power disconnect switch shall be provided with each actuator. A close-coupled, padlockable switch shall be provided with each actuator.

4. Local Control Station: Each actuator shall be provided with a local control station with the valve actuator assembly. The station shall include open, close, and stop push buttons, and a local/remote selector switch.
5. Manufacturers:
   a. Auma, SA Series (for valves 12 inches and smaller) or SA with GS worm gear (for valves 14 inches and larger).
   b. Limitorque, MX/QX Series
   c. Rotork, IQ3 Series
   d. No "Or-Equals" allowed.

C. Electric Motor Actuators (AC Modulating Control Type)

1. General: Where indicated, modulating electric motor actuators shall be the AC modulating type complete with a local control station with power disconnect switch or circuit breaker, provided with open/stop/close and local/off/remote selector switches on the actuator local control station, and open/close status lights.
2. Actuator Appurtenances: The actuator for each valve shall be provided with a padlockable disconnect switch, open and closed status lights, open, close and lockout stop pushbuttons, a local/off/remote selector switch, and other devices indicated. The disconnect switches in certain applications are required to be located remotely from the actuator body itself, as shown on the Contract Drawings. The local control station may also be provided as an integral part of the actuator or remotely as otherwise indicated or required to permit operation by a person at floor elevation and within sight of the valve actuator. The Contractor shall provide conduit and wiring between the actuator controls and the valve actuator for these applications.
3. Control Module: The control module shall be of the electronic solid-state ac type with control outputs for positioning the valve via 4 - 20 ma input signals.
4. Starter: The actuator shall control a solid-state reversing starter designed for minimum susceptibility to power line surges and spikes. The solid-state starter and control module shall be rated for continuous modulating applications. Power supply shall be 480 volt, 3 phase, 60 Hz or 120 volt 1-phase, 60 Hz as indicated on the drawings. A disconnect switch shall be included with each actuator. The assembly shall be rated for 100% duty continuous operation.
5. Construction: The control unit shall be microprocessor-based and shall contain an analog/digital converter, separate input-output switches, non-volatile random access memory for storage of calibration parameters and pushbutton calibration elements for field setup. Potentiometer adjustments shall contain a PID control function internally. In addition, the controller shall contain as standard feature a loss of command signal protection selectable to lock in last or lock in pre-set valve position and a valve position output signal in 4 - 20 ma. As an alternative to the construction requirement, the motor shall be capable of modulating at a rate of 600 starts per hour at the 50 percent to 85 percent travel range of the valve. The system shall allow control of the open, close, or percent open function when the local/off/remote switch is in the remote position. Each actuator shall have a frequency shut down system which when pre-programmed, shall function as directed upon receipt of an ESD signal.
6. Manufacturers:
   a. Auma, SA Series (for valves 12 inches and smaller) or SA with GS worm gear (for valves 14 inches and larger).
   b. Limitorque, MX/QX Series

c. Rotork IQ3 Series
d. No “Or-Equals” allowed.

D. 120 VAC Quarter-Turn and Multiturn Electric Valve Operators on Isolation Valves 3-Inch Dia. and Smaller. Where indicated on Contract Drawings, and primarily on vendor supplied equipment skids and control packages, 120 VAC electric actuators may be supplied on smaller valves of 3-inch diameter and smaller, as follows:

1. Provide 120 VAC, 1-phase motor-operated valve operator suitable for use with quarter-turn ball valves, multiturn diaphragm valves, and multiturn globe valves. Operator shall have the following characteristics and features:
   a. Reversing capacitor-start motor rated for operation on 120 V ac, 60 Hz, single phase. Output torque as required for valve application and pressure differential.
   b. Integral motor overload protection, with auto reset
   c. Permanently-lubricated gear train
   d. For open/close control, provide four single pole, double throw cam actuated limit switches (2 OPEN, 2 CLOSED). One set of limit switches shall be used for both motor control and local indication. The other set shall be available for connection to remote monitoring. Limit switch contacts shall be adjustable and shall be rated for not less than 5 amps at 120 V ac.
   e. Local Control Station: Open/Close: Corrosion-resistant, NEMA 4X, for mounting near valve actuator. Provide 2 position selector switch for LOCAL-REMOTE selection and 2 pushbuttons, OPEN and CLOSE. In addition, provide OPEN and CLOSE indicating lights operating at 120 V ac for connection to valve control limit switches.
   f. For modulating control, provide an electronic positioner and feedback potentiometer. The positioner shall utilize a 4 - 20 ma signal to adjust the valve opening. Feedback potentiometer shall be 0 - 1000 ohms.
   g. Local Control Station Modulating: Corrosion resistant, NEMA 4X, for mounting near valve actuator. Provide 2 position selector switch for LOCAL-REMOTE selection, one OPEN and one CLOSE push buttons, a resistance to current converter with 4 - 20 ma output, and a 0 to 100 percent electronic valve position indicator.
   h. Local power disconnect switch (NEMA 4X) for disconnecting 120 V ac power to valve. Disconnect shall be installed in the field within sight of the valve actuator, in accordance with the requirements of NPFA 70.
2. See Drawings for control diagram wiring interface.
3. Two wire control systems are not required for this actuator.
4. Operators shall be RCS, Asahi/America Quarter Master or equal.

PART 3 - EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Field Adjustments: Field representatives of manufacturers of valves or gates with pneumatic, hydraulic, or electric actuators shall adjust actuator controls and limit-switches in the field for the required function.

3.2 INSTALLATION

A. Valve and gate actuators and accessories shall be installed in accordance with Section 400551 - Valves, General. Actuators shall be located to be readily accessible for operation and maintenance without obstructing walkways. Actuators shall not be mounted where shock or vibrations will impair their operation, nor shall the support systems be attached to handrails, process piping, or mechanical equipment.

B. Inspection, Startup, and Field Adjustment: An authorized representative of the manufacturer shall visit the Site and witness the following:
   1. Installation of the equipment for not less than two (2) Work Days
   2. Inspection, checking, and adjusting the equipment for not less two (2) Work Days.
   3. Startup and field-testing for proper operation for not less than two (2) Work Days.

C. Instruction of Owner's Personnel: The authorized service representative shall visit the Site for not less than 2 Days to instruct the Owner's personnel in the operation and maintenance of the equipment including step-by-step troubleshooting procedures with necessary test equipment.

END OF SECTION

SECTION 400559–SLIDE AND WEIR GATES

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers Slide and Weir Gates and Operators. The equipment provided under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer.

B. Gates and operators shall be supplied with all the necessary parts and accessories indicated on the drawings, specified, or otherwise required for a complete, properly operating installation, and shall be the latest standard product of a manufacturer regularly engaged in the production of fabricated gates.

1.2 APPROVED MANUFACTURERS

A. Gates supplied shall be provided by one of the following manufacturers:
   1. Golden Harvest, Inc.
   2. Or equal

1.3 GOVERNING STANDARDS

A. Except as modified or supplemented herein, all gates and operators shall conform to the applicable requirements of AWWA standards.

1.4 QUALITY ASSURANCE

A. The manufacturer shall have 5 years experience in the production of substantially similar equipment, and shall show evidence of satisfactory operation in at least 10 installations. The manufacturer's shop welds, welding procedures and welders shall be qualified and certified in accordance with the requirement of the latest edition of AWS Sections D1.1, 1.2 and 1.6.

B. The fully assembled gates shall be shop inspected, tested for operation and leakage, and adjusted before shipping. There shall be no assembling or adjusting on the job sites other than for the lifting mechanism.

1.5 SUBMITTALS

A. The manufacturer shall submit for approval by the purchaser, drawings showing the principal dimensions, general construction and materials used in the gate and lift mechanism.

B. The manufacturer shall submit for approval by the purchaser, complete engineering design calculations in compliance with AWWA standards latest edition.

1.6 PERFORMANCE

A. Leakage: Sluice gates shall be substantially watertight under the design head conditions. Under the design seating head, the leakage shall not exceed 0.10 US gallons per minute per foot of seating perimeter. Under the design unseating head, leakage shall not exceed

0.10 US gallons per minute per foot of perimeter.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN

A. Gates shall be either self-contained or non self-contained of the rising stem or non-rising configuration as indicated on the gate schedule.

B. All parts of the gate shall have a minimum thickness of ¼ inch.

C. Wall thimbles shall be supplied by the gate manufacturer. Refer to the gate schedule for types and applicable locations. Minimum material thickness shall be ¼ inch.

2.2 STAINLESS STEEL SLIDE AND WEIR GATES

A. Frame
1. The gate frame shall be stainless steel and designed for maximum rigidity.
2. The fra7me configuration shall be of the flush-bottom type and shall allow the replacement of the top and side seals without removing the gate frame from the wall or wall thimble.

B. Slide
1. The slide shall consist of stainless steel plate reinforced to limit its deflection to L/360 of the slide gate's span and L/720 of the weir gate’s span under the design head.

C. Guides and Seals
1. The guides shall be provided with ultra high molecular weight polyethylene seats on both sides of the slide and shall be of such length as to retain and support at least two thirds (2/3) of the vertical height of the slide in the fully open position. Guide frame shall not weigh less than 13 lbs. per foot.
2. Side, invert and top seals shall be frame mounted. Seals shall be resilient neoprene J-bulb type with a slotted stainless steel retainer bar. All seals shall be mechanical and fully adjustable in the field.
3. The flush bottom resilient neoprene seal shall be mounted to bottom of disc and seal against the invert portion of the frame. Frame mounted invert seals will not be considered.
4. When required for shutoff purposes, a neoprene top seal shall be mounted to the top spigot member of weir gates.

D. Yoke and Pedestal.
1. The yoke, to support the operating bench stand, shall be formed by two structural members welded at the top of the guides to provide a one piece rigid frame.
2. Self-contained gates shall be provided with a yoke to support the operating bench stand. The yoke shall be formed by two structural members welded at the top of the guides to provide a one piece rigid frame. The maximum deflection of the yoke shall be L/360 of the gate's span.
3. Non-self contained gates shall be provided with pedestal mounted lifts. Pedestal shall be cast iron or mild steel and provided with shop coating

E. Lifting Assemblies

1. Stem and Couplings:
   a. The operating stem shall be of stainless steel designed to transmit in compression at least 2 times the rated output of the operating manual mechanism with a 40 lb effort on the crank or handwheel.
   b. The stem shall have a slenderness ratio (L/R) less than 200. The threaded portion of the stem shall have Acme type cold rolled threads with a maximum surface of 16 micro-inches.
   c. Where a hydraulic, pneumatic or electric operator is used, the stem design force shall not be less than 1.25 times the output thrust of the hydraulic or pneumatic cylinder with a pressure equal to the maximum working pressure of the supply, or 1.25 times the output thrust of the electric motor in the stalled condition.
   d. Stems in more than one piece shall be joined together by solid couplings.
   e. Gates having a width equal to or greater than two times their height shall be provided with two lifting mechanisms connected by a tandem shaft.
2. Stem Guides: Stem guides shall be fabricated from stainless steel. Stem guides shall be equipped with a UHMWPE bushing. Guides shall be adjustable and spaced in accordance with the manufacturer's recommendation. The L/R ratio shall not be greater than 200.
3. Stem Cover: Rising stem gates shall be provided with a clear polycarbonate stem cover. The stem cover shall have a cap and condensation vents and a clear mylar position indicating tape. The tape shall be field applied to the stem cover after the gate has been installed and positioned.
4. Lifting Mechanism
   a. Operators of the types listed in the schedule shall be provided by the gate manufacturer. Each manual operator shall be designed to operate the gate under the maximum specified seating and unseating heads by using a maximum effort of 40 lb on the crank or handwheel, and shall be able to withstand, without damage, an effort of 80 lb.
   b. Gearboxes shall be provided when required to maintain the operating force below 40 lb. All bearings and gears shall be totally enclosed in a weather tight housing. Operator housing shall be cast steel or cast iron. The pinion shaft of crank-operated mechanisms shall be supported by roller bearings. The operating shaft shall be fitted with a 2 inch square operating nut and removable crank. The crank shall be fitted with a corrosion-resistant rotating handle. The maximum crank radius shall be 15 inches and the maximum handwheel diameter shall be 24 inches.

F. Materials of Construction

Part	*Material*
Slide, Spigot, Frame, Stiffeners, Yoke, Guide angles.	Stainless Steel Type 304L or 316L ASTM A-276
Side and Top seals	Neoprene ASTM D-2000 or EDPM
Invert seal	Neoprene ASTM D-2000 or EDPM
Bearing bars, Guides, Stem guide liner	Ultra High Molecular Weight Polyethylene ASTM D4020
Bottom seal	Neoprene ASTM D-2000
Threaded stem, Stem guides	Stainless Steel ASTM A-276, Type 304 or 316

Fasteners	Stainless Steel Type 304L or 316
Pedestal	Cast Iron ASTM A126, class B or Mild Steel A36/A36M
Stem cover	Polycarbonate ASTM A-707
Lift and stop nut	Manganeze Bronze ASTM B584, UNS-C86500

2.3 ALUMINUM SLIDE AND WEIR GATES

A. Frame

1. The gate frame shall be extruded aluminum weighing not less then 4-1/4 pounds per foot. The guide grooves in which the head guide angle travel shall contain ultra high molecular weight polyethylene bearing bars in dovetail slots.
2. The frame configuration shall be of the flush-bottom type and shall allow the replacement of the top and side seals without removing the gate frame from the wall or wall thimble.

B. Slide

1. The slide shall consist of aluminum plate reinforced with shaped aluminum extrusion welded to the plate to limit its deflection to 1/720 of the gate's span under the design head.

C. Guides and Seals

1. The guide groves shall contain UHMW bearing bars in dovetail slots and shall be of such length as to retain and support at least two thirds (2/3) of the vertical height of the slide in the fully open position.
2. Side, invert and top seals shall be field adjustable resilient J-bulb seals attached to the spigot and held in place by a bolted retainer bar. Seals shall be fully adjustable.
3. The flush bottom resilient neoprene seal shall be mounted to bottom of disc and seal against the invert portion of the frame.
4. When required for shutoff purposes, a neoprene top seal shall be mounted to the top spigot member of weir gates.

D. Yoke and Pedestal.

1. Self-contained gates shall be provided with a yoke made of structural members or formed plates. The maximum deflection of the yoke shall be 1/360 of the gate's span.
2. Non-self contained gates shall be provided with pedestal mounted lifts. Pedestal shall be provided with shop coating.

E. Lifting Assemblies

1. Stem and Couplings:
   a. The operating stem shall be of stainless steel designed to transmit in compression at least 2 times the rated output of the operating manual mechanism with a 40 lb effort on the crank or handwheel.
   b. The stem shall have a slenderness ratio (L/R) less than 200. The threaded portion of the stem shall have Acme type cold rolled threads with a maximum surface of 16 micro-inches.
   c. Where a hydraulic, pneumatic or electric operator is used, the stem design force shall not be less than 1.25 times the output thrust of the hydraulic or pneumatic cylinder with a pressure equal to the maximum

working pressure of the supply, or 1.25 times the output thrust of the electric motor in the stalled condition.

d. Stems in more than one piece shall be joined together by solid couplings.

e. Gates having a width equal to or greater than two times their height shall be provided with two lifting mechanisms connected by a tandem shaft.

2. Stem Guides

a. Stem guides shall be fabricated from stainless steel. Stem guides shall be equipped with a UHMWPE bushing. Guides shall be adjustable and spaced in accordance with the manufacturer's recommendation. The L/R ratio shall not be greater than 200.

3. Stem Cover

a. Rising stem gates shall be provided with a clear polycarbonate stem cover. The stem cover shall have a cap and condensation vents and a clear mylar position indicating tape. The tape shall be field applied to the stem cover after the gate has been installed and positioned.

4. Lifting Mechanism

a. The operating stem shall be of stainless steel designed to transmit in compression at least 2 times the rated output of the operating manual mechanism with a 40 lb effort on the crank or handwheel.

b. Gates having a width equal to or greater than two times their height shall be provided with two geared lifting mechanisms interconnected by a tandem shaft.

c. The stem shall have a slenderness ratio (L/R) less than 200. The threaded portion of the stem shall have Acme type cold rolled threads with a maximum surface of 16 micro-inches.

d. Stem lengths requiring more than one piece shall be coupled or pinned to an extension tube.

F. Materials of Construction

Part	*Material*
Frame, yoke, slide, stem extension	Aluminum 6061-T-6 ASTM B-209, ASTM B-211
Side and Top seals	Neoprene ASTM D-2000
Bearing bars, Guides, Stem guide liner	Ultra High Molecular Weight Polyethylene ASTM D4020
Bottom seal	Neoprene ASTM D-2000
Threaded stem, Stem guides, Hard crank	Stainless steel ASTM A-276, Type 304 or 304L
Fasteners	Stainless steel Type 304 or 304L
Pedestal / Wall bracket	Cast Iron ASTM A126, class B or Mild Steel A36/A36M
Stem cover	Polycarbonate ASTM A-707
Lift and stop nut	Manganeze bronze , ASTM B584, UNS-C86500

PART 3 - EXECUTION

3.1 EXECUTION

A. Installation: Gates and appurtenances shall be handled and installed in accordance with the manufacturer's recommendations.

B. Field Tests: Following the completion of each gate installation, the gates shall be operated through at least two complete open/close cycles. If an electric or hydraulic operator is used, limit switches shall be adjusted following the manufacturer's instructions. Gates shall be checked for leakage by the contractor.

END OF SECTION 400559

SECTION 400562 - PLUG VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide plug valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 400557 - Valve and Gate Actuators apply to this Section.

C. Plug valves shall have undergone a proof-of-design test to demonstrate that the valve components operate at the service flow, pressure, temperature, and fluid conditions, free from binding, excessive noise, and premature failures. Proof-of-design test results shall be available to the Engineer on request. The proof-of-design test shall be conducted in accordance with the applicable provisions of AWWA C517.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300.

PART 2 - PRODUCTS

2.1 GENERAL

A. Plug Valves shall be quarter-turn, non-lubricated with resilient encapsulated plug. Valves shall have port areas of not less than 100% of pipe area.

