CITY OF MORRO BAY

WATER RECLAMATION FACILITY

TABLE OF CONTENTS

60% SUBMITTAL – NOT FOR CONSTRUCTION

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TABLE OF CONTENTS (Continued)

Number Title

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Number Title

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Section 01 33 00

SUBMITTAL PROCEDURES

1. SHOP DRAWINGS AND ENGINEERING DATA.

1.01. General.

This section stipulates the requirements for engineering data that the Supplier shall submit for design information and review. The document submittal procedures shall be in accordance with the requirements of this Specification.

Shop Drawings and engineering data (submittals) covering all equipment and all fabricated components and building materials which will become a permanent part of the Work under this Contract shall be submitted to Design-Builder for review, as required by the Schedule of Submittals. Submittals shall verify compliance with the Contract Documents, and shall include drawings and descriptive information in sufficient detail to show the kind, size, arrangement, and the operation of component materials and devices; the external connections, anchorages, and supports required; the performance characteristics; and dimensions needed for installation and correlation with other materials and equipment.

All submittals, regardless of origin, shall be approved by Design-Builder and clearly identified with the name and number of this Contract, and references to the applicable specification paragraphs and Contract Drawings. Each submittal shall indicate the intended use of the item in the Work. When catalog pages are submitted, applicable items shall be clearly identified and inapplicable data crossed out. The current revision, issue number, and date shall be indicated on all drawings and other descriptive data.

All deviations from the requirements of the Contract Documents shall be identified as deviations on each submittal and shall be noted by the Suppliers by red-lining a copy of the Specification and/or the Drawings. Such submittals shall, as pertinent to the deviation, indicate essential details of all changes proposed by the Supplier (including modifications to other facilities that may be a result of the deviation) and all required piping and wiring diagrams.

Technical data submittals shall be submitted in electronic format.

Electronic technical data submittals shall be made using the Project Central project collaboration system, a Web-based file transfer service. If Supplier does not already have Project Central transmittal capability, the Design-Builder will provide the required credentials for access upon Purchase Order award.

Notification to Design-Builder that submittals have been posted to Project Central shall be in accordance with the correspondence requirements of the Purchase Order.

1.02. Compliance Reports. Reports shall be submitted that record the tests and/or calculations required in the specification technical sections. Reports shall be submitted for each piece of equipment or each plant system. Specified drawings shall be submitted with the compliance reports.

1.03. Motor and Electric Actuator Information. If required by the Specifications, Motor and Electric Actuator Information shall be submitted in accordance with the Common Motor Requirements for Process Equipment section.

1.04. Drawings. Drawings shall be of sufficient detail to indicate the kind, size, arrangement, component weight, breakdown for shipment, and operation of component materials and devices; the external connections, anchorages, supports, and grouting requirement; the dimensions needed for installation and correlation with other materials and equipment; and the information specifically requested in both Section 2 of this Specification and the Schedule of Submittals section.

Drawings for use in installation and erection shall include a Bill of Quantity (BOQ), identifying the unit of measure, quantity, description, part number (or piece mark identifier), location reference on the drawing and any other details required by Design-Builder. It may be acceptable to have the BOQ detail in other means or media, if approved in advance by Design-Builder.

Supplier shall fully complete, check, and certify drawings, including drawings produced by a subcontractor, for compliance with the Purchase Order requirements prior to submittal. Drawings shall have title block entries that clearly indicate the drawing is certified.

Each submitted drawing shall be project unique and shall be clearly marked with the name of the project, unit designation, Design Builder's Purchase Order title, Design Builder's Purchase Order file number, project equipment or structure nomenclature, component identification numbers, and Design Builder's name. Equipment, instrumentation, and other components requiring Design-Builder-assigned identification tag numbers shall be clearly identified on the drawings. If standard drawings are submitted, the applicable equipment and devices furnished for the project shall be clearly marked.

Transmittal letters shall identify which Schedule of Submittals item (by item number) is satisfied by each drawing or group of drawings. The transmittal letter shall include the manufacturer's drawing number, revision number, and title for each drawing attached as well as all fields listed in the transmittal letter. Each drawing title shall be unique and shall be descriptive of the specific drawing

content. Transmittal letters for resubmitted drawings shall include the Design Builder's drawing numbers.

Catalog pages are not acceptable, except as drawings for standard nonengineered products and when the catalog pages provide all dimensional data, all external termination data, and mounting data. The catalog page shall be submitted with a typed cover page clearly indicating the name of the project, unit designation, specification title, specification number, component identification numbers, model number, Supplier's drawing number, and Design Builder's name.