B. Standards, Approvals and Verification:
   1. Valves shall be designed, manufactured and tested in accordance with American Water Works Association Standard ANSI/AWWA C517.
   2. All Plug Valves shall be certified Lead-Free in accordance with NSF/ANSI 372.
   3. Manufacturer shall have a quality management system that is certified to ISO 9001 by an accredited, certifying body.

C. Connections:
   1. Threaded valves shall have threaded NPT full size inlets. The connection shall be hexagonal for a wrench connection.
   2. Flanged valves shall have flanges with drilling to ANSIB16.1, Class 125.
   3. Mechanical Joint valves shall fully comply with ANSI/AWWA C111/A21.11.

D. Manufacture:
   1. Manufacturer shall demonstrate a minimum of ten (10) years' experience in the manufacture of plug valves. When requested, the manufacturer shall provide test certificates, dimensional drawings, parts list drawings and operation and maintenance manuals.
   2. The exterior of the valve for above ground service shall be coated with a universal alkyd primer. Valve exterior for buried service shall be coated with an epoxy coating.

3. Valve shall be marked with the Serial Number, Manufacturer, Size, Cold Working Pressure (CWP) and the Direct and Reverse Actuator Pressure Ratings on a corrosion resistant nameplate.
4. Acceptable Manufacturers:
   a. Valmatic (Basis of Design)
   b. DeZurik
   c. Or equal

2.2 ECCENTRIC PLUG VALVES (1/2-INCH TO 3-INCHES)

A. Design:
1. Threaded valve seat shall be a machined seating surface.
2. 2 ½ in. valves and larger shall have a valve seat that is a welded overlay of 95% pure nickel applied directly to the body on a pre-machined, cast seating surface and machined to a smooth finish.
3. Threaded valves shall have shaft seals which consist of V-type lip seal in a fixed gland with a resilient O-ring spring.
4. 2 ½ in. valves and larger shall have shaft seals which consist of V-type packing in a fixed gland with an adjustable follower designed to prevent over compression of the packing and to meet design parameter of the packing manufacturer. Removable POP™ shims shall be provided under the follower flanges to provide for adjustment and prevent over tightening.
5. Permanently lubricated, radial shaft bearings shall be supplied in the upper and lower bearing journals. Thrust bearings shall be provided in the upper and lower journal areas, except for threaded type which only have upper thrust bearings.
6. Both the packing and bearings in the upper and lower journals shall be protected by a Grit-Guard™ "drip tight" Buna-N shaft seal located on the valve shaft to minimize the entrance of grit into the bearing journal and shaft seal areas.
7. The threaded valve body shall have 1/8" NPT upstream and downsteam pressure ports.

B. Materials:
1. Valve bodies and covers shall be constructed of ASTM A126 Class B cast iron for working pressures up to 175 psig and ASTM A536 Grade 65-45-12 for working pressures up to 250 psig. The words "SEAT END" shall be cast on the exterior of the body seat end.
2. Threaded valve plugs shall be of one-piece construction and made of ASTM A126 Class B cast iron fully encapsulated with a resilient facing per ASTM D2000-BG and ANSI/AWWA C517 requirements.
3. 2 ½ in. plugs and larger shall be of one-piece construction and made of ASTM A126 Class B cast iron or ASTM A536 Grade 65-45-12 ductile iron and fully encapsulated with resilient facing per ASTM D2000-BG and ANSI/AWWA C517 requirements.
4. Threaded valves shall have radial shaft bearings constructed of self-lubricating Type 316 stainless steel. The top thrust bearing shall be Teflon.
5. 2 ½ in. plug valves and larger shall have radial shaft bearings constructed of self-lubricating Type 316 stainless steel. The top thrust bearing shall be Teflon. The bottom thrust bearing shall be self-lubricating Type 316 stainless steel. Cover bolts shall be corrosion resistant with zinc plating.

C. Actuators:
1. Threaded valves shall be equipped with a hand lever with a dial indicator and open memory stop.
2. Valves 2 ½ in. and larger shall be equipped with a 2-inch square nut for direct quarter turn operation. The packing gland shall include a friction collar and an open position memory

stop. The friction collar shall include a nylon sleeve to provide friction without exerting pressure on the valve packing.

3. All gear actuators shall be designed to withstand, without damage, a rim pull of 200 lb. on the hand wheel and an input torque or 300 ft-lbs. for nuts.
4. Buried service actuators shall be packed with grease and sealed for temporary submergence to 20 feet of water. Exposed worm shafts shall be stainless steel.

2.3 ECCENTRIC PLUG VALVES (3-INCHES TO 54-INCHES)

A. Design:

1. Valves shall have a valve seat that is a welded overlay of 95% pure nickel applied directly to the body on a pre-machined, cast seating surface and machined to a smooth finish.
2. Valves shall have shaft seals which consist of V-type packing in a fixed gland with an adjustable follower and removable shims under the follower flange to provide for adjustment and prevent over compression.
3. Permanently lubricated, radial shaft bearings shall be supplied in the upper and lower bearing journals to eliminate the need for grease fittings. Thrust bearings shall be provided in the upper and lower journal areas, except for threaded type which only have upper thrust bearings.
4. Both the packing and bearings in the upper and lower journals shall be protected by Buna-N shaft seals located on the valve shaft to minimize the entrance of grit into the bearing journal and shaft seal areas.

B. Materials:

1. Valve bodies and covers shall be constructed of ASTM A126 Class B for working pressures up to 175 psig. The words “SEAT END” shall be cast on the exterior of the body seat end.
2. Plugs shall be of one-piece construction and made of ASTM A536 Grade 65-45-12 ductile iron and fully encapsulated with resilient facing per ASTM D2000-BG and ANSI/AWWA C517 requirements.
3. Plug valves shall have radial shaft bearings constructed of self-lubricating Type 316 stainless steel. The thrust bearings shall be PTFE. Cover bolts shall be corrosion resistant with zinc plating.

C. Actuation:

1. Valves shall be equipped with a 2 inch square nut for direct quarter turn operation with a hand lever. The packing gland shall include a friction collar and an open position memory stop. The friction collar shall include a nylon sleeve to provide friction without exerting pressure on the valve packing.
2. Valves shall include a totally enclosed and sealed worm gear actuator with position indicator (above ground service only) and externally adjustable open and closed stops. The worm segment gear shall be ASTM A536 Grade 65-45-12 ductile iron with a precision bore and keyway for connection to the valve shaft. Bronze radial bearings shall be provided for the segment gear and worm shaft. Alloy steel roller thrust bearings shall be provided for the hardened worm.
3. All gear actuators shall be designed to withstand, without damage, a rim pull of 200 lb. on the hand wheel and an input torque or 300 ft-lbs. for nuts.
4. Buried service actuators shall be packed with grease and sealed for temporary submergence to 20 feet of water. Exposed worm gear shafts shall be stainless steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Plug valves shall be installed in strict accordance with the manufacturer's published recommendations.

B. Eccentric Plug Valves: Unless otherwise directed, the following rules shall be observed for the installation of eccentric plug valves on sewage, sludge, or other liquid systems containing solids, silt, or fine sand:
   1. The valves shall be positioned with the stem in the horizontal direction.
   2. In horizontal pipelines, the plug shall swing upwards when opening, to permit flushing out of solids.
   3. The orientation of the valve shall prevent the valve body from filling up with solids when closed; however, where the pressure differential through the valve exceeds 25 psi, the higher pressure for valves without worm gear, electric, or air operators shall be through the valve to force the plug against the seat.
   4. Valves which may be closed for extended periods (stand-by, bypass, or drain lines) and valves with reversed flow (higher pressure on downstream side, forcing the plug away from its seat), shall be equipped with worm gear operators for the full range of sizes.
   5. For special applications or when in doubt, consult with the manufacturer prior to installation.

C. Except as otherwise indicated, comply with the following requirements:
   1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.
   2. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane.

D. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

E. Valve System: Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

F. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

G. Locate all valves in locations which will allow easy operation and facilitates maintenance.

H. Provide chain operators for any valves located more than 8 feet above finished floor. This means double acting lever handles for quarter turn valves, or chain wheels for multi-turn valves. Arrange valves and set up chain length for proper operation.

3.2 ADJUSTING AND CLEANING:

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Valve Identification: Tag each valve in accordance with Division-22 section "Identification for

Piping and Equipment".

3.3 MANUFACTURER'S CUSTOMER SERVICE

A. Manufacturer's authorized representative shall be available for customer service during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

B. Manufacturer shall also make customer service available directly from the factory in addition to authorized representatives for assistance during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

END OF SECTION

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SECTION 400564 - BUTTERFLY VALVES

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide butterfly valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 400557 – Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300.

B. Shop Drawings
1. Complete Shop Drawings of butterfly valves and actuators.
2. Drawings showing valve port diameter complete with dimensions, part numbers, and materials of construction.
3. Certification of proof-of-design test from the valve manufacturer.
4. Certification: The Contractor shall obtain written certification from the butterfly valve manufacturer, addressed to the Owner, stating that the butterfly valves and the valve operators will efficiently and thoroughly perform the required functions in accordance with these Specifications and as shown, and that the manufacturer accepts joint responsibility with the Contractor for coordination of all butterfly valves and valve operators, including motors, drives, controls, and services required for proper installation and operation of the completely assembled and installed units. The Contractor shall submit all such certificates to the construction manager.
5. Technical Manuals: The Contractor shall furnish technical manuals for the butterfly valves, manual operators, and electric motor valve operators under one cover and in accordance with the requirements of Section 013300 - Contractor Submittals.
6. Valve Labeling: The Contractor shall submit a schedule of butterfly valves to be labeled indicating in each case the valve location and the proposed wording for the label.
7. Field Procedures: Written instructions for field procedures for erection, adjustments, inspection, and testing shall be provided prior to delivery of the butterfly valves and valve operators.

1.3 QUALITY ASSURANCE

A. Valves shall be subjected to performance, leakage, and hydrostatic tests in accordance with procedures and acceptance criteria established by AWWA C504.

PART 2 - PRODUCTS

2.1 RESILIENT SEATED BUTTERFLY VALVE

A. General
1. Valves shall conform to ANSI/AWWA C504 and shall be of the size indicated.

2. The manufacturer shall have produced AWWA butterfly valves for a minimum of five years.
3. Acceptable Manufacturers
   a. Bray
   b. Or equal

B. Design
1. Body
   a. Shall be one-piece wafer or lug design with extended neck to allow for 2" of piping insulation.
   b. Flange location holes shall be provided on wafer bodies to allow for quick and precise alignment during valve installation.
   c. Flange hole drilling per international flange standard as specified.
   d. A non-corrosive bushing and a self-adjusting stem seal shall be provided. No field adjustment shall be necessary to maintain optimum field performance.
2. Disc
   a. Disc edge and hub on metal discs shall be spherically machine and hand polished for torque and maximum sealing capability.
   b. The disc shall be a lens-shaped design to afford minimal pressure drop and line turbulence.
3. Stem
   a. Shall be one-piece design.
   b. Disc to stem connection shall be an internal double "D" design with no possible leak paths in the disc-to-stem connection. External disc-to-stem connections such as disc screws or pins are not allowed.
   c. Stem shall be mechanically retained in the body neck and no part of the stem shall be exposed to the line media.
4. Seat
   a. Shall be tongue-and-groove seat with a primary hub seal and a molded flange O-ring for weld-neck and slip-on flanges.
   b. The seat shall totally encapsulate the body isolating it from the line media and no flange gaskets shall be required.
   c. Seats may not be located on the disc or be retained by segments and/or screws.
5. Bearings
   a. Valve bearings shall be of a self-lubricating, nonmetallic material to effectively isolate the disc-shaft assembly from the valve body. Metal-to-metal thrust bearings in the flow stream are not allowed.
6. Testing: Valve shall be tested to 110% of the rated pressure.
7. Pressure rating
   a. Valve shall be rated for bubble-tight shut-off at the following pressure rating:
      1) Series 30/31: 150 psi
      2) Series 31H: 250 psi

C. Materials of Construction
1. Body: As noted in valve schedule
2. Disk:
   a. Water and wastewater service: coated ductile iron
   b. RO permeate water: Nylon 11 coated ductile iron
   c. Process air: stainless steel
3. Stem: 316 stainless steel
4. Seat:

a. Water and wastewater: EPDM
b. RO permeate water: EPDM
c. Process Air: EPDM or Viton where specifically noted.

2.2 DOUBLE OFFSET HIGH PERFORMANCE BUTTERFLY VALVE

A. General
1. Valves shall conform to ANSI/AWWA C504 and shall be of the size indicated.
2. The manufacturer shall have produced AWWA butterfly valves for a minimum of five years.
3. Acceptable Manufacturers
a. Bray
b. Keystone
c. Or equal

B. Design
1. Body
a. Shall be one-piece wafer, lug or double flanged design with extended neck to allow for 2" of piping insulation.
b. Flange hole drilling per international flange standard as specified.
c. Provided with top and bottom stem bearings consisting of a 316 stainless steel shell with a TFE/glass fabric liner bearing surface.
d. Equipped with an externally adjustable stem packing system that allows packing adjustment without removing the actuator.
e. Internal over-travel stop shall be provided to prevent over-travel of the disc and minimize possible seat damage.
2. Disc
a. Dis edge and hub on metal discs shall be spherically machine and hand polished for torque and maximum sealing capability.
3. Stem
a. Shall be one-piece design
b. Stem shall be provided with blow-out proof stem retention system to assure full retention of the stem in the unlikely event of an internal stem failure.
4. Seat
a. Design shall consist of a resilient energizer totally encapsulated by the seat.
b. Seat retainer shall be full-faced and firmly attached by bolts located outside the sealing area to protect them from corrosion.
c. The seat assembly shall be locked in the body recess by the full-faced retainer.
d. The seat shall be self-adjusting for wear and temperature changes.
e. The seat shall be easily field replaceable.
5. Testing: Valve shall be tested for tight shut-off per API 598 requirements.
6. Pressure ratings: Valves shall be rated for a minimum of 285 psi.

C. Materials of Construction
1. Body: Stainless steel
2. Disk: Stainless steel
3. Stem: 316 stainless steel
4. Seat: RTFE

PART 3 - EXECUTION

3.1 INSTALLATION

A. Exposed butterfly valves shall be installed with a means of removing the complete valve assembly without dismantling the valve or operator. Installation shall be in accordance with manufacturers recommendation.

B. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.

C. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane.

END OF SECTION

SECTION 400567 – BALL VALVES

PART 1 - GENERAL

1.1 SCOPE:

A. Furnish and install all valves complete and in accordance to the requirements of the Contract Documents.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve.

B. Shop Drawings: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

C. Maintenance Data: Submit maintenance data and spare parts list for each type of valve. Include this data, product data, shop drawings in maintenance manual; in accordance with requirements of Division 1.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of valves, of types and sizes required, whose products have been in satisfactory use in similar service.

B. Valve Types: Provide valves of same type by same manufacturer.

C. Valve Identification: Provide valves with manufacturer's name (or trademark) and pressure rating clearly marked on valve body.

D. Codes and Standards:

1. MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions".
2. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged- or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves".
3. U-PVC: Conforming to ASTM D1784 Cell Classification 12454 A
4. CPVC – Conforming to ASTM D1784 Cell Classification 23567 A
5. Polypropylene – Conforming to ASTM D4101 Cell Classification PP0210B67272
6. PVDF – Conforming to ASTM D3222-91A Cell Classification Type II

PART 2 - PRODUCT

2.1 PLASTIC BALL VALVES (1/2" – 6")

A. All valves shall be true-union design with 2-way blocking capability. PTFE seats shall have elastomeric backing cushions to provide smooth even stem torque and to compensate for wear. Valves shall feature molded ISO mounting top flange for actuation installation and Panel Mount feature on bottom of valve for securing in-line. The handle shall double as the spanner wrench for maintenance and carrier adjustment.

B. Valve shall have a pressure rating of 150 psig at 70ºF.

C. Where noted on contract drawings, a 1/8" Vent Hole factory drilled and de-burred by the manufacturer shall be added to eliminate the hazard of pressurization.

D. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering ball valves which may be incorporated in the work are:

1. Asahi America, Inc.
2. George Fischer
3. Dura Plastic Products, Inc.
4. Hayward
5. Or equal.

2.2 STAINLESS STEEL BALL VALVES

A. Features:
1. 316 SS Ball Construction
2. SS Body construction
3. RPTFE seat
4. Threaded
5. Full Port
6. Two piece body design
7. Solid Ball Construction
8. SS Lever and Nut
9. Blow out proof stern design
10. Nylon lever grip
11. 150 psig rated

B. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering ball valves which may be incorporated in the work are:
1. Apollo Valves
2. Or equal

PART 3 - EXECUTION

3.1 INSTALLATION:

A. General: Except as otherwise indicated, comply with the following requirements:

Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.

Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane.

B. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

C. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with the following ends or types of pipe/tube connections.

1. Pipe Size 2" and Smaller: One of the following, at Installer's option:

a. Threaded valves.
b. Flanged valves.

2. Pipe Size 2-1/2" and Larger:

a. Flanged valves.
b. Grooved joint valves.

D. Valve System: Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

E. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

3.2 ADJUSTING AND CLEANING:

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Valve Identification: Tag each valve in accordance with Division-22 section "Identification for Piping and Equipment".

3.3 VALVE INSTALLATION:

A. Locate all valves in locations which will allow easy operation and facilitates maintenance.

B. Provide chain operators for any valves located more than 8 feet above finished floor. This means double acting lever handles for quarter turn valves, or chain wheels for multi-turn valves. Arrange valves and set up chain length for proper operation.

END OF SECTION

SECTION 409000 – INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. General requirements which apply to all Instrumentation and Control for Process Systems (hereafter referred to as I&C).

B. Related Sections

1. The Contract Documents are a single integrated document. As such, all Divisions and Sections are applicable. The Contractor and its Subcontractors are responsible to review all parts of the Contract Documents in order to provide a complete and coordinated project.