Drawings shall be submitted with all numerical values in English units.

All multi sheet documents shall be submitted in their entirety for all revisions.

1.04.01 Drawing Submittal. Drawings shall be submitted electronically in Portable Document Format (PDF). AutoCAD or MicroStation format files are not acceptable. If Supplier does not have the capability to provide Portable Document Format (PDF), an alternative submittal format shall be used as mutually agreed between Design-Builder and Supplier.

1.04.02 Drawing Processing. Supplier's engineering schedule shall allow a minimum of three (3) weeks for transmittal, processing, and review of drawings and data by Design-Builder.

Unless this Purchase Order indicates that a drawing or engineering data submittal by Supplier is to be for Design-Builder's information only, Design-Builder, upon receipt of submittals, shall review and return same to Supplier, marked "No Exceptions Noted," "Exceptions Noted," "Received for Distribution," "Returned for Corrections," "Release for Record," "Void," "Superseded" or "Hold" The timing of Supplier's submittals and Purchaser's review shall be in accordance with the Completion Dates for same as set forth in the Purchase Order. The submittal of any drawing or other submittal document by Supplier to Design-Builder under this Purchase Order will be certified by Supplier that the information set forth therein is accurate in all material respects.

1.04.02.01 No Exceptions Noted (NE) or Received for Distribution (RD). Upon receipt of a submittal marked "No Exceptions Noted" or "Received for Distribution," Supplier may proceed with its Work to the extent of and in accordance with the submittal. Supplier shall not resubmit unless the drawing or document is revised, in which case it shall be resubmitted as a new document revision in accordance with the Resubmittals section.

1.04.02.02 Exceptions Noted (EN). Upon receipt of a submittal marked "Exceptions Noted" and if Supplier concurs with Design-Builder's comments, Supplier shall incorporate same and may proceed with its Work to the extent of and in accordance with the annotated submittal. Supplier shall submit to Design-

Builder within fourteen calendar days a revision to the original submittal in which Design-Builder's comments have been incorporated. If Supplier determines that it cannot incorporate Design-Builder's comments without prejudice to Supplier's warranty or other obligations under this Purchase Order, Supplier shall so advise Design-Builder in writing within seven calendar days of its receipt of Design-Builder's comments, stating the reasons therefore. Supplier may proceed with its Work to the extent of and in accordance with the annotated submittal only upon Design-Builder and Supplier resolving Design-Builder's comments.

1.04.02.03 Returned for Corrections (RC). Upon receipt of a submittal marked "Returned for Corrections," Supplier shall immediately take all necessary action to revise its submittal in accordance with Design-Builder's comments, the Specification, and the Drawings, and shall resubmit to Design-Builder for review the corrected original submittal, voiding previous information and adding new documents if required. In no event shall Supplier proceed with the affected Work until its revised submittals have been returned to Supplier marked "No Exceptions Noted" or "Exceptions Noted" by Purchaser.

1.04.02.04 Release for Record (RR). Receipt of a submittal marked "Release for Record" indicates that there are no specific objections to the document. Work may proceed. Certain project information required by the Design-Builder's document management system may have been added electronically to the drawing and provided to Supplier for the record. Supplier shall not resubmit the drawing or document unless revisions to the design are required. If revisions are required, Supplier shall incorporate Design-Builder's information and resubmit as a new revision. Design-Builder's project-specific information shall be added if future revisions and submittals are made.

1.04.02.05 Void (VO) or Superseded (SS). Receipt of a submittal marked "Void" or "Superseded" does not require any action by Supplier. "Void" indicates that the submittal is no longer applicable to the project and is not being replaced by other drawings or data. "Superseded" indicates that different drawings or data have replaced the previously submitted drawings and data; this status does not pertain to revisions of the same drawings and data.

1.04.02.06 Hold (HO). A submittal may be given a status of "Hold" by the Design-Builder, or the Supplier may have "Holds" on the submitted drawing.

For a Hold status designated by the Design-Builder, the Supplier shall not proceed with the work that is designated on "Hold" except as specifically directed by the Design-Builder. Additional information required for the Supplier to release the "Hold" will be transmitted from the Design-Builder later.

The Supplier shall provide information to the Design-Builder about the cause for any "Holds" designated on the drawing and immediately take all action necessary to resolve the "Holds". The Supplier shall resubmit the drawing for review once the "Holds" are removed from the drawing and should make all efforts to not

submit drawings to the Design-Builder until drawing review comments have been received back from the Design-Builder.

1.04.02.07 Resubmittals. If during or subsequent to the completion of the submittal process, Supplier makes further changes to the equipment and materials shown on submittals that have been reviewed by Design-Builder, the changes shall be clearly marked on the submittal by Supplier and the submittal process shall be repeated. If changes are made by Supplier after delivery to the Jobsite, drawings conforming to construction records indicating the changes shall be prepared by Supplier and submitted to Design-Builder for review. Any resubmittal of information shall clearly identify the revisions by footnote or by a form of back-circle, with revision block update, as appropriate. The Supplier shall put the Black & Veatch drawing number on the transmittal letter and submit a complete document.

1.04.02.08 Design-Builder's Review. Design-Builder's review of drawings and other submittals will cover only general conformity of the data to the Specifications and Drawings, external connections, interfaces with equipment and materials furnished under separate specifications, and dimensions that affect plant arrangements. Design-Builder's review does not include a thorough review of all dimensions, quantities, and details of the equipment, material, device, or item indicated or the accuracy of the information submitted. Review and comment by Design-Builder of Supplier's Drawings or other submittals shall not relieve Supplier of its sole responsibility to meet the Completion Dates requirement of this Purchase Order and to supply Goods that conform to the requirements of this Purchase Order.

1.04.02.09 File Returns to Supplier. The Project Central or project-specific web service will be used by Design-Builder to return PDF files to Supplier.

A copy of the manifest will be returned to Supplier indicating drawings statused as NE (No Exceptions Noted).

Each packet of drawings returned to Supplier will include a manifest generated by Design-Builder. The manifest will include a list of drawings transmitted, manufacturer's drawing numbers, Design-Builder's assigned drawing numbers, Design-Builder's drawing titles, and the status of the drawings.

Files returned to Supplier will be in PDF format.

2. OPERATION AND MAINTENANCE DATA AND MANUALS. Adequate operation and maintenance information shall be supplied for all equipment requiring maintenance or other attention. The equipment Supplier shall prepare a Project specific operation and maintenance manual for each type of equipment indicated in the individual equipment sections or the equipment schedule.

Unless otherwise agreed by Design-Builder, the operation and maintenance manual for each type of equipment shall only be submitted for review following completion of review of all shop drawings and engineering data pertaining to that equipment.

Parts lists and operating and maintenance instructions shall be furnished for other equipment not listed in the individual equipment sections or the equipment schedule.

Operation and maintenance manuals shall include the following:

a. Equipment function, normal operating characteristics, and limiting conditions.

b. Assembly, installation, alignment, adjustment, and checking instructions.

c. Operating instructions for startup, routine and normal operation, regulation and control, shutdown, and emergency conditions.

d. Lubrication and maintenance instructions.

e. Guide to troubleshooting.

f. Parts lists and predicted life of parts subject to wear.

g. Outline, cross section, and assembly drawings; engineering data; and wiring diagrams.

h. Test data and performance curves, where applicable.

i. Electronic file of Computer Maintenance Management System (CMMS) input data with all required preventative maintenance for seamless transition to incorporate into CMMS database.

The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered, or which may be required by Design-Builder.

Manuals shall be submitted in electronic format to Design-Builder prior to the date of shipment of the equipment and as indicated in the Schedule of Submittals. The manuals shall be submitted and Design-Builder's review comments retrieved, through the Project website accessible through the Internet. When review by Design-Builder is complete, the electronic O&M manual shall be delivered on via the project website to Design-Builder. Each CD or DVD shall contain only one copy of one manual. The completed O&M manual shall also be filed to the Project website. Delivery of the final O&M shall be made in accordance with the Schedule of Submittals section.

All material shall be marked with Project identification, and inapplicable information shall be marked out or deleted.

Shipment of equipment will not be considered complete until all required manuals and data have been received.

2.01. Electronic Operation and Maintenance Manuals. Electronic manuals shall be in Portable Document Format (PDF), and shall be prepared at a resolution between 300 and 600 dots per inch (dpi), depending on document type. Optical Character Recognition (OCR) capture shall be performed on these documents. OCR settings shall be performed.