C. Complete I&C System

1. The requirements for the I&C System shall be the responsibility of a single company hereafter referred to as the Instrumentation Supplier (IS). The IS shall be responsible for all parts of this Section and Sub-Sections as well as all other related sections that may pertain to the I&C System.
2. The Contractor, through the IS and qualified electrical and mechanical installers, shall be responsible to the Owner for the implementation of a complete I&C System. The IS shall provide all necessary coordination, material and labor such that the entire system be complete and functional. This includes but is not limited to the proper operation and monitoring of electrical power systems, process systems, mechanical equipment, instrumentation, control panels, programmable controllers, communications/networking, and SCADA system.
3. The overall I&C system design is based upon non-certified information that has been furnished by various equipment manufacturers and vendors. It is the Contractor's responsibility to include in the bid and installation all labor and material to provide a complete system based upon actual information from equipment being supplied for the project. Any changes or additions due to non-certified manufacturer or vendor information shall be provided at no additional cost to the Owner.

1.2 REFERENCES

A. The installation and commissioning of the I&C System shall conform to all applicable codes, regulations, standards and specifications, including, but not limited to those listed below. These publications are referenced to by designation but not by edition. The latest edition accepted by the Authority Having Jurisdiction in effect at the time of bid shall govern.

1. State and Local Codes and Authority Having Jurisdiction (AHJ)
2. American National Standards Institute (ANSI)

3. American Petroleum Institute (API)
4. Federal Communications Commission (FCC)
5. Federal Occupational Safety and Health Act (OSHA)
6. International Society of Automation (ISA)
7. Institute of Electrical and Electronic Engineers (IEEE)
8. National Electric Code (NEC).
9. National Electrical Manufacturers Association (NEMA)
10. National Fire Protection Association (NFPA)
11. Underwriters Laboratories, Inc. (UL)

1.3 DEFINITIONS

A. The following definitions may be used throughout this section and subsections (refer to the contract drawings sheet GI-1 for instrumentation abbreviations):

1. CTC: Communications termination cabinet.
2. FAT: Factory acceptance test.
3. HMI: Human machine interface.
4. I&C: Instrumentation and control for process systems
5. IS: Instrumentation supplier.
6. LAN: Local area network.
7. LCP: Local control panel.
8. NC: Normally closed.
9. NO: Normally open.
10. OIT: Operator interface terminal.
11. OSI: Owner's System Integrator.
12. PC: Personal computer.
13. PID: Control action, proportional plus integral plus derivative.
14. PLC: Programmable logic controller.
15. P&ID: Process and instrumentation diagram
16. RIO: Remote input/output
17. SCADA: Supervisory control and data acquisition.
18. SI: System Integrator.
19. UPS: Uninterruptible power supply.
20. VCP: Vendor control panel.
21. WAN: Wide area network.

1.4 I&C SYSTEM REQUIREMENTS

A. The Work is to provide a complete and operational I&C System as described by the Contract Documents. This includes but is not limited to the following:

1. Before providing a bid as the IS, coordinate with all bidders such that all costs associated with a complete I&C System are accounted for. The Owner shall not be responsible for any additional costs for scope items that have been excluded from the bid as a result of not coordinating with all bidders.

2. The IS shall submit a statement of qualifications verifying that it meets the requirements of 409000.1.8. The IS must be approved by the Engineer before proceeding with the Work.

3. In order to provide a complete system, oversee and coordinate with all equipment and services being provided outside of Contractor's scope.
   a. The Engineer is responsible to ensure that equipment being supplied by the Owner related to the I&C System complies with the requirements of the Contract Documents.
   b. The Contractor and IS are responsible to coordinate the installation, commissioning and scheduling of equipment related to the I&C System that are provided by the Owner.

4. Oversee and coordinate with all equipment and services being provided by the Contractor but outside of the IS's scope.
   a. Inform all vendors and suppliers providing equipment related to the I&C System the requirements of Division 40.
   b. The Owner is not responsible for any additional costs incurred by requiring vendors and/or subcontractors to meet the requirements of Division 40.
   c. If a vendor or supplier is unable to meet the requirements of Division 40, the Contractor may submit in writing to the Engineer the reasons for non-compliance. The Engineer will then evaluate the reasons and determine whether a solution may be determined or if a different vendor or supplier is required.
   d. The Contractor and IS are responsible for coordinating with vendors and suppliers the FAT, installation, commissioning, calibration and scheduling for the associated I&C equipment.
   e. The IS is responsible to ensure that panel and loop drawings be supplied for vendor and subcontractor equipment. If the vendors and/or subcontractors are preparing the panel and/or loop drawings, they shall comply with the requirements of Division 40 and shall match those provided by the IS.

5. The IS shall conduct a Pre-Submittal Conference before producing any submittals. The conference should include all parties involved with the I&C System including the Engineer and Owner. The purpose of the conference shall be to review the project as a whole, make sure all parties understand their roles and responsibilities and to go over submittal requirements.

6. Prepare I&C System Submittals which includes the following:
   a. Instrumentation hardware submittal (including TR20 forms).
   b. Control panels design and submittal.
   c. Loop drawings design and submittal.
   d. Recommended spare parts submittal.

7. Following submittal approvals, do the following:
   a. Procure all instrumentation hardware and accessories.
   b. Procure hardware for and fabricate all control panels being provided.
   c. Perform FAT's for all control panels being provided.

8. Loop drawings design and submittal shall be supplied by the IS. Obtain all pertinent information for the project that is to be shown on the loop drawings from vendors, manufacturers, submittals, manuals, etc.

9. Programming and integration shall be supplied by the OSI. Oversee and coordinate the programming and integration with the OSI for a complete I&C System.

10. Oversee the installation of the I&C System.

11. Perform bench and field calibrations of instruments as required.

12. Oversee and document loop testing.

13. Oversee and document commissioning.

14. Maintain record drawings.
    a. Maintain on the construction site a set of the Instrumentation Drawings that shall be continuously marked up during construction.
    b. The drawings should be updated at least weekly and will be checked monthly by the Owner's representative.
    c. Upon completion of startup, submit the marked-up drawings to the Engineer for review and for drafting.

15. Prepare O&M manuals.
    a. Provide O&M manuals in accordance with Section 017823.
    b. Prepare an O&M manual for each major process area or building. Each of these manuals shall be divided into the following categories:
        1) Table of Contents/Index.
        2) Process & Instrumentation Diagrams.
        3) Control Panel Record Drawings, Bill of Materials and Design Data.
        4) Record Loop Drawings.
    c. Prepare O&M manuals that cover comprehensive information for the I&C System. These manuals shall include the following:
        1) Table of Contents/Index.
        2) Finalized Instrument Summary.
        3) Finalized TR20 Instrument Forms.
        4) Instrumentation Installation Details.
        5) Instrument Operational Manuals.
        6) Recommended Spare Parts List.

16. Provide training.

1.5 ACTION SUBMITTALS

A. General
1. Submittals for Division 40 shall meet the requirements of Section 013300 Contractor Submittals. In addition, the following requirements shall be met:
    a. Submittals shall include bills of materials with quantities, makes, models, exact part numbers and descriptions.
    b. Edit all submittals such that only pertinent information is submitted. Neatly cross out information that does not apply, options that are not being supplied, etc.

c. Show product dimensions, construction and installation details, wiring diagrams, and specifications.
d. If there are exceptions to the Contract Drawings and Specifications, provide a list of exceptions with detailed explanations for the exceptions. The Engineer will review the list of exceptions and determine whether a solution may be determined or if the exception(s) will not be allowed.

2. Furnish submittal required by each Section within Division 40.
3. When submitting on equipment, use the equipment and instrumentation tags depicted in the Contract Drawings.

B. Instrumentation hardware submittal

1. Provide a comprehensive submittal that includes all instrumentation being supplied by the IS. Divide the submittal into the following:
   a. Table of Contents/Index.
   b. Instrument summary.
   c. Instrument TR20 Forms.
   d. Instrument Cut Sheets.
   e. Instrument Installation Drawings.
2. Provide an instrument summary (sorted by tag number) that has the following information:
   a. Tag number.
   b. Make, model and description.
   c. Associated process.
   d. Location.
   e. Calibrated range.
   f. Referenced loop drawing number and P&ID.
   g. Associated PLC.
3. Furnish TR20 instrumentation forms for each instrument using the forms outlined in ISA-TR20.00.01-2007. This requirement includes all instruments that are being installed as part of the project, whether they are Contractor, Owner and/or Vendor supplied. Show on each sheet who is the responsible party for supplying the instrument. The TR20 sheets should be provided electronically in Microsoft Word or Excel as well.
4. Provide instrument cut sheets for each instrument make and model being supplied for the project. Each cut sheet should have a list of instrument tag numbers that pertain to that particular cut sheet. The cut sheets should have enough information to verify that the instrument conforms to the Contract Drawings and Specifications.
5. Instrument installation drawings
   a. Provide instrument installation drawings for each make and model of instrument being supplied.
   b. Delineate what is being supplied by the IS and what is being supplied by other installers.
   c. Show overall dimensions, mounting locations and elevations.
   d. Show all cabling, conduit and piping locations.
   e. Show the ambient conditions of the location where the instrument is being installed which includes ambient temperature and humidity extremes, whether or not the atmosphere is corrosive and the area classification.
   f. Show mounting requirements, brackets, stands and anchoring.
   g. Show means for sun protection where required.

C. Control panels submittal

1. Provide a comprehensive submittal that includes all control panels supplied by the IS. The submittal should show that the panels are in conformance with the requirements of Section 409513. Divide the submittal into the following:
   a. Table of Contents/Index.
   b. Panel Bill of Materials and Design Data.
   c. Panel Shop Drawings.
   d. Panel Hardware Cut Sheets.
2. The Panel Bill of Materials and Design Data shall include the following:
   a. Each panel will have its own Bill of Materials and Design Data information presented in association with the panel drawings. The Bill of Materials shall include all hardware inside or on the enclosure. The design data will include UPS and/or battery load calculations to show that the UPS is sized appropriately for load and for backup time. The design data will show panel weight, materials and finishes. HVAC design data shall be shown. Seismic criteria shall be shown if required by the Contract Documents.
3. Panel Shop Drawings:
   a. Each control panel shall be designed to perform its function(s) as shown in the Contract Drawings. The control panel designs shall take into account information shown throughout the Contract Drawings and Specifications.
   b. Show every internal wire and connection diagrammatically. Show all interfaces between the control panel and external equipment to be connected for power, controls, signal, communications, etc.
   c. All shop drawings shall include a title block with the name of the firm designing the control panels. The title block shall also include project information, Owner information and/or logo, drawing number and description, revision fields and date.
   d. All shop drawings shall be developed utilizing AutoCAD version 2008 or later. All shop drawings should be submitted in PDF and AutoCAD formats and as required by Section 013300.
   e. Panel layout drawing(s):
      1) Each control panel shall have shop drawing(s) which depict the front, back, sides and top/bottom of the panel. This includes showing any hardware mounted on the inside or outside of the panel.
      2) Layout drawings should include subpanel and swing-out panel layouts.
      3) Layout drawings should show locations of panel penetrations for cutouts, conduit entry and/or access plates.
      4) Layout drawings should show all of the components and provide a reference to the bill of materials.
      5) Show the elevations of door devices from the finished floor.
   f. AC and/or DC power distribution diagrams:
      1) Each panel shall show power distribution schematics that shows how the panel receives power and feeds all of its internal loads as well as associated external loads.
   g. Communications and/or Network diagrams:
      1) For panels that utilize any means of communications both internally and externally, provide a diagram depicting each communication connection.
   h. Input/Output and/or Internal wiring diagrams
   i. Terminal block diagrams
4. Provide panel hardware cut sheets for each make and model of equipment being supplied for the project. The cut sheets should have enough information to verify that the equipment conforms to the Contract Drawings and Specifications.

D. Loop Drawings Submittal

1. Provide a comprehensive submittal that includes loop drawings for every control loop on the project. This includes but is not limited to all loops shown on the P&ID's, all loops associated with auxiliary inputs/outputs not shown on the P&ID's (e.g., UPS status information).
2. Loop drawings may only be finalized after all control panels, MCC's and other electrical submittals, and instrumentation submittals have been approved. Obtain all of the required information from each of these submittals to properly show the wiring of each control loop. The loop drawings shall not be submitted with incomplete information due to the lack of obtaining the appropriate information for each loop.
3. The loop drawings shall be designed for and printed to 11x17 size paper. Divide the submittal into the following:
   a. Laminated Cover and Back and Spiral Binding.
   b. Table of Contents/Index (by loop number).
   c. Loop Drawings.
4. Loop Drawings Requirements:
   a. All loop drawings shall include a title block with the name of the firm designing the loop drawings. The title block shall also include project information, Owner information and/or logo, drawing number and description, revision fields and date.
   b. All loop drawings shall be developed utilizing AutoCAD version 2008 or later. All loop drawings should be submitted in PDF and AutoCAD formats and as required by Section 013300.
   c. Each loop drawing shall have a look and feel that follows that of the example loop drawing shown in the Contract Drawings.
   d. Each loop drawing should have the following as a minimum:
      1) Six area divisions, from left to right which are:
         a) Field/Process Area (this area will show field and process equipment).
         b) Junction Boxes (this area will show any field junction boxes associated with the loop).
         c) Local Control Panel (this area will show any local control panels associated with the loop).
         d) Electrical Room (this area will show electrical equipment such as starters, VFD's, power feeders, etc. associated with the loop).
         e) Programmable Logic Controller (this area will show PLC Inputs/Outputs associated with the loop).
         f) SCADA (this area will show logical connections for the Inputs/Outputs from the PLC to the SCADA System).
   e. Each loop drawing will show each instrument or field device associated with the loop and its wiring connections and wire labels.
   f. Each electrical enclosure (junction box, local control panel, PLC panel, starter panel, etc.) will show terminal numbers and terminal block group references.
   g. All wires to be installed by the Contractor shall be dashed while all wires installed by the panel shop should be solid.
   h. Show continuation lines to associated loops that may interface with each loop.
   i. Show all wiring associated for the loop including power, controls, signal and communications.

E. Recommended Spare Parts Submittal

1. Submit a list of spare parts for all of the equipment associated with the I&C System. The list of spare parts shall include list pricing for each item.

2. Provide the name, address and phone number for each manufacturer and manufacturer's local sales representative.
3. Indicate whether or not the spare parts are being provided under this contract or not.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.8 QUALITY ASSURANCE

A. All equipment supplied for this project shall meet the requirements of the National Electric Code (NEC) and shall be listed by and bearing the label of the Underwriters' Laboratories (UL).

B. The IS shall be a company that has been actively involved in the installation and commissioning of I&C Systems for a minimum period of five years.

C. The IS shall have adequate facilities, manpower and technical expertise to perform the Work associated with the I&C System and as outlined by the Contract Documents.

D. The IS shall have similar project experience of at least four successfully completed projects for a similar wastewater system. The IS company must have performed similar work for these projects as required herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials provided under this Contract shall be new and free from defects.

2.2 MANUFACTURERS

A. All equipment provided for the I&C System shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

B. Instruments which utilize a common measurement principle (for example, float switches) shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

2.3 OPERATING CONDITIONS

A. The I&C System shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:
   1. Environment: Wastewater Treatment Plant.
   2. Temperature Extremes: -4°F to 104°F (Outdoors); 40°F to 104°F (Indoors).
   3. Relative Humidity: 20% to 90%, non-condensing.

B. Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The Contractor shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. Instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

2.4 SPECIAL TOOLS

A. The IS shall furnish a priced list of special tools required to calibrate and maintain the instrumentation provided. The Owner and Engineer will select which tools are to be purchased and the IS will supply them at the prices listed.

B. Special tools shall be delivered to the Owner before startup commences.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

B. Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the Engineer. If such tests reveal defects, the equipment shall be replaced.

3.2 MANUFACTURER'S SERVICES

A. Manufacturer's services shall be furnished for the following equipment:
   1. Vendor supplied equipment that contain programmable controllers, operator interfaces and/or instrumentation that requires site calibration.
   2. ORP Analyzers
   3. Dissolved Oxygen Analyzers
   4. Open Channel Flow Meters
   5. Mass Flow Meters

B. The Contractor shall furnish the following manufacturer's services for the instrumentation listed below:
   1. Perform bench calibration.
   2. Oversee installation.
   3. Verify installation of installed instruments.
   4. Certify installation and reconfirm manufacturer's accuracy statement.
   5. Oversee loop testing and pre-commissioning
   6. Train the Owner's personnel.

3.3 INSTALLATION

A. Instrumentation shall be installed per the Instrument Installation Drawings that have been submitted and approved and per the requirements of Division 40. This includes all instrumentation for the I&C System, regardless of who the supplier is. Instrumentation shall be mounted so that it is easily accessible and viewable and such that it does not restrict access to other equipment. Mount instrumentation to pipe stands or wall mounts if they are not directly mounted or if the Contract Drawings indicate otherwise.

B. The I&C System indicated throughout the design are diagrammatic and therefore locations of equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the Owner exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the Contractor shall make such changes without additional cost to the Owner.

C. The I&C System is integrally connected to electrical, mechanical and structural systems. Coordinate with these other disciplines the installation of these related components. All conduit, cables and field wiring shall be as required by Division 26.

D. Instruments, control panels and all other I&C System related equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

E. Each existing instrument to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The Contractor shall provide certification of this Work prior to reinstallation of each instrument.

F. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation system. The Contractor shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the Engineer for approval prior to commencing that Work. Such changes shall not be a basis of claims for extra Work or delay.

G. Instrumentation, control panels, wiring and all other I&C equipment shall be properly tagged and/or labeled per the requirements of Section 260553.

H. Installation of the I&C System shall be according to the finalized Loop Drawings

3.4 FACTORY ACCEPTANCE TESTING (FAT)

A. The IS shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the Engineer and Owner to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, and other pertinent systems and devices. A minimum of 10 days notification shall be furnished to the Engineer prior to testing. No shipments shall be made without the Engineer's approval.

B. For each FAT, the IS shall develop and submit a FAT Plan and Procedure Document within 10 days of the FAT. The FAT Plan and Procedure shall as a minimum shall have the following:
   1. Descriptions of test methods to be performed during the FAT.
   2. FAT Schedule and Procedure
   3. FAT Checklists that allow for sign-off and comments for each test method and procedure.