Documents prepared in PDF format shall be processed as follows:

1. Pages shall be searchable (processed for optical character recognition) and indexed when multiple files are required.
2. Pages shall be rotated for viewing in proper orientation.
3. A bookmark shall be provided in the navigation frame for each entry in the Table of Contents.
4. Embedded thumbnails shall be generated for each completed PDF file.
5. The opening view for PDF files shall be as follows:
   Initial View: Bookmarks and Page
   Page Number: Title Page (usually Page 1)
   Magnification: Set to Fit in Window
   Page: Single Page
6. Where the bookmark structure is longer than one page the bookmarks shall be collapsed to show the chapter headings only.
7. When multiple files are required the first file of the series (the parent file) shall list every major topic in the Table of Contents. The parent file shall also include minor headings bookmarked based on the Table of Contents. Major headings, whose content is contained in subsequent files (children) shall be linked to be called from the parent to the specific location in the child file. The child file shall contain bookmark entries for both major and minor headings contained in the child file. The first bookmark of any child file shall link back to the parent file and shall read as follows "Return to the *Equipment Name* Table of Contents", e.g. Return to the Polymer Feed System Table of Contents.

8. Drawings shall be bookmarked individually.
9. Files shall be delivered without security settings to permit editing, insertion and deletion of material to update the manual provided by the manufacturer.

2.03. Labeling. As a minimum, the following information shall be included on all final O&M manual materials, including CDs or DVDs, jewel cases, and hard copy manuals:

Equipment name and/or O&M title spelled out in complete words.
Project Name.
Owner Project/Contract Number.
Specification Section Number. Example: "Section 15500"
Manufacturer's name.
File Name and Date.

For example:

MBR Operation and Maintenance Manual
Morro Bay WRF
Project/Contract No. 400530
Specification Section 46 61 35
Manufacturer
OM11110-001.pdf, 5/05/07

End of Section

Section 01 45 33

CODE REQUIRED SPECIAL INSPECTIONS AND PROCEDURES

PART 1 - GENERAL

1-1. SCOPE. Owner, or Registered Design Professional in Responsible Charge of construction acting as Owner's Agent, will engage one or more Approved Agencies to conduct tests and special inspections specified in this section and related sections, and as may be specified in other sections of these specifications. The Approved Agency shall not be employed by Design-Builder or a supplier materially participating in the project.

1-2. GENERAL. This Section includes administrative and procedural requirements indicated in the governing building code.

Structural testing and special inspection services are required to verify compliance with the construction documents and standards referenced herein. These services do not relieve Design-Builder of responsibility for compliance with the construction documents.

Specific quality-assurance and quality-control requirements for individual construction activities are also referenced in other Sections. Requirements in those Sections may also cover production of standard products.

Specified tests, inspections, and related actions do not limit Design-Builder's other quality-assurance and quality-control procedures that facilitate compliance with the construction documents.

Requirements for Design-Builder to provide quality-assurance and quality-control services required by Owner or Authority Having Jurisdiction (AHJ) are not limited by provisions of this Section.

1-3. DEFINITIONS.

Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved by the Authority Having Jurisdiction.

Approved Fabricator: An established and qualified person, firm or corporation registered and approved by the Authority Having Jurisdiction to perform work without Special Inspection.

Authority Having Jurisdiction (AHJ): The officer or other designated authority charged with the administration and enforcement of the building code, or a duly authorized representative. Also commonly known as the Building Official.

Construction Documents: Written, graphic and pictorial documents prepared or assembled for describing the design, location and physical characteristics of the elements of a project necessary for obtaining a building permit. Construction documents include all supplemental instructions, sketches, addenda, and revisions to the drawings and specifications issued by the Registered Design Professional beyond those issued for a building permit.

Pre-Engineered Structural Elements: Structural elements specified by the Registered Design Professional but which may be designed by another Registered Design Professional. (Examples are items such as open web steel joists and joist girders, metal joists, pre-cast concrete elements, pre-fabricated metal buildings, pre-stressed wire wrapped tanks, tilt-up concrete panel reinforcement and lifting hardware.)

Registered Design Professional (RDP): An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

Registered Design Professional in Responsible Charge (RDPRC): A Registered Design Professional engaged by Owner to review and coordinate certain aspects of the project, as determined by the AHJ and Construction Documents, for compatibility with the design of the buildings or structure, including submittal documents prepared by others, deferred submittal documents and phased submittal documents.

Shop Drawings / Submittal Data: Written, graphic and pictorial documents prepared and / or assembled by Design-Builder or Supplier based on the Construction Documents.

Special Inspection: Inspection and/or testing required by the governing building code, as amended by the AHJ, of the materials, installation, fabrication, erection or placement of components and connections requiring special expertise to ensure compliance with approved Construction Documents and referenced standards.

Special Inspection, Continuous: The full-time observation or testing of work requiring special inspection by an approved Special Inspector who is present in the area where the work is being performed.

Special Inspection, Periodic: The part-time or intermittent observation or testing of work requiring Special Inspection by an approved Special Inspector who is present in the area where the work has been or is being performed and at the completion of the work.

Special Inspector: A qualified person demonstrating competence, to the satisfaction of the AHJ and RDPRC, for inspection of the particular type of construction or operation requiring special inspection. The Special Inspector will be qualified as specified herein.

Structural Observations: Visual observation of the structural system by a Registered Design Professional for general conformance to the approved Construction Documents. Structural observations are not considered part of the tests and special inspections and do not replace inspections and testing by the Approved Agency. Owner will employ a RDP to perform Structural Observations.

Testing Agency: A qualified materials testing laboratory under the responsible charge of a Registered Design Professional, approved by the AHJ and the RDPRC, to measure, examine, test, calibrate, or otherwise determine the characteristics or performance of construction materials and verify confirmation with construction documents.

1-4. INSPECTION AND TESTING AGENCY QUALIFICATIONS. Special Inspectors and testing agencies will be employed or retained by Owner, and will have the minimum qualifications as described in this section. The qualifications of all personnel performing special inspection and testing activities are subject to the approval of the AHJ.

Minimum qualifications of inspection and testing agencies and their personnel will comply with ASTM E329 “Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection,” or IAS AC 291 “Accreditation Criteria for Special Inspection Agencies.”

Inspectors and individuals performing tests will be certified for the work being performed as listed below and in Table 1 of IAS AC291, or by alternate certifications when acceptable to the AHJ. The AHJ may have additional requirements.

Abbreviation used in this Section	**Description**
AIA	Architect licensed in the state of the project, specializing in the design of building structures
Licensed Engineers	
PE/SE	Structural Engineer (SE) or Professional Engineer (PE) licensed in the state of the project, specializing in the design of building structures
PE/GE	Geotechnical Engineer (GE) or Professional Engineer (PE) licensed in the state of the project, specializing in soil mechanics and foundations
PE/EE	Electrical Engineer (EE) or Professional Engineer (PE) licensed in the state of the project, specializing in electrical systems
PE/ME	Mechanical Engineer (ME) or Professional Engineer (PE) licensed in the state of the project, specializing in mechanical systems

Abbreviation used in this Section	Description
EI/EIT	Engineering Intern or Engineer-in-Training: a graduate engineer who has passed the Fundamentals of Engineering examination working under the direct supervision of a Professional Engineer licensed in the state of the project and with a minimum of one year of experience performing inspections.
American Concrete Institute (ACI) Certification	
ACI-CFTT	Concrete Field Testing Technician – Grade 1
ACI-CCI	Concrete Construction Inspector
ACI-LTT	Laboratory Testing Technician – Grade 1 or 2
ACI-STT	Strength Testing Technician
American Welding Society (AWS) Certification	
AWS-CWI	Certified Welding Inspector
AWS/AISC-SSI	Certified Structural Steel Inspector
American Society of Non-Destructive Testing (ASNT) Certification	
ASNT	Non-Destructive Testing Technician For Ultrasonic Testing (UT) and Radiographic Testing (RT) Certified as Level III through examination by ASNT or certified as Level II by their employer for flaw detection. For Magnetic Particle Testing (MT) and Liquid Penetrant Testing (PT) certified as Level II by their employer or certified as Level III through examination by ASNT and certified by their employer
International Code Council (ICC) Certification	
ICC-SMSI	Structural Masonry Special Inspector
ICC-SWSI	Structural Steel and Welding Special Inspector
ICC-SFSI	Spray-Applied Fire-proofing Special Inspector
ICC-PCSI	Prestressed Concrete Special Inspector
ICC-RCSI	Reinforced Concrete Special Inspector
ICC-SBSI	Structural Steel and Bolting Special Inspector
ICC-WSI	Structural Welding Special Inspector
National Concrete Masonry Association	
NCMA	Concrete Masonry Testing Technician
National Institute for Certification in Engineering Technologies (NICET)	
NICET-CT	Concrete Technician – Levels II, III & IV

Abbreviation used in this Section	Description
NICET-ST	Soils Technician - Levels II, III & IV
NICET-GET	Geotechnical Engineering Technician - Levels II, III & IV
Exterior Design Institute (EDI) Certification	
EDI-EIFS	EIFS Third Party Inspector