C. Control Panel Completion Test Methods: The following test methods should be performed during the FAT for each control panel:
   1. Completed Shop Drawings: Demonstrate that the control panel has been built according to the shop drawings and that the shop drawings are accurate.
   2. Panel Layout: Demonstrate that the control panel has been laid out as designed and as required by Division 40.
   3. Power Distribution: Demonstrate all power distribution circuits, including but not limited to AC power circuits, UPS operation, signals and circuits and DC circuits.
   4. Control Circuits: Demonstrate the correct installation of each control circuit. Using a signal generator or multi-meter, show the correct operation of each input, output, relay, barrier, buttons, switches, or any other control device. Demonstrate the proper functionality of any hard-wired interlocks that may be associated with each control circuit.
   5. Panel Networking/Communications: If any form of communications is associated with the control panel, verify the proper operation of each communication port and link.

D. Control Loop Test Methods: In order to demonstrate that the control panel will provide its function as intended, provide the following control loop test methods. If programming for the control panel is provided by others, coordinate with the programmer to have all programming

completed and tested prior to the FAT. If needed, coordinate to have the programmer present for the FAT.

1. Alarm Functions: Verify and/or simulate each alarm condition associated with each control loop.
2. Local Manual and Auto Functions: Verify and/or simulate each Local Manual and/or Auto function associated with each control loop.
3. SCADA Manual and Auto Functions: Verify and/or simulate each SCADA Manual and/or Auto function associated with each control loop.
4. Control Loop Interlocks: Demonstrate the functionality of any software interlocks that may be associated with each control loop.

E. If the FAT does not pass and needs to be repeated, the IS shall be responsible for additional per diem costs incurred by the Engineer and Owner.

F. All changes and/or corrections made during the FAT shall be noted on the checklists.

G. Following completion and approval of all FAT, provide the finalized checklists to the Engineer and as part of the equipment shop drawings.

3.5 FIELD QUALITY CONTROL

A. Allow for inspections by the Engineer and/or Owner of the I&C System at any time during the construction. Inspections shall be conducted to verify that the installation is per the requirements of the Contract Documents.

3.6 CALIBRATION

A. Devices provided under Division 40 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment. Such adjustments, if required, shall be made only after consultation with the Engineer.

D. Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. For each instrument calibration, provide a calibration sheet and update the corresponding TR20 Instrument Form with the new calibration data. The Calibration sheet shall include the following as a minimum:

1. Date of calibration.
2. Project Name.
3. Tag Number.
4. Manufacturer, model and serial number.
5. Calibration data including range, input, output and measurement at each calibration point.
6. Space for comments.
7. Space for sign-off by party performing calibration.

G. A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the Engineer. The IS shall sign the tag when calibration is complete. The Engineer will sign the tag when the calibration and testing has been accepted.

3.7 LOOP TESTING

A. Each control loop shall have been installed according to the finalized loop drawing. Prior to the commencement of loop testing, the following pre-requisites should have been met:
   1. All associated equipment, conduit and wire has been permanently installed, terminated and inspected.
   2. All wiring has been properly pulled, terminated and labeled.
   3. Each wire has been tested with a point-to-point test.
   4. All control panels and electrical equipment have been checked out and tested as required by Division 26.
   5. All instrumentation has been appropriately installed and calibrated.
   6. Loop Test Forms for each loop to be tested have been created and will be available during the loop testing.

B. Each loop test shall have a Loop Test Form prepared and ready prior to each loop test. The loop test form shall have the following:
   1. Loop Number and Description
   2. Check-Off List with room for sign-off and dated by the IS, Programmer, and Owner's Witness as well as room for comments. The list of items to be checked off for each loop should include but is not limited to the following:
      a. Each power distribution circuit.
      b. Each control circuit.
      c. Each alarm circuit.
      d. Each PLC input/output point.
      e. Each Local Manual, Local Auto, SCADA Manual & SCADA Auto function.
      f. Each hard-wired and software interlock.

C. Upon completion of the above pre-requisites for loop testing, the IS shall oversee and coordinate each loop test. The IS is responsible to be present for all loop testing, whether the equipment was supplied by the IS or not. The IS is responsible to have all responsible parties associated with each loop present. This includes but is not limited to manufacturer representatives, vendor technicians, electrical installers, mechanical installers, and programmer. The IS shall coordinate with the Owner and Engineer to allow for witnessing of loop testing as deemed necessary by the Owner and Engineer.

D. Issues that arise during loop testing should be addressed and fixed immediately. If it is not feasible to immediately fix the issues, the loop testing should be re-scheduled as soon as

possible to avoid delays. Any costs associated with re-testing and requiring all parties to return to the site shall in no way be incurred to the Owner.

E. Following a successful loop test, the appropriate parties should sign and date the Loop Test Forms. All Forms shall be certified and submitted to the Engineer as part of the O&M Manuals.

F. Following loop testing, in no way should any parts of the loop be modified. In no way shall any wiring be re-routed or re-terminated. If any such work occurs, all affected loops shall be re-tested at no expense to the Owner.

3.8 COMMISSIONING

A. The IS shall oversee, coordinate and be present during all commissioning activities. The IS shall be responsible for obtaining the assistance of the Contractor and Subcontractors as may be required for commissioning activities.

B. Commissioning shall commence after acceptance of wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Pre-commissioning shall demonstrate proper operation of every system with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

C. Commissioning and test activities shall follow detailed test procedures and check lists accepted by the Engineer. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the Engineer, which include calculated tolerance limits for each step. Completion of system commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the Engineer with a clear and unequivocal statement that system commissioning and test requirements have been satisfied.

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

E. Electronic control stations incorporating proportional, integral or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control

element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

3.9 TRAINING

A. Develop a Training Plan for the training requirements of Division 40 and submit it to the Engineer for approval. Coordinate with the Engineer and Owner the time and locations of each training session. Schedule the trainings for after the equipment has been pre-commissioned.

B. As part of the Training Plan, submit a résumé for each individual to be providing training. Training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

C. Each training session shall include a written agenda.

D. The Contractor shall train the Owner's personnel on the maintenance, calibration and repair of instruments provided.

E. Within 10 days after the completion of each session, the Contractor shall submit the following:
   1. A list of Owner personnel who attended the training.
   2. A copy of the training materials used during the session with notes, diagrams and comments.

END OF SECTION 409000

SECTION 409113 – CHEMICAL PROPERTIES PROCESS MEASUREMENT DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. ORP Process Measurement Devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall consist of a sensor and an analyzer/transmitter. Where shown on the drawings, the analyzer/transmitter may be utilized for multiple sensors. When an analyzer/transmitter is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each analyzer/transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
   b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
   a. Modbus RTU (Two-Wire RS-485)

C. Each analyzer/transmitter shall be powered by 115VAC (+/- 10%) at 60Hz unless specifically shown on the drawings as being powered by 24VDC (+/- 15%). Each analyzer/transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding analyzer/transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the analyzer/transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All analyzers/transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors shall be rated for permanent submersion and shall be corrosion resistant.

2.2 ORP PROCESS MEASUREMENT DEVICES

A. Each ORP analyzer/transmitter shall be rated for operation with ambient temperature within -4°F to 122°F. If the analyzer/transmitter is to be installed in locations that may experience temperatures less than -4°F, it shall be housed in an enclosure which is equipped with a thermostatically controlled heater. If the analyzer/transmitter is to be installed in locations that may exceed 122°F, it shall be housed in an air-conditioned enclosure. All enclosures and air conditioners shall be rated NEMA 4X.

B. The ORP Sensor assembly shall meet the following criteria:

1. Contain the sensing elements and electronics for digital communications to the analyzer/transmitter in a self-contained, corrosion-resistant and submersible housing.
2. Built-in temperature compensation.

3. Allowed to be installed in liquids whose temperatures are 32 to 200°F and whose pressure is up to 100 psi.
4. The sensor shall have a measuring range of -1500 to 1500 mV.
5. Shall not require sample conditioning or electrolyte solutions.

C. Acceptable Manufacturers:
1. Hach model DRD ORP System with SC4200, or SC1500 analyzer/transmitter.
2. YSI.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all analyzers/transmitters five feet off of floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 409000 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 409000.

END OF SECTION 409113

SECTION 409123 – MISCELLANEOUS PROPERTIES PROCESS MEASUREMENT DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dissolved Oxygen Process Measurement Devices.
2. Flow Process Measurement Devices.
3. Level Process Measurement Devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall typically consist of a sensor and an analyzer/transmitter. Where shown on the drawings, the analyzer/transmitter may be utilized for multiple sensors. When an analyzer/transmitter is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each analyzer/transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
   b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
   a. Modbus RTU (Two-Wire RS-485)

C. Each analyzer/transmitter shall be powered by 115VAC (+/- 10%) at 60Hz unless specifically shown on the drawings as being powered by 24VDC (+/- 15%). Each analyzer/transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding analyzer/transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the analyzer/transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All analyzers/transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 DISSOLVED OXYGEN PROCESS MEASUREMENT DEVICES

A. Each DO analyzer/transmitter shall be rated for operation with ambient temperature within -4°F to 122°F. If the analyzer/transmitter is to be installed in locations that may experience temperatures less than -4°F, it shall be housed in an enclosure which is equipped with a thermostatically controlled heater. If the analyzer/transmitter is to be installed in locations that may exceed 122°F, it shall be housed in an air-conditioned enclosure. All enclosures and air conditioners shall be rated NEMA 4X.

B. The DO Sensor assembly shall meet the following criteria:

1. Contain the sensing elements and electronics for digital communications to the analyzer/transmitter in a self-contained, corrosion-resistant and submersible housing.
2. Built-in temperature compensation.

3. Allowed to be installed in liquids whose temperatures are 32 to 200°F and whose pressure is up to 100 psig.
4. The sensor shall have a measuring range of 0 to 20 ppm.
5. The sensor shall continuously measure dissolved oxygen by exciting a luminescent material and then detecting light emitted by the material that is proportional to the amount of dissolved oxygen in the liquid.

C. Shall not require sample conditioning or electrolyte solutions.

D. Acceptable Manufacturers:

1. Hach model LDO Probe 2 with SC4200 or SC1500 analyzer/transmitter.
2. YSI.

2.3 FLOW PROCESS MEASUREMENT DEVICES

A. ROTAMETERS

1. Rotameters in chemical solution lines and where indicated shall have vertical bottom inlets and top outlets with ANSI 150-lb flanged ends for vertical mounting.

2. The meters shall have Hastelloy C floats, 10-inch long scales, and a range of 10:1 with an accuracy of plus or minus 2 percent. Meters shall be rated for a minimum working pressure of 150 psig. Flanged rotameters for chemical solutions and where indicated shall be calibrated in gallons per minute.

3. The bodies shall have union ends for ease of maintenance, polysulphone tubes, aluminum or brass end fittings, Type 316 stainless steel internal parts and scales suitable for the indicated capacity range.

4. The meters shall have accuracy within plus and minus 5 percent of the capacity range indicated.

5. Meters in air and pump seal flushing lines shall be of the modified rotameter design with screwed ends, spring-loaded pistons, and union bodies for mounting in any position.

6. For activated carbon solution, bodies shall be Type 316 stainless steel construction with magnetically actuated float and scale.

7. For other chemicals bodies shall have Type 316 stainless steel ends with heavy borosilicate glass tubes and packing glands or other best suitable material.

8. Rotameters with NPT screwed ends for water, air, and fuel gas service shall be calibrated in gallons per minute or cubic feet per minute. The scales shall be suitable for the capacity ranges indicated.

9. Acceptable Manufacturers:
   a. Krohne VA40 Series.
   b. Dwyer UV Series.
   c. Or Approved Equal.

B. FLOW SWITCHES

1. Thermal dispersion type flow switches

a. Thermal dispersion type flow switches shall be used for pump discharge monitoring, chemical injection monitoring, gas flow monitoring and for flows in pipes with velocities greater than 0.25 fps.

b. The flow element shall be constructed of a material that is best suited for the liquid or gas that it is serving. Typically for chemicals the material will be Hastelloy C and for other liquids or gases it will be 316SS.

c. The switch shall be capable of operating in liquids or gases whose temperatures range from -40°F to 350°F and up to 2000 psig operating pressure.

d. The flow switch assembly shall be insertion type with ¾" male NPT threads. The insertion length shall be such that the thermal dispersion elements are in the center of the pipe.

e. The flow switch shall accept 115VAC or 24VDC as shown on the Contract Drawings. It shall have two SPDT relay outputs rated at 5A up to 240VAC.

f. The flow switch shall be rated to be installed in Class 1, Division I Groups B, C & D hazardous locations. The electronics shall be housed in a powder coated aluminum enclosure that is rated NEMA 4X.

g. Acceptable Manufacturers:
   1) Fluid Components International (FCI) FLT93 Series.
   2) Sierra Instruments Innova-Switch Series.
   3) Dwyer V6 Series.
   4) Or Approved Equal.

C. MAGNETIC FLOW METER

1. Materials

a. All mounting hardware shall be 316 stainless steel, the instrument enclosure and the spool mag shall be rated NEMA 4X, the flow sensor liner shall be hard rubber, and the electrode material shall be hastelloy.

b. Spool size shall be as specified on the drawings.

c. All applications with flow element below grade where no de-watering means or in submersible applications shall provide the flow element as NEMA 6P (IP-68).

d. Transmitter shall be integral or remote to the flow element as shown on the P&ID's.

2. Design and fabrication

a. Utilize characterized field principle of electromagnetic induction to produce signal directly proportional to flow rate. The meter shall use a pulsed DC magnetic field excitation.

b. Provide flanged end connections per ANSI B16 rated for piping system operating and test conditions.

c. Operating pressure: 150 psig.

d. Operating temperature: 122°F.

e. Grounding requirements: per manufacturer requirements. Typically, inlet and outlet grounding rings of same material as electrode.

f. When the transmitter is remote to the flow element, provide cable between flow element and transmitter. Coordinate with the installer the length of the cable required. No splices in any way will be allowed.

g. Complete zero stability shall be inherent to the meter system. The system shall have a programmable low flow cutoff.

h. Empty pipe detection to prevent false measurement when pipe is empty or partially filled.

i. Forward and reverse flow measurement and totalization as well as net flow totalization.

j. 4-20mA DC isolated output into maximum 800 ohms. Signal shall be programmable to indicate forward and/or reverse flow.

k. Provide a dry contact output for flow direction indication.

l. Provide a programmable frequency output for flow totalization.

m. +/- 0.5% accuracy for flow rates above 1 fps.

3. Acceptable Manufacturers
   a. Siemens SITRANS F 5100W.
   b. Endress+Hauser Promag 53.
   c. Rosemount 8700.
   d. ABB WaterMaster.
   e. Krohne.
   f. Or Approved Equal.

D. INSERTION THERMAL MASS FLOW METERS

1. Materials

a. All mounting hardware shall be 316SS. The instrument enclosure shall be rated NEMA 4X. For hazardous locations, the assembly shall be rated for Class 1 Division I Groups B,C & D locations.

b. Sensor Material: 316L Stainless Steel, all welded construction.

c. Sensor Support Material: 316L Stainless Steel all-welded construction.

d. Process Connection: 316 Stainless Steel Compression Fitting to fit 1" FNPT Fitting on pipe (by Contractor).

e. LCD display for setup, calibration and flow monitoring.

2. Design and Fabrication

a. Velocity Measurement Accuracy: ±2% of reading from 10 to 100% of calibrated range.

b. Output 4-20ma signal proportional to flow rate. 700 ohms maximum resistance.

c. Power Supply 18 to 30 VDC

d. Repeatability: 0.25% or better.

e. Process Temperature Rating: -10°C to +120°C.

f. Process Pressure Rating: 150 PSIG.

g. Sensor Material: 316L Stainless Steel, all welded construction.

h. Sensor Support Material: 316L Stainless Steel all-welded construction.

i. Insertion Length: Per manufacturer's recommendations.

j. Process Line Sizes: 3" pipe and larger.

k. Sensor Enclosure Temperature Rating: -20°C to +50°C.

l. Field Wiring: 1 pair of twisted and shielded 14-18 gauge wire having a maximum loop resistance of 4 ohms.

m. Installation location shall be in a location that maximizes the number of upstream and downstream diameters. A minimum of 15 pipe diameters upstream and 5 pipe diameters downstream shall be required. If this is not possible, flow conditioning plates shall be installed per the manufacturer's recommendation or a factory calibrated inline assembly.

3. Acceptable Manufacturers

a. Sierra Instruments 640S Series (Insertion Type).
b. Fluid Components International (FCI) ST51 Series (Insertion Type).
c. Sierra Instruments 780S (Inline Type).

d. Or Approved Equal.

2.4 LEVEL PROCESS MEASUREMENT DEVICES

A. FLOAT SWITCHES

1. Float switches shall consist of a mechanical switch, hermetically sealed in a plastic casing, freely suspended at the desired height from its own cable. When the liquid level reaches the float switch, the casing will tilt, and the mechanical switch will change state.

2. The casing shall be constructed of polypropylene with the sheathed cable extruding from the casing. The cable shall be three conductors, made specifically for underwater use and heavy flexing service.

3. The float switch shall have a 10A resistive rating up to 250VAC.

4. Weight and buoyancy shall be such that contaminants like a cake of grease will not result in the float switch changing operating level more than one inch.

5. A NEMA 4X 316SS junction box shall be supplied for termination of the float cable(s) allowing for conventional wiring and conduit to be run from the junction box to a control panel. It shall have terminal blocks for the required number of circuits and shall accept sealed fittings.

6. Float switch cables shall be suspended in a manner that provides minimum strain to the cable and will not damage it. This is typically achieved with a stainless-steel cord support grip or strain relief grip as manufactured by Kellems. When support grips are used, a stainless-steel hook shall be installed for hanging the support. All screws, fasteners, boxes and grips shall be 316SS. In no way are any steel or galvanized steel components allowed.

7. The float cable length shall be long enough for easily removing the float from the water for testing and long enough to reach its termination junction box.

8. If the float switch is to be installed in a classified area, an appropriate intrinsically safe barrier shall be utilized to guarantee the circuit may not abnormally create an ignition.

9. Manufacturers:
   a. Flygt ENM-10.
   b. Or Approved Equal.

B. FLOOD SWITCHES

1. High level flood switches shall be the type that is suspended on a column. A ¼” NPT connection with flying leads allows the column and float assembly to be attached to a junction box. The junction box shall be rated NEMA 4X and be nonmetallic. The flood switch shall be CPVC and shall be made for use with liquid chemicals and corrosive liquids. Switch contacts shall be SPST N.O. with 20VA rating minimum.

2. If the flood switch is to be installed in a classified area, an appropriate intrinsically safe barrier shall be utilized to guarantee the circuit may not abnormally create an ignition.

3. Manufacturers:
   a. GEMS LS-74780.
   b. Or Approved Equal.

C. SUBMERSIBLE LEVEL TRANSMITTERS

1. The submersible level transmitter shall consist of a submersible transducer, electronic transmitter, support cable, and interconnecting cable with cable shield and vent tube for atmospheric reference. The vent tube shall be provided with a replaceable moisture barrier. The submersible transducer shall be the strain gauge type suitable for sensing pressure equivalent to the liquid level range indicated.

2. The transducer shall have 316 stainless steel process wetted parts and shall be provided with a waterproof interconnecting cable. The transducer shall be suspended by a corrosion resistant cable as recommended by the manufacturer. The installation shall allow easy removal of the transducer and cable assembly for maintenance purposes. The electronic level transmitter shall be remote mounted and shall produce a 4 - 20 mA DC signal linearly proportional to the level range indicated and be capable of driving a load of 700 ohms.

3. The interconnecting cable shall have a pull strength of 200 pounds, be factory attached to the transducer, and shall be terminated in a NEMA 4X 316SS enclosure. The enclosure shall house the vent tube moisture barrier and local indication.

4. The measurement system shall be suitable for the area classification and operation over a temperature range of 32 to 122 degrees Fahrenheit with an accuracy of plus or minus 0.5 percent of span. The transmitter shall have a non-fouling, large diaphragm (greater than 2”). The diaphragm shall be protected by a spacer assembly that also allows the transducer to sit on the floor of the wet well.

5. For lengths greater than 20 feet the transducer shall have ½” threads and shall be suspended in the wet well by ½” stainless steel conduit.

6. Acceptable Manufacturers
   a. Dwyer series PBLTX.
   b. KPSI model 750.
   c. Or Approved Equal.

D. ULTRASONIC LEVEL MEASURING SYSTEM

1. As indicated on the drawings, the ultrasonic level measuring system shall be setup as a level transducer with remote mounted transmitter or as a single transducer/transmitter assembly. For hazardous locations, the single transducer/transmitter shall be utilized. It shall be loop powered and shall be installed with an appropriate intrinsically safe barrier to guarantee the circuit may not abnormally create an ignition.

2. All transducer and transducer/transmitter assemblies shall be rated IP68 for permanent submergence. Remote transmitter shall be in a non-corrosive NEMA 4X housing. Transmitters shall have an LCD display and shall be programmable by buttons on the transmitter or with a handheld programmer. When programmed with a handheld programmer, each transmitter shall be supplied with an accompanying programmer.

3. The transducer shall be encapsulated in chemical and corrosion resistant material, such as Kynar, Teflon or TEFZEL. It shall be capable of operating from -40°F to 158°F. The transducer shall be compatible with the level range as indicated on the Contract Drawings. As a minimum, the transducer shall be capable of measuring a range of 40 feet.

4. When the transducer is remotely mounted from the transmitter, it shall have a waterproof shielded cable whose length is long enough to reach the transmitter. In no way shall splicing of the transducer cable be allowed.

5. Each transmitter shall provide a 4-20mA output signal that is programmable to a user desired level range.

6. Remote transmitters shall be provided to accept two transducers for differential level monitoring or for monitoring two separate levels. A second 4-20mA output signal shall be provided for the second level. The remote transmitter shall have six programmable relays rated at 5A up to 250VAC.

7. Manufacturers:
   a. Siemens SITRANS Probe LU (transducer/transmitter assembly); Hydroranger 200 (remote transmitter) with XPS-15 or greater (transducer).
   b. Or Approved Equal.

E. RADAR LEVEL MEASURING SYSTEM

1. The radar level measuring system shall be setup as a single loop powered transducer/transmitter assembly. For hazardous locations, it shall be installed with an appropriate intrinsically safe barrier to guarantee the circuit may not abnormally create an ignition.

2. All transducer/transmitter assemblies shall be rated IP68 for permanent submergence. Transmitters shall have an LCD display and shall be programmable by buttons on the transmitter or with a handheld programmer. When programmed with a handheld programmer, each transmitter shall be supplied with an accompanying programmer.

3. The transducer shall be encapsulated in chemical and corrosion resistant material and shall be hermetically sealed. The antenna supplied (horn or rod) shall be per the recommendation of the manufacturer. It shall be capable of operating from -40°F to 158°F. The transducer shall be compatible with the level range as indicated on the Contract Drawings. As a minimum, the transducer shall be capable of measuring a range of 40 feet.

4. Coordinate with the mechanical installers the method of installing the radar system (flanged or threaded connection). It is critical that the radar level measuring system be installed according to the manufacturer's installation guidelines. Install shield sections if

required. Keep the radar emission cone free of interference from pipes, beams, pouring liquids, etc. Locate the assembly away from side walls of tanks or vessels.

5. Each transmitter shall provide a 4-20mA output signal that is programmable to a user desired level range.

6. Provide a software package by the same manufacturer as the radar system that is used to commission and maintain the system. The software shall be able to configure the system, view radar echo profiles and modify the programming to suppress false echoes.

7. Manufacturers:
   a. Siemens SITRANS LR200 with SIMATIC PDM Software.
   b. Or Approved Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades for proper connection to piping and other mechanical equipment.

B. Install all analyzers/transmitters five feet off floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 409000 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 409000.

END OF SECTION 409123

SECTION 409433 – HUMAN-MACHINE INTERFACES

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the human-machine interfaces (HMI) used for control and monitoring as indicated on the Contract Documents. HMI's include the following:
   1. Operator Interface Terminals (OIT) or touch screens.
   2. Personal Computers or Servers used as HMI's to the SCADA System.

B. For software related to HMI equipment, refer to Section 409600.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 QUALITY ASSURANCE

A. Hardware to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that HMI equipment and software being provided is compatible with the requirements. Provide all necessary accessories to the HMI equipment for a complete and operable system.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver the HMI hardware as a complete system in accordance with Section 409000.

PART 2 - PRODUCTS

2.1 OPERATOR INTERFACE TERMINALS

A. OITs shall be furnished with hardware to monitor and control equipment, as listed in the specifications, and shown on the Contract Drawings.

B. OITs shall be 10" color touch screens unless otherwise indicated on the Contract Drawings. Each OIT shall have the following features:
   1. Has serial and Ethernet ports with built-in communications protocols drivers as required by the project.

2. Has associated software for programming the OIT and its screens, database, alarms, etc.
3. Has a 640 x 480 minimum resolution with TFT color screen.
4. Has at least 64MB of memory.
5. Has no limitations on the number of screens or tags that may be used as long as within the memory limitations of the OIT.

C. Acceptable Manufacturers
1. Allen Bradley Panelview Plus 7.
2. Or Approved Equal.

2.2 SCADA PC HARDWARE

A. SCADA PC Hardware shall be provided by the Owner's System Integrator.

PART 3 - EXECUTION

3.1 INSTALLATION

A. OIT's and Panel PC's shall be installed on the doors of control panels as shown in the Contract Drawings. The control panel assembly and installation shall be as required by Section 409513.

B. Following control panel Factory Acceptance Testing, OIT's and Panel PC's shall be removed from the control panels and put back in their original packaging and shipped to the Site loose. The OIT's and Panel PC's shall not be re-installed until they are needed for loop testing. The goal of doing this is to protect the screens from damage during construction. While the OIT's and Panel PC's are not in the control panel, cover and seal the open space on the door of the control panels to protect the interior of the panel.

C. OIT's and Panel PC's shall be installed in accordance with the manufacturer's installation guidelines and instructions.

3.2 TRAINING

A. Provide training for the OIT and SCADA PC hardware supplied for the project as required by Section 409000.

END OF SECTION 409433

SECTION 409443 – PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the programmable logic controllers (PLC) used for control and monitoring as indicated on the Contract Documents.

B. Provide one full version of PLC programming software that is applicable to the PLC hardware being supplied for the project. Include auxiliary software (such as communications software, drivers, networking configuration software, etc.) that may be required for a complete and operable system.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Wiring diagrams showing connections to all devices; input and output (I/O), analog and discrete. The wiring diagrams shall indicate the I/O address point to be used in the PLC programs.

C. Submit calculations that show the following:
   1. PLC Power Supply Budget
   2. Calculated number of I/O quantities required
   3. Estimated PLC memory usage

1.3 QUALITY ASSURANCE

A. Hardware and software to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that PLC equipment and software being provided is compatible with the requirements. Provide all necessary accessories to the PLC equipment for a complete and operable system.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver the PLC hardware and software as a complete system in accordance with Section 409000.

PART 2 - PRODUCTS

2.1 GENERAL

A. PLCs shall be furnished with hardware and software necessary to monitor and control equipment, as listed in the specifications, and shown on the Plans.

B. Each field input and output shown as an I/O Point shall be connected as per the manufacturers' recommendations.

C. The Contractor shall provide the hardware, software, and installation necessary for connecting additional future equipment as indicated on the Plans. In addition to allocating for future I/O, each PLC shall be supplied with a minimum of 20% spare I/O of each type. In other words, the total I/O for each type shall be (current I/O + future I/O) * 120%. Provide enough panel space to install up to 200% of future I/O modules and/or PLC racks/bases.

D. The type of field input and output shall be defined as follows unless specified otherwise on the plans:
   1. Analog inputs and outputs: 4-20mA DC.
   2. Discrete inputs: I/O device shall be a dry contact; inputs shall be powered by the PLC at 24VDC (preferred) or 120VAC.
   3. Discrete outputs: Isolated dry contact outputs.

E. All PLC I/O shall have I/O modules that are installed and wired at a UL508 Panel Shop. All I/O points shall be wired down to terminal blocks. In no way should field wiring go to any part of the PLC assembly.

F. Vendor and Contractor supplied PLC's shall meet the requirements of this Section and of Division 40. Vendor supplied PLC's shall have a Factory Acceptance Test (FAT) performed by the Vendor as required by Section 409000. Contractor supplied PLC's shall have a FAT performed by the Contractor as required by Section 409000.

G. The PLC shall be capable of handling online program modifications without taking the system offline or requiring a download.

H. Acceptable Manufacturers
   1. Allen Bradley CompactLogix

2.2 PROCESSORS

A. The PLC processor shall be a microprocessor based industrial controller with a temperature rating of 0 to 60 degrees C, and a humidity rating of 5 to 85% non-condensing, minimum.

B. The processor's memory shall be sized according to the number of I/O points and amount of logic required for the application. As a minimum, the memory shall be at least 3 megabytes.

C. The processor shall retain its memory and programming when power is removed.

D. The processor shall have tag-based memory.

E. Processors shall be the CompactLogix L3 or L4 Series.

2.3 PLC POWER SUPPLY

A. The power supply shall provide power for the processor, and I/O modules. The power supply shall have built-in over voltage and under voltage detection circuitry, protection against overcurrent conditions, and automatic power-up sequence that enables outputs only when proper operating tolerances are reached. Power requirements shall be 24 VDC unless shown as otherwise on the Contract Documents.

2.4 COMMUNICATIONS NETWORKS

A. Each PLC shall be equipped with network ports (and corresponding network modules if necessary) as shown on the Contract Drawings. Each PLC shall be equipped with an Ethernet port for connection to the Plant SCADA System.

B. Ethernet ports shall be setup to communicate with the Allen-Bradley Ethernet/IP protocol.

C. The PLC shall be programmable through the Ethernet port or through a USB port.

2.5 INPUT/OUTPUT MODULES

A. Only I/O modules that have typical wiring diagrams shown in the Contract Drawings shall be allowed for each PLC.

B. Analog I/O modules shall have a minimum of 12 bits of resolution and shall be setup as 4 to 20 mA signals unless indicated otherwise on the Contract Drawings. Analog inputs shall be setup to be connected to loop powered (2-wire) or self-powered (4-wire) signals. All analog inputs and outputs shall be protected by a fuse. 4 to 20 mA signals shall be protected by a 32mA fuse.

C. Each discrete I/O module shall be fused (fuse body shall be equipped with a blown fuse indicator). Each discrete output module and shall have interposing relays for each point with form C relay contacts. Indicator lights shall also be provided on each I/O point to indicate status of each signal. Each individual input or output point shall be optically isolated to protect the controller I/O circuitry from high voltage transients.

2.6 SPARE PARTS

1. In addition to the spare parts requirements of Section 409000, provide the following:
    a. One spare processor for each type of PLC processor supplied for the project.
    b. One spare I/O card for every type of I/O card supplied for the project.
    c. One spare PLC power supply for every type supplied for the project.
    d. One spare network adapter for each type of network adapter supplied for the project.
    e. One spare base for rack style PLC's.

PART 3 - EXECUTION

3.1 FACTORY ACCEPTANCE TESTING

A. All PLC assemblies shall be built up in control panels and shall be part of a Factory Acceptance Test as required by Section 409000.

3.2 INSTALLATION

A. The PLC assemblies shall be installed in control panels made specifically for the PLC. The control panel assembly and installation shall be as required by Section 409513.

B. The PLC assemblies shall be installed in accordance with the manufacturer's installation guidelines and instructions.

3.3 TRAINING

A. Provide training for the PLC hardware supplied for the project as required by Section 409000.

END OF SECTION 409443

SECTION 409513 – PROCESS CONTROL PANELS AND HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes the requirements for all control panels and associated hardware for the project. This includes, but is not limited to, vendor control panels, PLC panels, local control panels and instrumentation panels.

B. Related Requirements:
   1. The requirements of Division 26 shall apply to this section.

1.2 ACTION SUBMITTALS

A. Submit the Control Panels Submittal as required by Section 409000.

1.3 CLOSEOUT SUBMITTALS

A. Submit the operation and maintenance data, including record control panel drawings for all control panels as required by Section 409000.

1.4 QUALITY ASSURANCE

A. Referenced Standards:

   1. National Electric Code (NEC).
   2. American Society for Testing and Materials (ASTM).
   3. Joint Industrial Council (JIC).
   4. National Electrical Manufacturers Association (NEMA):
      a. ICS 4, Terminal Blocks for Industrial Use.
      b. ICS 6, Enclosures for Industrial Controls and Systems.
      c. 250, Enclosures for Electrical Equipment (1000 V Maximum).
   5. Underwriters Laboratories Inc. (UL):
      a. 50, Enclosures for Electrical Equipment.
      b. 508, Industrial Control Equipment.
      c. 508A, Standard for Industrial Control Panels.

B. Hardware to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. All panels shall be assembled in and labeled by a listed UL 508A panel shop. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

C. Examine the Contract Documents and verify that control panel hardware being provided is compatible with the requirements. Provide all necessary accessories to the control panels for a complete and operable system.

D. The Contractor shall not place any conduit feeds for any control panel until the Control Panel Submittal has been approved. Once approved, conduits shall be placed strategically to best suit the layout of the control panel. Power entry and separation of power, controls and signal shall be considered.

E. All painted control panels shall have matching paint colors and tones.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the control panel hardware as required by Section 409000.

PART 2 - PRODUCTS

2.1 GENERAL

A. All control panels shall have an overall NEMA rating suitable for withstanding the mechanical, electrical, thermal stresses, humidity and corrosion that the panel will be subjected to in its installed location.

B. The following rules shall be followed when determining the NEMA rating requirement for each control panel:

1. NEMA 1, 3 & 3R shall not be allowed for control panels.
2. NEMA 4 shall be utilized for outdoor or wet locations in non-corrosive, unclassified areas. NEMA 4 control panels shall be painted steel.
3. NEMA 4X shall be utilized in corrosive, unclassified areas. NEMA 4X enclosures shall be 316SS except for the following exceptions with which the enclosure shall be polycarbonate or fiberglass reinforced polyester (FRP):
   a. Chemical areas or rooms.
   b. Locations where stainless steel is incompatible.
   c. Where specifically noted on the Contract Drawings.
4. NEMA 7 shall be utilized for classified areas as required by NEC. NEMA 7 enclosures shall be constructed of cast aluminum.
5. NEMA 12 shall be utilized in dry, non-corrosive, unclassified areas. NEMA 12 control panels shall be painted steel.

C. Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks or a disconnect operable from the control panel front. Each control panel shall be provided with identified terminal strips for the connection of external conductors. The SUPPLIER shall provide sufficient terminal blocks to connect 30 percent additional conductors for future use.

D. PLC Discrete outputs from the control panel shall be provided by electrically isolated contacts rated for 10 amps at 120 VAC. Analog inputs and outputs shall be isolated 4 to 20 mA, 2 wire signals with power supply.

E. Control panel mounted devices shall be mounted a minimum of 3-feet above finished floor elevation. Touchscreens shall be mounted at a height of 66" from the finished floor to the center of the touchscreen. All control panels will be situated on housekeeping pads, this is not considered the finished floor elevation.

2.2 ENCLOSURES

A. Enclosures shall be either freestanding, pedestal-mounted or equipment skid-mounted, as indicated. Internal control components shall be mounted on an internal back-panel or side-panel as required.

B. Enclosure dimensions indicated on the Contract Drawings are based upon non-certified information and shall be considered the minimum panel size. It is the responsibility of the Contractor to design the size of all control panels. When sizing the control panels, adhere to the following criteria:
   1. Maximum panel depth is 24". If there are special reasons for a deeper enclosure, approval must first be obtained from the Engineer.
   2. The panel size shall provide space for all equipment, wire-ducts, wire, terminations, and space for future expansion.
   3. If the panel size needs to be enlarged, coordinate with the installing Contractor that there is adequate space for the larger size. If there is not space, coordinate with the Engineer to come up with a solution.