Inspection or Testing Item	Qualification Standards
Fabricators	Varies by product as listed below
Steel Construction – Welding Inspection	ICC-SWSI, ICC-WSI, AWS-CWI or AWS/AISC-SSI
Steel Construction – Non-Destructive Weld Testing	ASNT
Steel Construction – Details	PE/SE, ICC-SWSI, ICC-SBSI or AWS/AISC-SSI
Steel Construction – High Strength Bolts	PE/SE or ICC-SBSI
Concrete Construction - Field Tests	ACI-CFTT or NICET-CT
Concrete Construction - Field Inspection	PE/SE, ICC-RCSI, ACI-CCI or NICET-CT
Concrete Construction - Laboratory Testing	ACI-LTT, ACI-STT or NICET-CT
Prestressed Concrete Construction	ICC-PCSI
Masonry Construction - Field Inspection	PE/SE or ICC-SMSI
Masonry Construction - Laboratory Testing	NCMA
Soils (special grading, excavation and filling)	PE/GE, NICET-ST or NICET-GET under the direct supervision of Registered Civil (geotechnical) Engineer
Pile Foundations	PE/GE, Appropriate structural material inspection and NICET-ST or NICET-GET under the direct supervision of Registered Civil (geotechnical) Engineer
Pier Foundations	PE/GE, Appropriate structural material inspection and NICET-ST or NICET-GET under the direct supervision of Registered Civil (geotechnical) Engineer
Wall Panels and Veneers	ICC-SMSI
Sprayed Fire-Resistant Materials	ICC-SFSI
Exterior Insulation and Finish Systems (EIFS)	ICC Building Inspector or EDI-EIFS
Post Installed Anchors in Concrete	ICC Building Inspector, ICC-RCSI, or PE/SE
Post Installed Anchors in Masonry	ICC Building Inspector, ICC-SMSI, or PE/SE
Smoke Control Systems	IBC 1705.18.2
Other Architectural Systems	ICC Building Inspector, AIA, or PE/SE
Mechanical Systems	ICC Building Inspector or PE/ME

Inspection or Testing Item	Qualification Standards
Electrical Systems	See NFPA 70

1-4.01. Structural Steel Testing Agency Requirements. Submit the following to the RDPRC and the AHJ prior to beginning testing:

Written practices for monitoring and control of the inspection and testing agency operations including

Inspection and testing agency's procedures for the selection and administration of inspection personnel, describing the training, experience, and examination requirements for qualification and certification of inspection personnel.

Inspection and testing agency's inspection procedures, including general inspection, material controls, and visual welding inspection.

Qualifications of management and quality assurance personnel designated for the project.

Qualification records for inspectors and NDT technicians designated for the project.

NDT procedures and equipment calibration records for NDT to be performed and equipment to be used for the project.

1-5. CONFLICTING REQUIREMENTS, REPORTS AND TEST RESULTS.

1-5.01. General. If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to the RDPRC for a decision before proceeding.

1-5.02. Minimum Quantity or Quality Levels. The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to the RDPRC for a decision before proceeding.

1-5.03. Precedence. The Approved Agency reports and testing results shall have precedence over reports and test results provided by Design-Builder.

1-5.04. Conflict. Where a conflict exists between the construction documents and approved shop drawings/submittal data, the construction documents shall govern unless the shop drawings/submittal data are more restrictive. All conflicts shall be brought to the attention of the RDPRC.

1-6. TECHNICAL ATTACHMENTS. The following forms are required as part of the comprehensive administrative, testing and inspection requirements. The forms are available from the AHJ, or are included herein, as indicated:

Form Title	AHJ Provided	Included Herein	Notes
Statement of Special Inspections (SSI)		x	To be completed jointly by the RDPRC and the Approved Agency, and sealed by the RDPRC after completion. Design-Builder or Owner shall submit the form to the AHJ as part of the building permit application process.
Request for Approval of Special Inspector		x	To be completed by Approved Agency. Approved Agency will submit the form to the AHJ and RDPRC for their approval of individual inspectors.
Request for Approval to Provide Special Inspection of Non-Local Fabrication		x	To be completed by Approved Agency and submitted to Owner, AHJ and RDPRC.
Design-Builder's Statement of Responsibility		x	To completed by Design-Builder and his relevant suppliers and submitted to Owner and AHJ.
Fabricator's Certificate of Compliance		x	To be completed by Design-Builder's fabricators, as applicable, and submitted to AHJ.
Final Report of Special Inspections		x	To be completed and sealed by Approved Agency. Approved Agency or Owner will submit to AHJ at the completion of

			construction.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3-1. DESIGN-BUILDER AND FABRICATOR RESPONSIBILITIES. Each Fabricator or Design-Builder responsible for the construction of a seismic-force-resisting system, designated seismic system, seismic resisting component, main wind force-resisting system, or a wind-resisting component listed in the SSI shall submit a Design-Builder's Statement of Responsibility to the AHJ and to Owner prior to the commencement of work.