C. Materials
   1. Steel panel section faces shall be 12-gauge minimum thickness for free standing panels and 14-gauge minimum thickness for wall-mounted or pedestal-mounted panels. Materials shall be selected for levelness and smoothness.
   2. Structural shapes and strap steel shall comply with ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates, Grade C.
   3. Bolting Material: For outdoor, wet or corrosive areas, all bolting materials shall be 316SS. In dry, non-corrosive locations, carbon steel may be used. Commercial quality bolts, nuts, and washers shall be 1/2-inch diameter with UNC threads. Carriage bolts shall be used for attaching end plates. Other bolts shall be hex end machine bolts. Nuts shall be hot pressed hex, American Standard, heavy. Standard wrought washers shall be used for foundation bolts and attachments to building structures. Other bolted joints shall have SAE standard lock washers.
   4. Control panels shall be structurally designed such that the completed and installed control panels shall safely withstand seismic requirements for the project. All equipment mounted within the panel shall be properly braced to prevent damage during a seismic event.

D. Acceptable Manufacturers
   1. Hoffman.
   2. Saginaw.
   3. Or Approved Equal.

2.3 CONTROL PANEL ASSEMBLY

A. General

1. The following requirements must be met when mounting to the back panels or side panels of the control panel:
   a. Holes shall be drilled and tapped with less than 50% diminishment in thread.
   b. Back panel shall be cleaned front and back after any drilling and tapping.
   c. Tek Screws are not acceptable.
   d. Any component mounted to a back panel or side panel shall be mounted at an exact square to the vertical and horizontal planes.
   e. Any duct running between back panels and side panels shall align horizontally with no overlaps.
   f. All DIN rail mounted to the panels shall have ½" stand-offs allowing for wires and other equipment to be routed beneath the rail if necessary.
2. Enclosure doors shall be flush fitting, gasketed, and be of the hinged lift-off type with lockable door handles. A common key shall be provided for the doors on each panel assembly. Removable access panels shall be provided with dished handle fasteners. Screwdriver 1/4 turn or Dzus type fasteners are not acceptable.
   a. The flanged edges of panels shall be straight and smooth. Corners shall be welded and ground smooth.
   b. The face of the panel shall be true and level after flanging.
   c. Panel cutouts and holes may be cut or drilled by any standard method that does not cause deformation. Burrs shall be ground smooth.
   d. Adjacent panels shall assemble with faces flush. Gaps or cracks shall not be visible from the front of the assembled instrument board.
   e. Panels shall be self-supporting as defined below.\
3. Control panels that are supplied with three phase power and/or are powering motor loads shall be supplied with a main feeder disconnect that is door operated. The door operator for the disconnect shall be defeatable with a screwdriver. If the upstream overcurrent protection device feeding the control panel is not in the same room as the control panel, provide a main circuit breaker as part of the main disconnect assembly. Fused disconnects shall not be used unless specifically shown on the Contract Drawings.

B. Preparation of Bare Metal Panel Surfaces

1. Grind high spots, burrs, and rough spots.
2. Sand or sandblast to a smooth, clean, bright finish.
3. Every trace of oil shall be removed with a solvent.
4. Apply the first coat of primer immediately.

C. Panel Finishing

1. Repair damaged primer on inside surfaces.
2. Apply primer to the entire panel surface.
3. Apply 2 coats of satin finish lacquer enamel over the entire surface.
4. Colors shall match original paint color.

D. Instrument Finishing: The final coat applied to painted surfaces of instrument cases, doors, or bezels which are visible from the front of panels shall be manufacturer's standard unless otherwise indicated. Black japan or "crinkle" finishes on instrument cases are not acceptable.

E. Mounting of Instruments

1. The panel shop shall provide cutouts and shall mount instrument items indicated to be panel mounted, including any instruments indicated to be furnished by other vendors but installed in the panel.
2. The panel shop shall also mount behind the panels other instrument accessory items as required.
3. Equipment mounted at the rear of panel shall be installed to allow for commissioning adjustments, servicing requirements, and cover removal
4. Spare space shall be kept clear of wiring, etc., to give maximum space for future additions.
5. All equipment mounted with fasteners shall be mounted with grade 5 or greater Phillips head fasteners.

F. Electrical Requirements

1. Each panel shall be serialized with its own UL serial number and label.
2. Each terminal block shall have a printed label as shown on the panel drawings. Handwritten labels in any location of the panel will not be accepted. Wiring shall be identified with printed tubular wire end markers.
3. Back panels and side panels shall have visible machine printed adhesive labels that detail the following items:
   a. Terminal block torque ratings for field connections.
   b. Terminal block sections as detailed in the panel drawings.
   c. All equipment within the panel including, but not limited to, PLCs, switches, circuit breakers, UPS, Power Supplies, and any other piece of equipment.
4. Screw torque shall not exceed 0.4 N*M (4.4 Lb*In) (7 Lb-In).
5. Wire duct for AC signals and wiring shall be light grey. All duct for DC signals shall be white. Wiring for AC circuits and DC circuits must be kept within their respective ducts.
6. Freestanding panels shall be provided with switched lighting as indicated in the panel drawings.
7. Freestanding panels shall be provided with a 15-amp, 120-volt, service outlet circuit within the back-of-panel area as shown in the panel drawings.
8. Wall-mounted or pedestal-mounted panels shall be sized to adequately dissipate heat generated by equipment mounted in or on the panel.
9. Outdoor panels shall be provided with thermostatically controlled heaters to maintain inside temperatures between above 40°F.
10. Any panel with heat producing equipment such as a PLC, UPS or VFD shall have cooling capabilities to maintain the inside temperature below 104°F.
11. All outdoor panels equipped with heating and/or cooling shall be insulated with a minimum R value of 2.0.
12. Provide a laminated fuse list matrix detailing fuse numbers and sizes mounted on the inside of the enclosure door. The fuse list matrix must be easily visible and at minimum size 14 font. Handwritten fuse matrices will not be accepted. See panel drawings approximate locations.
13. Provide a pocket mount on the inside of each panel door large enough to hold type 8.5 x 11 size paper. See panel drawings for approximate locations. Pockets must be accessible with no equipment obstructing the entrance of the pocket for at least ten inches above the pocket. The pocket mount shall be fastened. No adhesive type pockets allowed.
14. Where required crimped fork or ring terminals will be properly installed on the conductors for connection integrity.
15. Signal and Control Circuit Wiring

a. Wire type and sizes: Conductors shall be flexible stranded tin machine tool wire, UL 1015 listed Type MTW, and shall be rated 600 volts. Wires for instrument signal circuits and alarm input circuits shall be 14 AWG. Other wires, including shielded cables, shall be 16 AWG minimum.

b. Wire Insulation Colors: Conductors supplying 120 VAC power on the line side of a disconnecting switch shall have a black insulation for the ungrounded conductor. Grounded circuit conductors shall have white insulation. Insulation for ungrounded 120 VAC control circuit conductors shall be red. Wires energized by a voltage source external to the control panel shall have yellow insulation. Insulation for DC conductors shall be blue.

c. Wire Marking: Wire numbers shall be marked using white numbered wire markers made from plastic-coated cloth, Brady Type B 500 or equal, or shall be heat shrink plastic. Wire labels must be machine printed. All conductors within the control panel are to be permanently marked with wire labels at each end. Wire labels are to correspond to the labels on the approved shop drawings.

d. For case grounding, panels shall be provided with a ground lug complete with solderless connector for one no. 1 AWG bare stranded copper cable.

e. Panel doors shall be connected to panel ground.

f. Wire Fastening: Provision shall be made utilizing cable tie bases such as type CTM1 or equivalent, fastened inside the wire duct to allow for the fastening of the shop wire harnesses upon final installation.

16. Power Supply Wiring

a. Unless otherwise indicated, control power shall be 120 VAC. Where the electrical power supply to the control panel is something other than 120 VAC, the control panel shall be provided with a control panel transformer. Control conductors shall be provided in accordance with the indicated requirements.

b. At a location near the top of the panel (or bottom), the panel fabricator shall provide terminal box connections for the main power supply entry.

17. Signal Wiring

a. Signal wire shall be shielded twisted pair or triads. Cable shall be 18 AWG copper signal wires.

b. Color code for instrument signal wiring shall be as follows:

1) Positive (+) – Red or Clear

2) Negative (-) – Black

c. Multiconductor cables where indicated shall consist of no. 16 AWG copper signal wires twisted in pairs with 90-C, 600 V fault insulation. A copper drain wire shall be provided for the bundle with a wrap of aluminum polyester shield. The overall bundle jacket shall be PVC.

d. RTD cabling shall be Belden 8770 cabling or equal.

e. Multi-conductor cables, wireways, and conduit shall be sized to allow for 25 percent spare signal wire.

18. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and be secured to the inside face of the panel using adhesive mounts.

19. Wiring to rear terminals on panel-mount instruments shall be in plastic wireways secured to horizontal brackets above or below the instruments in about the same plane as the rear of the instruments.

G. Labor and Workmanship: Panels shall be fabricated, piped, and wired by fully qualified workmen who are properly trained, experienced, and supervised.

2.4 CONTROL PANEL COMPONENTS

A. Nameplates and labels

1. All control components within the control panel shall be labeled with adhesive labels that have a thermal transfer type ink system on a UL-508A approved label. Labels shall be provided for marking wire ducts, terminal block sections, PLC modules, networking modules, signal isolators, intrinsic barriers, relays, breakers, power supplies, surge suppressors and all other pertinent components within the control panel.
2. All components on the exterior of the control panel shall have nameplates fabricated from black-letter, white-face laminated plastic engraving stock, Rowmark Ultramatte or equal. Engraved characters shall be block style with no characters smaller than 1/8 inch. Adhesive shall be high strength, low profile double strength, double sided as produced by Bron or Tessa or approved equal. Stainless steel fasteners shall be used in addition to the adhesive on all equipment where the fasteners do not derate the NEMA rating of the enclosure.

B. Pilot Devices

1. Provide pilot devices from a single manufacturer.
2. Pilot devices shall have NEMA ratings that match the overall control panel rating. They shall be 30mm in diameter and heavy duty.
3. All pilot devices shall have an associated nameplate that clearly describes the function of the device.
4. Pilot lights shall be LED and shall have colors as follows:
   a. The Contract Drawings shall take precedence for light colors. Refer to the P&ID's and schematics.
   b. On/Running/Opened: Green.
   c. Off/Stopped/Closed: Red.
   d. Power: White.
   e. Alarm/Fail: Red.
5. Acceptable Manufacturers
   a. Square D Types K (for NEMA 4 or 12) or Types SK (NEMA 4X).
   b. Allen-Bradley Types 800T (NEMA 4/12) or Types 800H (NEMA 4X, 7).
   c. Or Approved Equal.

C. Door Mounted Meters

1. Digital Process Meters
   a. Provide digital process meters to display a numeric process value as required by the Contract Drawings.
   b. The meter shall accept and re-transmit an analog input signal which is in proportion with the process value. The meter shall be capable of receiving the following signals:
      1) 0 or 4 to 20 mA current.
      2) 0 to 5 or 10 DC volts.
      3) RTD and Thermocouple type inputs.
   c. The meter shall be programmable to scale the numeric display to process engineering units. It shall be capable of showing up to three decimal points.
   d. The meter shall be capable of powering the input and re-transmitted signal.
   e. Acceptable Manufacturers:

1) Precision Digital Trident Series.
2) Red Lion PAX Series.
3) Or Approved Equal.

2. Elapsed Time Meters (ETM)
   a. Provide ETM's for each motor and/or machine provided for the project. Each ETM shall accumulate hours in tenths of an hour.
   b. The ETM enclosure shall be panel mount, polycarbonate, shock resistant and totally sealed.
   c. Acceptable Manufacturers:
      1) Hobbs 20000 Series.
      2) Or Approved Equal.

D. Terminal Blocks

1. Terminal blocks shall mount on standard DIN rail and be of the size required for conductors therein. A minimum of 25 percent spares shall be provided in each terminal box. No more than 2 conductors shall be allowed per termination. Jumper bar assemblies shall be installed for interconnecting terminal blocks, distributing power and signal commons. Terminal blocks shall be U.L. rated for 600 Volts, and 30 Amps, minimum.
2. Grounding terminal blocks shall be provided for instrumentation cable shields. The terminal blocks shall have distinctive 2-color bodies yellow and green, and shall be mounted to the DIN rail with metal screw down type clamps, providing a positive ground connection. One grounding terminal block shall be installed for every 2 instrument cables terminated. Grounding terminal blocks shall be U.L. rated for 600 Volts, and 20 Amps, minimum.
3. Terminal blocks shall be available in a variety of colors, including red, green, blue, gray, black, yellow, and orange.
4. DIN mount fuse holders shall have blown fuse indicators for DC and AC circuits. Fuse holders shall be of the compression clamp type. Fuse holders shall be U.L. listed and rated for 600 Volts. Fuse sizes shall not exceed the U.L. current rating for the fuse holders.
5. Terminal blocks for 4 to 20 milliamp signals shall have knife disconnect switches, and accessible test points for testing and measurement of current loop signals, without the need for removing wire terminations.
6. Approved Manufacturers
   a. Phoenix Contact UT Series.
   b. Allen-Bradley 1492 Series.
   c. Or Approved Equal.

E. DIN Rail

1. DIN rail shall be prepunched, RoHS compliant, treated with galvanic zinc plating and passivation. Symmetrical DIN rail shall be 35 mm X 15 mm.
2. Acceptable Manufacturers
   a. Iboco Omega 3AF.
   b. Or Approved Equal.

F. Wire Ducts

1. Wire ducts shall have narrow slots (approximately every ½") to accommodate high-density terminal blocks and other hardware.
2. Wire ducts shall be made of lead-free PVC, shall be UL rated for continuous use up to 122°F, and shall be flame retardant.
3. Wire duct colors shall be as follows:
    a. Light grey for all wiring 120V and higher.
    b. White for all wiring 48V and lower.
    c. Blue for all intrinsically safe wiring.
4. Acceptable Manufacturers
    a. Panduit Type F Series.
    b. Or Approved Equal.

G. Surge Protection Devices

1. Provide a Surge Protection Device (SPD) for power feeds which feed power to the control panel.
2. Each SPD shall have a short circuit current rating that exceeds the rating of the power feed that it is protecting.
3. All SPD's shall be properly grounded to the ground grid per NEC and per the SPD manufacturer's recommendations.
4. Three phase power feeds and single-phase power feeds for non-sensitive loads.
    a. Provide a parallel, DIN rail mountable, SPD whose location is immediately downstream of the main panel disconnect or circuit breaker.
    b. Capable of handling a 10kA surge current.
    c. Acceptable Manufacturers
        1) Transtector 12R Series.
        2) Or Approved Equal.
5. Single phase power feeds for control panels with sensitive electronics
    a. Provide an inline, DIN rail mountable, SPD that also provides EMI filtering.
    b. The SPD shall be capable of handling a 10kA surge current.
    c. The inline SPD shall have a set of dry contacts that indicate when the unit is healthy and operating correctly.
    d. Acceptable Manufacturers
        1) Phoenix Contact SFP Series.
        2) Or Approved Equal.
6. Low Voltage Signals
    a. Provide surge protection for low-voltage signals where shown on the Contract Drawings.
    b. Acceptable Manufacturers
        1) Phoenix Contact Termitrab.
        2) Or Approved Equal.
7. Coaxial Transmission Lines
    a. For radio type systems, provide surge/lightning protection for all coaxial lines leaving the control panel.
    b. Surge/lightning protectors shall be rated for the frequency at which signals are to be transmitted on the cabling.
    c. Acceptable manufacturers
        1) Polyphaser.
        2) Or Approved Equal.

H. Circuit Breakers

1. Circuit breakers shall meet the requirements of Section 262816.
2. Provide a main circuit breaker with panel disconnect if required as described in 2.3.A.
3. All control panels fed by 120VAC shall have a main DIN rail mounted circuit breaker.
4. The following types of loads shall be individually fed by circuit breakers:
    a. Panel mounted receptacles.
    b. UPS equipment.
    c. DC Power Supplies.
5. Circuit breakers shall be sized according to the loads they are powering.
6. Acceptable Manufacturers
    a. Square D.
    b. Cutler Hammer.
    c. Or Approved Equal.

I. Motor Controllers

1. All motor controllers shall meet the requirements of Division 26.

J. Uninterruptible Power Supplies (UPS)

1. All UPS equipment shall meet the requirements of Section 263353.
2. UPS equipment intended to be installed in control panels shall meet the following criteria:
    a. The UPS shall be UL listed and shall maintain the UL listing of the control panel.
    b. The UPS shall be properly mounted to withstand vibration and seismic requirements for the project.
    c. The UPS shall be sized for 200% of the calculated panel load.
    d. The UPS shall have a minimum backup time of 30 minutes unless specifically stated as otherwise on the Contract Drawings.
    e. For PLC panels, the UPS shall be equipped with dry contacts for monitoring the UPS for any alarm conditions and low battery.
3. Where specifically shown on the Contract Drawings, an industrial DC UPS may be used as backup power for the control panel. This will typically be the case where all critical loads are at 24VDC.
4. Unless indicated as otherwise on the Contract Drawings, the UPS equipment shall be the line-interactive type and operate at 120VAC.
5. UPS equipment shall provide surge, EMI
6. Acceptable Manufacturers
    a. Powerware 5000 series (line-interactive) or 9000 series (online).
    b. Sola SDU Series (24VDC UPS).
    c. Or Approved Equal.

K. Power Supplies

1. Provide 24VDC Power Supplies or other DC voltages as required for the application.
2. All power supplies shall be oversized for a minimum 150% of the calculated load.
3. All power supplies shall be properly protected by a DIN rail mount circuit breaker whose trip rating is per the manufacturer's recommendation.
4. All power supplies shall have a set of dry contacts that indicate when the power supply is operating normally.

5. Where shown on the Contract Drawings, provide redundant power supplies and corresponding diodes.
6. Power supplies shall meet the following criteria:
    a. Input Voltage: 100 to 240VAC.
    b. Output Voltage: ±1% of rated output.
    c. Operating Temperature: 0°C to 60°C.
    d. Built in transient surge protection.
    e. DIN rail mountable, metal housing.
7. Acceptable Manufacturers
    a. Phoenix Contact Quint Series.
    b. Or Approved Equal.

L. Signal Isolators/Converters

1. Furnish signal isolators as required that optically isolate the input signal from the output signal. If output signal is to be a different type of signal than the output than the isolator shall convert the signal as required.
2. Isolators output shall be adjustable for zero and span.
3. If input signal is part of a Hart system, the isolator shall be made specifically to pass on the Hart signal.
4. Acceptable Manufacturers
    a. Phoenix Contact.
    b. Action Instruments.
    c. Or Approved Equal.

M. Intrinsically Safe Barriers

1. Provide intrinsically safe barriers wherever analog or discrete input signals are coming from classified areas.
2. Intrinsically safe barriers shall be located in their own enclosure whose assembly is UL rated. Install the barriers and field wiring as per the requirements of NEC and the manufacturer's installation guidelines.
3. If input signal is part of a Hart system, the isolator shall be made specifically to pass on the Hart signal.
4. Acceptable Manufacturers
    a. Phoenix Contact.
    b. Pepperl Fuchs.
    c. Or Approved Equal.

N. Relays

1. Provide relays whose contact ratings are sized according to the load requirements and size of the protection device associated with the circuit in which the contacts are wired. As a minimum contact ratings shall be 10A resistive up to 250VAC.
2. Provide relays whose coil voltage is as required by the application.
3. Relays with DC rated coils shall have a freewheel diode installed across the coil.
4. Relays with AC rated coils shall have a surge suppressor installed across the coil.
5. Relays shall have based with relays which plug into the base. Bases shall have screw-type connections.
6. Relays shall have an LED indicating when the relay is coil is energized.

7. Provide enough relay contacts for each relay as required by the application. If the number of contacts required exceeds the number of contacts on the relay, provide additional relay(s) to provide enough sets of contacts.
8. Acceptable Manufacturers
    a. Idec R Series.
    b. Allen-Bradley 700H Series.
    c. Or Approved Equal.

O. Time Delay Relays

1. Provide time delay relays to control on and off delay times as required by the application.
2. Time delay relays shall meet the requirements of relays as listed above with the following additional requirements:
    a. Time delay shall be adjustable from 0.1 seconds to 600 hours.
    b. Timers shall be multi-function and shall be capable of providing on-delay, off-delay, cycle timing and one-shot type timing control.
3. Acceptable Manufacturers
    a. Idec RTE Series.
    b. Phoenix Contact ETD Series.
    c. Or Approved Equal.

P. Panel HVAC Components
1. Provide heating, ventilation, and air conditioning, devices in order to maintain all components within the control panel within the acceptable range as specified in Section 409000.
2. HVAC equipment shall maintain the required NEMA rating for the control panel assembly.
3. Externally mounted HVAC equipment (such as air-to-air exchangers or air conditioners) shall be housed in an enclosure whose material matches the material of the control panel. Where in corrosive environments, all components that will come in contact with outside air shall be corrosion resistant for that environment.
4. All HVAC equipment shall be UL rated. For equipment mounted on the control panel, the equipment shall have a corresponding NEMA rating.
5. Provide power as required for the HVAC equipment. HVAC loads shall be included in feeder and control power transformer sizing calculations.
6. Panel Heating
    a. Heating shall be provided when ambient temperatures are expected to fall below the allowed range as specified in Section 409000. As a minimum, heating shall be sized to keep the panel temperature at or above 50°F.
    b. Except for small anti-condensation heaters, heating equipment shall have fans which distribute the heat throughout the enclosure. Heaters shall be installed according to the manufacturer's installation instructions. Provide enough space between the heating equipment and other components such that the other components to not experience abnormally high temperatures.
    c. Provide anti-condensation heaters for all outdoor enclosures which house electronics, instrumentation and/or motor controllers.
    d. All heaters shall be thermostatically controlled by a DIN rail mounted thermostat.
    e. Acceptable Manufacturers
        1) Hoffman.
        2) Or Approved Equal.
7. Panel Ventilation

a. Where ventilation is determined to maintain the control panel's maximum temperature as required by Section 409000, the following requirements shall be adhered to:
   1) Ventilation shall maintain the required NEMA rating for the control panel assembly.
   2) For indoor, non-corrosive locations (panels with NEMA 12 ratings), conventional ventilation with fans and vents may be used.
   3) For corrosive or outdoor locations, side or top mounted air-to-air heat exchangers shall be used.
b. The fan(s) and corresponding vents or air-to-air heat exchangers shall be properly sized and located to move enough air through the panel to remove the generated heat as well as allow air flow across all heat generating equipment.
c. All ventilation shall be thermostatically controlled by a DIN rail mounted thermostat.
d. Acceptable Manufacturers
   1) Hoffman.
   2) Pfannenberg.
   3) Or Approved Equal.

8. Panel Air Conditioning
   a. Where it is deemed necessary to air condition a control panel to maintain the control panel's maximum temperature as required by Section 409000, the following requirements shall be adhered to:
      1) Air conditioners shall be side or top mounted and shall be sized based upon the heat generated within the control panel, the maximum outside air temperature, and the amount of sunlight the control panel may be exposed to. Air conditioners shall be oversized by a safety factor of 25%.
      2) Air conditioners shall be thermostatically controlled by a DIN rail mounted thermostat. In addition, the air conditioner shall turn off if the panel door(s) are not closed.
   b. Acceptable Manufacturers
      1) Hoffman.
      2) Pfannenberg.
      3) Thermal Edge.
      4) Kooltronics.

PART 3 - EXECUTION

3.1 FACTORY ACCEPTANCE TESTING

1. All control panels shall be factory acceptance tested (FAT) as required by Section 409000.

3.2 INSTALLATION

A. All control panels shall be installed according to the requirements of Section 409000.

B. All control panels shall be installed so that their surfaces are plumb and level.

C. All control panels shall be properly mounted so as to withstand the seismic requirements for the Site. Anchor panels securely to the wall or floor at each corner as a minimum.

D. Control panels shall have been designed according to locations for conduit entry. Floor mounted panels in electrical rooms shall have cutouts in the bottom of the enclosure that were cutout by the panel shop. All conduit holes shall be cut in the field.

E. Field wiring
   1. Wires that are terminated in control panels after permanent panel installation are deemed as field wires. Field wiring shall be installed in the allocated wire ducts and shall be properly labeled and terminated.
   2. All field wires shall be long enough to reach each corner of the enclosure. Neatly coil up extra wire length at the bottom of the enclosure. Do not use the wire ducts for storing extra wire length.

3.3 FIELD QUALITY CONTROL

A. Refer to Section 409000.

END OF SECTION 409513

SECTION 409533 – PROCESS CONTROL NETWORKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Structured Cabling System (SCS).
2. Communications Termination Cabinets (CTC).
3. Process Control Network Components.

B. Related Sections

1. The requirements of Division 26 shall apply to this section.

1.2 DEFINITIONS

A. The following definitions may be used throughout this section and subsections (refer to the contract drawings sheet GI-1 for instrumentation abbreviations):

1. CTC: Communications termination cabinet.
2. HMI: Human machine interface.
3. LAN: Local area network.
4. LCP: Local control panel.
5. OIT: Operator interface terminal.
6. OSP: Outside Plant.
7. PC: Personal computer.
8. PLC: Programmable logic controller.
9. SCADA: Supervisory control and data acquisition.
10. SCS: Structured Cabling System.
11. UPS: Uninterruptible power supply.
12. WAN: Wide area network.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each CTC cabinet supplied.

C. Network Drawings: Submit drawings for physical connections between all network hardware.

D. Exchange of Technical Information: During the period of these submittals, the Contractor shall authorize a direct, informal liaison with the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized informally by the Engineer but will not alter the scope of work or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the

Engineer shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Submit the operation and maintenance data, including record drawings as required by Section 409000.

1.6 QUALITY ASSURANCE

A. Referenced Standards:

1. National Electric Code (NEC).
2. American Society for Testing and Materials (ASTM).
3. National Electrical Manufacturers Association (NEMA).
4. Underwriters Laboratories Inc. (UL).
5. Telecommunications Industry Association / Electronic Industries Association (TIA/EIA) 568B – Commercial Building Telecommunications Cabling Standards.
6. TIA/EIA 569B – Commercial Building Standard for Telecommunications Pathways and Spaces.
7. International Standards Organization/International Electrotechnical Commission (ISO/IEC) 11801 – Information Technology – Generic cabling for customer premises.
8. Institute of Electrical and Electronic Engineers (IEEE)

B. Hardware and software to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

C. Examine the Contract Documents and verify that Process Control Network equipment and software being provided is compatible with the requirements. Provide all necessary accessories for the Process Control Network for a complete and operable system.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver the Process Control Network hardware and software as a complete system and as required by Section 409000.

1.8 SPECIAL WARRANTY REQUIREMENTS

A. The Contractor shall provide a Ten (10) year warranty on the following items:

1. Fiber Optic Cabling.
2. Fiber Optic Terminations and Cross-Connect Equipment.
3. Outside-Plant (OSP) Category 6 Cabling.
4. Copper Patch Panels and Indoor Category 6 Cabling.
5. CTC Hardware (excluding UPS and other electronic devices).

B. Extended Period for Correction of Defects: The Contractor shall correct all defects in the SCS upon notification from the OWNER within 2 years from the date of Substantial Completion. Corrections shall be completed within 5 days after notification.

PART 2 - PRODUCTS

2.1 GENERAL

A. Current Technology: Cabling, Hardware and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

B. Hardware Commonality: All like equipment shall be provided by a single manufacturer.

2.2 EQUIVALENT PRODUCTS

A. Equivalent products may be considered for substitution for those products specified, however, the equivalent product must be approved, and show demonstrated and documented equivalence to the product specified. Documentation shall include, but is not limited to: product samples, data sheets, and actual test data. The request for product substitution and supporting documentation must be submitted in writing prior to submitting the bid. Written approval for product substitution must be submitted with the bid.

2.3 FIBER OPTIC CABLING

A. Fiber optic cabling shall be provided between facilities and furnished with the quantity of fibers as designated on the contract drawings.

B. All fiber in a cable run shall be from the same manufacturer and shall be the same type. A mix of fibers from different manufacturers may not be used without written permission.

C. Fiber optic cabling exposed to the elements shall be an armored type fiber optic cable.

D. No fiber splicing or closures are allowed except to replace existing splices.

E. Singlemode Fiber

1. All singlemode fiber optic cables within the premises shall use graded-index fibers with 9 micron cores only.
2. Optical Specifications
   a. Fibers shall have dual wavelength capability at 1310nm and 1550nm.
   b. Attenuation: ≤ 0.4 dB/km at 1310nm and 0.3 dB/km at 1550nm.

c. Bandwidth: Operation of 10 Gigabit Ethernet at 10,000 meters at 1310nm and 30,000 meters at 1550nm.
d. Numerical Aperture: 0.14.

3. All fibers shall be color coded to facilitate individual fiber identification. Fibers shall have CPC® or approved equivalent color coatings that resist color degradation, minimize microbending losses and improve handling. The coating shall be mechanically strippable.
4. Dimensional Specifications
   a. Core Diameter: 8.2 µm
   b. Cladding Diameter: 125.0 ± 0.7 µm
   c. Core-Clad Concentricity: ≤ 0.5 µm
   d. Cladding Non-Circularity: ≤ 0.7%
   e. Coating Diameter: 242 ± 5 µm
   f. Coating-Cladding Concentricity: < 12 µm
5. Environmental Specifications
   a. Operating Temperature: -60ºC to +85ºC
   b. Cable shall be UV resistant, waterproof and corrosion resistant.
6. Mechanical Specifications
   a. Minimum tensile strength: 100,000 psig
   b. Fiber Minimum Bending Radius: 0.75 Inches
   c. Cable Minimum Bending Radius (During Installation): 20 times cable diameter
   d. Cable Minimum Bending Radius (After Installation): 10 times cable diameter
   e. Cable shall be rated for Underground, Buried and Aerial, OSP
   f. Cable shall bear OFNP (Plenum Rated), OFNR (Riser Rated) and/or appropriate markings for the environment in which they are installed.
   g. Cable shall utilize 3.0mm buffer tubes containing up to twelve 250 µm color-coded optical fibers.
7. Fiber Cabling shall contain the number of fibers specified in the Drawings.
8. Acceptable Manufacturers
   a. Corning SMF-28e+.
   b. Or approved equal.

F. Multimode Fiber

1. All multimode fiber optic cables shall use graded-index fibers with 50 micron cores only.
2. Optical Specifications
   a. Fibers shall have dual wavelength capability at 850nm and 1300nm.
   b. Attenuation: ≤ 3.0 dB/km at 850nm and 1.5 dB/km at 1300nm.
   c. Bandwidth: Effective Modal Bandwidth of 4700 MHz*km and shall guarantee operation of 10 Gigabit Ethernet at 550 meters at 850nm.
   d. Numerical Aperture: 0.200 ± 0.015.
3. All fibers shall be color coded to facilitate individual fiber identification. Fibers shall have CPC® or approved equivalent color coatings that resist color degradation, minimize microbending losses and improve handling. The coating shall be mechanically strippable.
4. Dimensional Specifications
   a. Core Diameter: 50 ± 2 µm
   b. Cladding Diameter: 125.0 ± 2.0 µm
   c. Core-Clad Concentricity: ≤ 1.5 µm
   d. Cladding Non-Circularity: ≤ 1.0%
   e. Core Non-Circularity: ≤ 5.0%

f. Coating Diameter: 245 ± 5 µm
g. Coating-Cladding Concentricity: < 12 µm

5. Environmental Specifications
   a. Operating Temperature: -60ºC to +85ºC
   b. Cable shall be UV resistant, waterproof and corrosion resistant.
6. Mechanical Specifications
   a. Minimum tensile strength: 100,000 psig
   b. Fiber Minimum Bending Radius: 0.75 Inches
   c. Cable Minimum Bending Radius (During Installation): 20 times cable diameter
   d. Cable Minimum Bending Radius (After Installation): 10 times cable diameter
   e. Cable shall be rated for Underground, Buried and Aerial, OSP
   f. Cable shall bear OFNP (Plenum Rated), OFNR (Riser Rated) and/or appropriate markings for the environment in which they are installed.
   g. Cable shall utilize 3.0mm buffer tubes containing up to twelve 250 µm color-coded optical fibers.
7. Fiber Cabling shall contain the number of fibers specified in the Drawings.
8. Acceptable Manufacturers
   a. Corning LANScape Class.
   b. Or approved equal.

G. Innerduct

1. Inner duct shall be used where space is available. All new and spare 2” conduits shall use inner duct with the fiber optic cable.

H. Buffer Tube Fiber Fan-Out Kits

1. Buffer Tube Fan-Out Kits shall be supplied for the termination of each buffer tube at end of the installed fiber cables.
2. Fan-Out Kits shall be color coded to match the color scheme of the fiber cabling.
3. Fan-Out Kits shall have a minimum length of 25 inches.
4. Acceptable Manufacturers
   a. Corning FAN-BT25-12.
   b. Or Approved Equal.

I. Fiber Optic Connectors

1. Fiber Optic Connectors shall be of ceramic construction and shall have a loss ≤ 0.5 dB. They shall be made specifically for the type of fiber being connected to and required bandwidth. The connector shall have no metal parts.
2. Fiber Optic Connectors shall utilize the LC type connector.
3. Acceptable Manufacturers
   a. Corning 95 Series.
   b. Or Approved Equal.

J. Fiber Patch Cords

1. The fiber patch cord shall be duplex and consist of buffered, graded-index fiber with a 50 or 62.5 µm core for multimode and 9 µm for singlemode and a 125 µm cladding. The fiber cladding shall be covered by aramid yarn and a jacket of flame-retardant PVC.
2. The fiber patch cord shall be rated for 10 Gigabit Ethernet.

3. For 50 µm multimode the cords shall be Aqua in color.
4. For 62.5 µm multimode the cords shall be Orange in color.
5. For singlemode the cords shall be Yellow in color.

2.4 Fiber Testing and Termination Toolkits and Training

A. Fiber Termination Toolkit shall be provided to the Owner following the completion of the SCS installation. The Toolkit shall be compatible with the Connectors used for terminating the fiber cabling and shall have the necessary components to make at least 100 additional terminations.

B. The Toolkit shall contain hard copies of installation instructions as well as an installation video that illustrates the step-by-step procedure for installing the Fiber Optic Connectors.

C. The Toolkit shall have test equipment that is capable of determining if a Connector was installed correctly.

D. The Toolkit must be an approved installation system of the manufacturer of the fiber optic cabling and connectors.

E. Acceptable Manufacturers
1. Corning SP1000 (polishing/termination kit).
2. Fluke FTK 1450 (fiber testing kit).
3. Or Approved Equals.

F. The Contractor is to provide two four hour sessions of training. These sessions will be with select city staff and focus on the use of the polishing kit to replace damaged terminations. Each trainee shall have the opportunity to use the polishing kit during these training courses. The Contractor shall also provide a DVD with step by step instructions and demonstrations on the polishing process.

2.5 COPPER NETWORK CABLING

A. Outside Plant Cabling (OSP)

1. All building-to-building copper network cabling shall be shielded and shall be rated as outside plant (OSP), Category 6 cables.
2. The cabling shall be terminated in the CTC in each building and shall be punched down at the patch panel on the CTC. The shield shall be grounded only on one end of the cable inside the CTC.
3. Shielded OSP Category 6 Specifications
   a. Category 6 Transmission performance characterized to 500MHz.
   b. Aluminum metallic shield tape for protection against EMI/RFI
   c. Four 23 AWG solid twisted pairs
   d. UV/Sunlight resistant black jacket
   e. Acceptable Manufacturers
      1) Superior Essex BBDN6.
      2) Or Approved Equal.