To be considered an Approved Fabricator that may perform work without Special Inspection, the Fabricator shall submit copies of certifications from the International Accreditation Service (IAS) or other recognized and acceptable accreditation organization a minimum of 30 days prior to the start of fabrication. Acceptance as an Approved Fabricator is subject to approval by the AHJ. If the project specifications required an Approved Fabricator, and the AHJ does not accept the Fabricator as an Approved Fabricator, special inspection may become necessary in the fabricator's shop. Such inspections will be performed by Approved Agency and Design-Builder shall reimburse Owner for the cost for the inspections.

Design-Builder shall assist in coordination of the inspection and testing services with the progress of the work. Design-Builder shall provide sufficient notice to allow proper scheduling of all inspection and testing personnel. Design-Builder shall provide safe access to inspection and testing personnel and shall ensure that all work requiring special inspection is inspected and/or tested prior to concealment.

Design-Builder shall submit schedules to Owner, RDPRC and testing and inspecting agencies. Schedules will note milestones and durations of time for materials requiring tests and special inspections.

Design-Builder shall provide the Special Inspector access to approved plans at the job site or fabrication shop as applicable.

Design-Builder shall retain at the job site or fabrication shop, as applicable, all special inspection records submitted by an Approved Agency or Special Inspector and shall provide these records for review by the AHJ's inspector upon request.

Design-Builder shall repair and/or replace work that does not meet the requirements of the construction documents.

Design-Builder shall engage an engineer to prepare repair and/or replacement procedures for any deficiencies identified. Design-Builder's engineer shall be registered in the state in which the project is located. Design-Builder's engineer shall be acceptable to the RDPRC, AHJ, and Owner. Procedures shall be submitted for review and acceptance by the RDPRC, AHJ, and Owner before proceeding with corrective action.

Design-Builder shall be responsible for costs of:

Re-testing and re-inspection of materials, work, and/or products that do not meet the requirements of the Contract Documents or shop drawing/submittal data.

Review of proposed repair and/or replacement procedures by the RDPRC and the inspectors and testing agencies.

Repair or replacement of work that does not meet the requirements of the Construction Documents.

3-2. APPROVED AGENCY AND SPECIAL INSPECTOR RESPONSIBILITIES.

3-2.01. Preliminary Approvals. The Approved Agency will submit a "Request for Approval of Special Inspector" form to the AHJ for each proposed Special Inspector or testing technician. The form will include the individual's credentials, which as a minimum will meet the requirements indicated in Paragraph 1-4 in this Section. Inspector certifications by organizations other than those listed herein will not be acceptable without approval of the AHJ. The AHJ may have additional requirements to those specified herein. It is the responsibility of the testing and inspection agencies to meet local requirements and comply with local procedures.

When fabrication will take place away from the local proximity of the project, Approved Agency will submit a "Request for Approval to Provide Special Inspection of Non-Local Fabrication" form for review and approval by Owner, the RDPRC, and the AHJ prior to subcontracting with an inspection/testing agency in the locale of the fabricating plant.

3-2.02. Perform Inspections and Tests. Be present for and perform continuous or periodic inspections and tests as listed in the SSI for conformance of the work to the AHJ approved Construction Documents. Notify Design-Builder personnel of their presence and responsibilities. Reference the applicable "Code or Standard Reference" column in the SSI for the minimum level of inspections and testing. When the SSI column titled "Code or Standard Reference" indicates "Manufacturer's research reports", inspector will obtain the most current ICBO-ES Report, ICC-ES Legacy Report, ICC-ES Report, or IAPMO UES Evaluation Report (as applicable) prior to the applicable inspection, for the type and brand of products or materials being inspected.

Provide additional inspections and testing as necessary to determine compliance with the Construction Documents. Perform special inspections in a timely manner to avoid delay of work.

The Approved Agency shall be responsible to insure that any non-local inspection/testing agency fully complies with this Section and the SSI.

3-2.03. Defective Work. Immediately notify Design-Builder of the need for corrective action when work does not conform to Construction Documents.