B. Indoor Cabling

1. Network cabling from the CTC's to wall jacks, control panels, MCCs, phones and all other Ethernet devices shall utilize Category 6 unshielded cable. The Category 6 cable shall be rated for Plenum use if it is run through any Plenum rated areas, otherwise it shall be rated for Riser use.
2. The following color scheme shall be utilized for indoor network cabling:
   a. Blue – Wall Jacks network connections
   b. Gray – Control Panels or MCCs
   c. Yellow – Patch Cables within the CTC
   d. Black – Outside Plant (OSP) cables
   e. Red – Security System / Fire System Cables
   f. White – Wall Jack phone connections
   g. Pink – Miscellaneous Ethernet devices
3. Unshielded Category 6 Specifications
   a. Category 6 Transmission performance characterized to 500MHz.
   b. Four 23 AWG solid twisted pairs
   c. Plenum rated cable shall have FEP insulation with a FRPVC jacket
   d. Riser rated cable shall have FRPE insulation with a PVC jacket.
4. Acceptable Manufacturers
   a. Superior Essex Series 77.
   b. Or Approved Equal.
5. Patch Cords
   a. Patch cords shall be TIA/EIA Category 6 Compliant. Cords shall be straight through unless cross-over is necessary. Cords shall be 24AWG stranded copper with FRPE insulation and a PVC jacket. RJ45 jack shall have contacts with 50 micro-inch gold plating and a high-impact, UL 94V-0 rated thermoplastic housing.
   b. Patch cords shall have a molded boot cover for protecting the RJ45 connector.
   c. All patch cords in the CTC shall be yellow.

2.6 CROSS-CONNECT EQUIPMENT

A. Cross-Connect Housings shall be provided within each CTC for permanent termination of the fiber optic cabling. The Housing shall be 19" rack mountable and shall be capable to support the termination of four 12-strand fiber optic cables.

B. Cross-Connect Housings when being provided in industrial enclosures such as PLC panels shall be panel mounted. The Housing shall be capable to support the termination of four 12-strand fiber optic cables.

C. The Housing shall be suitable for both loose tube, tight-buffered and optical fiber ribbon cables.

D. Acceptable Manufacturers
   1. Panduit FMD Series (19" Rack Mount).
   2. Panduit FWME Series (Wall Mount).
   3. Or Approved Equal.

E. Adapter Panels for the Cross-Connect Housings shall utilize LC type connectors. Multimode adapter panels shall have LC Duplex Connectors, shall be of ceramic construction for bandwidths of 4700 MHz, shall have a loss ≤ 0.5 dB. Singlemode adapter panels shall have 6

LC Duplex Connectors, shall be of ceramic construction for singlemode fiber, shall have a loss ≤ 0.5 dB.

2.7 COMMUNICATIONS TERMINATION CABINETS (CTC)

A. CTC's shall be 19" rack type systems that shall be able to support and organize electronic equipment, cross-connection and/or termination hardware for fiber optic cabling, station cabling, riser cabling, or building entrance cabling as may be required by design. The rack face shall have a conventional equipment mounting width of 19".

B. The rack must be designed for cable and jumper management and have hardware to organize and support cabling and patch cords in the vertical and horizontal planes. The rack system shall be equipped for electrical grounding to meet EIA/TIA 606 Standards. The fastening system for the equipment shall facilitate easy installation with roll-formed threads in the screw holes for greater strength and durability. The mounting screws shall have pilot points.

C. For NEMA 1 enclosures, all rack components shall be charcoal black in color and made of lightweight 6061-T6 extruded aluminum. For NEMA 4X enclosures the enclosure shall be 304SS.

D. The rack shall be shipped with all necessary hardware to assemble the included frame. It shall be packed in cartons with suitable shipping inserts such that no damage occurs to the rack finish. The finish shall not be scratched, chipped or marred.

E. Each CTC cabinet shall be supplied with a dedicated 20A, 120VAC circuit with associated receptacle mounted in the back of the cabinet.

F. Free Standing Rack Specifications

1. Self-Supported Rack Framework
   a. The self-supporting equipment rack shall be inside the CTC. Standard grade frames shall be capable of supporting equipment to be mounted inside the CTC.
   b. Dimensions: As required to fit in CTC with 19 inch center mounting and a minimum of 67" of usable vertical space. Base Footprint of 20.25" wide by 36" deep.
   c. Hole Pattern: EIA310-D 5/8" – ½" alternating.
   d. Mounting Screws: #12-24 thread combination Phillips/straight heads and pilot points.
   e. Materials: 6061-T6 high strength aluminum.
   f. Flanges: Flange edge to edge internal measurement is 17.75"
2. Racks shall be mounted inside NEMA 1 Enclosures with front and rear access doors.
3. Enclosures shall have glass front doors and solid vented rear doors.
4. Approved ground lug and #6 AWG jacketed green ground wire.
5. CTC shall be installed with at least 36" clear working space in front and behind cabinet.
6. Minimum 72" tall free standing enclosures.
7. Equipped with a slide-out shelf suitable for a laptop computer to be placed on it for system configuration/programming. The shelf shall be vented.
8. Equipped with a vertical power strip installed with a minimum of 10 outlets rated at 15 amps. The vertical power strip shall be surge protected.
9. Approved Manufacturers

a. Great Lakes.
b. Rittal.
c. CPI.
d. Or Approved Equal.

G. NEMA 1 Wall Mount Rack Specifications

1. Self-Supported Rack Framework
   a. The self-supporting equipment rack shall be inside the CTC. Standard grade frames shall be capable of supporting equipment to be mounted inside the CTC.
   b. Dimensions: As required to fit in CTC with 19 inch center mounting. Base Footprint of 20.25” wide by 24” deep.
   c. Hole Pattern: EIA310-D 5/8” – ½” alternating.
   d. Mounting Screws: #12-24 thread combination Phillips/straight heads and pilot points.
   e. Materials: 6061-T6 high strength aluminum.
   f. Flanges: Flange edge to edge internal measurement is 17.75”
2. Racks shall be mounted inside NEMA 1 Wall Mount Enclosures with a double hinge system allowing front and rear access.
3. Enclosures shall have glass or plexiglass front doors and solid vented rear doors.
4. Approved ground lug and #6 AWG jacketed green ground wire.
5. CTC shall be installed with at least 36” clear working space in front and 36” on the hinge side of the cabinet to allow access to the rear.
6. Panel mounting height shall be such that the top of the wall mount CTC does not exceed 80” above the finished floor.
7. Approved Manufacturers
   a. Great Lakes.
   b. Rittal.
   c. CPI.
   d. Or Approved Equal.

H. NEMA 4X Wall Mount Rack Specifications

1. Self-Supported Rack Framework
   a. The self-supporting equipment rack shall be inside the CTC. Standard grade frames shall be capable of supporting equipment to be mounted inside the CTC.
   b. Dimensions: As required to fit in CTC with 19 inch center mounting. Base Footprint of 20.25” wide by 24” deep.
   c. Hole Pattern: EIA310-D 5/8” – ½” alternating.
   d. Mounting Screws: #12-24 thread combination Phillips/straight heads and pilot points.
   e. Materials: 6061-T6 high strength aluminum.
   f. Flanges: Flange edge to edge internal measurement is 17.75”
2. Racks shall be mounted inside NEMA 4X Wall Mount Enclosures with a double hinge system allowing front and rear access.
3. Enclosures shall have glass or plexiglass front doors and solid vented rear doors.
4. Approved ground lug and #6 AWG jacketed green ground wire.
5. CTC shall be installed with at least 36” clear working space in front and 36” on the hinge side of the cabinet to allow access to the rear.
6. Panel mounting height shall be such that the top of the wall mount CTC does not exceed 80” above the finished floor.

7. Approved Manufacturers
   a. Hoffman Protek Series.
   b. Or Approved Equal.

2.8 CTC HVAC EQUIPMENT

A. All CTC cabinets shall be properly designed to maintain the inner temperatures of the enclosure within the allowed limits defined in Section 409000.

B. Any HVAC equipment shall maintain the NEMA rating of the CTC assembly.

C. Preferably, fans, air-to-air exchangers and AC units are mounted on the top of each CTC.

2.9 PATCH PANELS

A. Each CTC cabinet shall be supplied with a 19" rack mountable 110 punch down to RJ45 jack patch panel. The panel shall be rated for CAT6 cabling.

B. The 110 punch blocks shall support wiring and be labeled for both T568A and T568B standards. The patch panel shall have at a minimum 24 RJ45 ports and at least 12 spare ports. Each RJ45 port shall have a plastic label holder for custom labels.

2.10 WALL JACKS AND PLATES

A. Jacks shall be TIA/EIA Category 6 Compliant and shall support wiring and be labeled for both T568A and T568B standards. Plates shall be constructed of high-impact, flame-retardant, UL 94V-0 thermoplastic. Plates shall be available in single gang with 1-4 ports and double gang with 8 ports. Color of jacks and plates shall be determined by the Owner.

2.11 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Each CTC shall have an online double conversion UPS installed in it for surge protection and battery backup of critical network equipment. The UPS shall be 19" rack mountable and shall be mounted with sliding rails where possible.

B. Each UPS shall be capable of running the connected load for a minimum of 30 minutes.

C. UPS Electrical Input Specifications

1. Nominal Voltage: 120VAC
2. Voltage Range: 80-144VAC
3. Input Power Factor: > 0.95
4. Frequency: 60 Hz ±3 Hz.

D. UPS Electrical Output Specifications

1. Voltage Regulation: ± 3% of Nominal
2. Efficiency: > 85%

3. Frequency Regulation: ± 3 Hz on utility, ± 1 Hz on battery

E. UPS Communications Specifications

1. A USB port shall be available for monitoring and configuring the UPS. An appropriate cable shall be supplied to connect to the UPS with a PC.
2. An Ethernet port shall be available as an option with the ability to monitor and configure the UPS over an Ethernet network.

F. UPS Battery Specifications

1. All batteries shall be sealed, lead-acid batteries and shall be maintenance free. Batteries shall be hot-swappable. The UPS will indicate when the battery is weak and needs to be replaced.
2. The UPS shall be able to accept additional battery modules to extend the runtime of the UPS.

G. Acceptable Manufacturers
1. Powerware 9 Series.
2. Liebert GTX4 Series.
3. Or Approved Equal.

2.12 NETWORK SWITCHES

A. Each CTC shall contain a rack mountable network switch as indicated in the Contract Drawings.

B. Each PLC cabinet shall contain a DIN rail mountable network switch as indicated in the Contract Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies which it provides. The Contractor shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it provides.

B. All components of the SCS shall be the installation responsibility of the Contractor unless specifically noted otherwise. After the installation of the SCS is completed, the installation shall be inspected jointly by the Contractor and the Equipment Manufacturer's representatives. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the Engineer. The certification shall state that all cabling and terminations have been inspected and are installed in accordance with the manufacturer's guidelines.

C. All installations shall be done in conformance with EIA/TIA 568B standards and with the manufacturer's installation requirements. The Contractor shall confirm that the maximum pulling tensions of the specified distribution cables are not exceeded and cable bends maintain the proper radius during the placement of the facilities. Failure to follow the appropriate guidelines will require the Contractor to provide in a timely fashion the additional material and labor necessary to properly rectify the failure. Any and all damage to the cables during the construction of this project is the sole responsibility of the Contractor.

D. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 12 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 24 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 48 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 6 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

4. 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:
   a. Electrical Equipment Rating Less Than 2 kVA: 3 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

5. Separation between Cables and Electrical Motors and Transformers: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 6 inches.

E. Miscellaneous Equipment. The Contractor shall provide any necessary screws, anchors, clamps, tie wraps, distribution rings, wire molding, and support hardware, etc., necessary to facilitate the installation of the CTCs within the SCS. All metal fasteners and straps in corrosive or wet areas shall be 316SS.

F. Special Equipment and Tools. It shall be the responsibility of the Contractor to furnish any special installation equipment or tools necessary to properly complete the SCS. This may include, but is not limited to, tools for terminating cables, testing and splicing equipment for copper/fiber cables, communication devices, jack stands for cable reels, or cable wrenches.

G. Labeling. The Contractor shall be responsible for printed labels for all cables and cords, distribution frames, and outlet locations, according to Owner specifications. No labels are to be written by hand.

H. Cable Storage. The Contractor shall not roll or store cable reels without an appropriate underlay and the prior approval of the Owner.

I. Damages. The Contractor will be held responsible for any and all damages to portions of the building caused by it, its employees or subcontractors; including but not limited to:

1. Damage to any portion of the building caused by the movement of tools, materials or equipment.
2. Damage to any component of the construction of spaces "turned over" to the Contractor.
3. Damage to the electrical distribution system and/or space "turned over" to the Contractor.
4. Damage to the electrical, mechanical and/or life safety or other systems caused by inappropriate operation or connections made by the Contractor or other actions of Contractor.

J. Penetrations of Walls, Floors, and Ceilings. The Contractor shall make no penetration of existing walls, floors and/or ceilings without the prior consent of the Owner. Where penetrations through acoustical walls, fire-rated doors or other walls for cableways are to be installed, such penetrations shall be sealed by the Contractor in compliance with applicable code requirements.

K. The CTC's and all components of the system shall be installed in a neat, workmanlike manner. Wiring color codes shall be strictly observed and terminations shall be uniform throughout the system. Identification markings and systems shall be uniform. TIA/EIA 568B wiring codes as shown on the drawings shall standardize all SCS wiring. The CTC shall be level and plumb.

L. All structured wiring shall be neatly routed, protected and tied down. Install Velcro wrap on all cable bundles within the network rack/enclosure. All cabinets shall be cleaned out. All spare parts and documentation shall be turned into the Owner.

M. At the completion of the SCS, the Contractor shall restore to its former condition, all aspects of the project site and on a daily basis, shall remove all waste and excess materials, rubbish debris, tools and equipment resulting from or used in the services provided under this Contract. All clean up, restoration, and removal noted above will be by the Contractor and at no cost to the Owner. If the Contractor fails in its duties under this paragraph, the Owner may upon notice to the Contractor perform the necessary clean up and deduct the costs thereof from any amounts due or to become due to the Contractor.

3.2 NETWORK PROGRAMMING AND COMMISSIONING

A. Programming and Commissioning of the Network shall be by the Owner's System Integrator.

3.3 TESTING

A. Optical Fiber Cable Testing

1. All fiber testing shall be performed on all fibers in the completed end to end system. There shall be no splices unless approved in writing by the Engineer. Testing shall consist of a bidirectional end to end OTDR trace performed per EIA/TIA 455-61. All tests shall be conducted using 200ft launch cables. The system loss measurements shall

be provided at 850 and 1310 nanometers for multimode fibers and 1310nm and 1550 nm for singlemode fibers.

2. The Contractor shall test all fiber optic cable prior to the installation of the cable. The Contractor shall assume all liability for the replacement of the cable should it be found defective at a later date.
3. Loss Budget: Fiber links shall have a maximum loss of:
   a. (3.0 dB loss/km)*(km of fiber in link) + (0.5dB) * (number of connectors)
   b. Note that a mated connector to connector interface is defined as a single connector for the loss calculation.
   c. Any link not meeting the requirements of the standard shall be brought into compliance by the Contractor, at no charge to the Owner.
4. Documentation of all fiber optic cabling tests shall be provided in both hard and electronic copies to the Engineer.

B. Copper cable testing

1. Testing of all copper wiring shall be performed prior to system commissioning. All Ethernet cabling shall be certified for conformance to EIA/TIA 568B for Category 6. Testing shall be done with a TIA/EIA Certified Level 3 test set. Test shall include length, mutual capacitance, characteristic impedance, attenuation, near-end and far-end crosstalk. Any pairs not meeting the requirements of the standard shall be brought into compliance by the Contractor at no charge to the Owner.
2. Documentation of all copper cabling tests shall be provided in both hard and electronic copies to the Engineer.

3.4 FIELD QUALITY CONTROL

A. On-going inspections shall be performed during construction by the Contractor and by the Engineer to confirm that all work is performed in a high quality manner and the overall appearance is clean, neat and orderly. The following points will be examined and must be satisfactorily complied with:

1. Is the design documentation complete? Are all cables properly labeled, from end-to-end?
2. Have all terminated cables been properly tested in accordance with the specifications for the specific category as well as tested for opens, shorts, polarity reversals, transposition and presence of AC and/or DC voltage?
3. Is the cable type suitable for its pathway? Are the cables bundled in parallel?
4. Have the pathway manufacturer's guidelines been followed? Are all cable penetrations installed properly and fire stopped according to code?
5. Has excessive cable bending been avoided?
6. Have potential EMI and RFI sources been considered?
7. Is Cable fill correct?
8. Are hanging supports within 1.5 meters (5 feet)?
9. Does hanging cable exhibit some sag?
10. Are telecommunications closet terminations compatible with applications equipment?
11. Have Patch Panel instructions been followed?
12. Are identification markings uniform, permanent and readable?

END OF SECTION 409533

SECTION 409600 – PROCESS CONTROL SOFTWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. PLC Programming Software
2. OIT Programming Software
3. SCADA System Software

B. Owner's System Integrator will be SKM Engineering, LLC. These services will be provided thru the Engineering Construction Services.

C. Related Sections:

1. Refer to Section "409443 Programmable Logic Controllers" for PLC Hardware requirements.
2. Refer to Section "409433 Human Machine Interfaces" for OIT and SCADA System requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Software to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment.

B. Examine the Contract Documents and verify that Software being provided is compatible with the requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the Software to the Owner prior to startup and commissioning.

PART 2 - PRODUCTS

2.1 PLC PROGRAMMING SOFTWARE

A. PLC Programming Software shall be provided by the Owner's System Integrator.

2.2 OIT PROGRAMMING SOFTWARE

A. OIT Programming Software shall be provided by the Owner's System Integrator.

2.3 SCADA SYSTEM SOFTWARE

A. SCADA System Software shall be provided by the Owner's System Integrator.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with the Owner the installation of all software on PC's. Ensure that each software package is compatible with the PC's operating system.

B. Refer to the requirements of Sections 409000 and 409443 as well as the Contract Drawings.

3.2 TRAINING

A. Refer to the requirements of Section 409000.

END OF SECTION 409600