3-2.04. Uncorrected Defective Work. Notify the AHJ and RDPRC when deficiencies have not been corrected. Notice will be made prior to the completion of that phase of the work.

3-2.05. Interim Inspection Reports. Furnish interim inspection reports to the AHJ, the RDPRC, Design-Builder, and Owner during the progress of the work. Frequency of reports will be as established in the SSI. Reports will indicate that work inspected was done in conformance to the approved Construction Documents, or that the work was defective, as applicable.

Special inspection reports and test results will include, but not be limited to, the following:

Project name and address.

Permit number.

Special Inspection Agency name, address, and phone number.

Unique identification of the report and of each page.

Date and time of inspection.

Description of inspections or tests performed, including item description and location (reference grid lines, floors, elevations, etc.). Identify approved agencies employed to carry out tests.

Identification of test/inspection equipment used.

Statement noting that the work, material, and/or product conforms or does not conform to the construction document requirements. Describe defective items.

Name and signature of Design-Builder's representative who was notified of work, material, and/or products that do not meet the construction document requirements.

Name and signature of Special Inspector and/or testing agency representative performing the work.

3-2.06. Report of Defective Work. Each agent will maintain a log that identifies work that does not meet the requirements of the construction documents. Include:

Description and exact location.

Reference to applicable drawings and specifications.

Reference to original inspection/test report and subsequent dates of re-inspection/retesting.

Name and title of each individual notified and method of notification.

How defective items were resolved or unresolved, as applicable.

Itemized changes authorized by the RDPRC and AHJ if not included in a defective item.

3-2.07. Submittal Schedule. Documentation of reports, test results, and non-compliant work will be submitted at the frequency indicated in the SSI.

3-2.08. Final Report of Special Inspections. Each agent listed in the SSI shall submit a final report to the Approved Agency documenting the performed special inspections and the correction of any discrepancies noted. The Approved Agency shall cumulate the reports and submit a comprehensive final report at a point in time as agreed upon by the permit applicant and the AHJ prior to the start of work.

3-3. STRUCTURAL OBSERVATION. Owner, or RDPRC on Owner's behalf, shall employ a RDP to perform Structural Observation. Prior to the commencement of observations, the structural observer shall submit to the AHJ a written statement identifying the frequency and extent of structural observations. Structural observations may be made periodically as determined by the Registered Design Professional.

At the conclusion of the work requiring observation, the structural observer shall submit to the AHJ a written statement that the site visits have been made and identify any reported deficiencies which, to the best of the structural observer's knowledge, have not been resolved.

Statement of Special Inspections

Project:
Project Address:
Permit Applicant:
Applicant Address:
Owner:
Owner Address:

Registered Design Professional in Responsible Charge (RDPRC) :

Discipline	Name	License Number	Expiration Date
Structural Engineer			
Geotechnical Engineer			
Mechanical Engineer			
Electrical Engineer			
Architect			

This Statement of Special Inspections includes a *Schedule of Special Inspections* applicable to the above referenced project as well as the identity of the individuals, agencies, or firms intended to be retained for conducting these inspections.

The Special Inspector(s) shall keep records of all inspections and shall furnish interim inspection reports to the Authority Having Jurisdiction (AHJ) and to the Registered Design Professional in Responsible Charge (RDPRC). Discrepancies shall be brought to the immediate attention of the Design-Builder for correction. If the discrepancies are not corrected, the discrepancies shall be brought to the attention of the AHJ and the RDPRC prior to completion of that phase of work. A *Final Report of Special Inspections* documenting required special inspections and correction of any discrepancies noted in the inspections shall be submitted by each agent.

The Special Inspection program does not relieve the Design-Builder of the responsibility to comply with the Contract Documents. Jobsite safety and means and methods of construction are solely the responsibility of the Design-Builder.

Inspection work shall be performed in accordance with the following codes and standards. Unless otherwise indicated within the Statement of Special Inspections, the applicable edition for all codes and standards shall be as follows.

Work	In Accordance With
Building Code	2016 California Building Code (CBC)
Seismic Criteria for Nonstructural Components	ASCE 7-10
Standard Tests and Practices	Listed American Society for Testing and Materials (ASTM) specifications
Concrete	ACI 318-14 and ACI 350-06
Masonry	ACI 530-13 and ACI 530.1-13
Structural Steel	AISC 360-10 and AISC 341-10

Work	In Accordance With
Structural steel welding	AWS D1.1 Structural Welding Code - Steel
Aluminum welding	AWS D1.2 Structural Welding Code – Aluminum
Sheet steel welding	AWS D1.3 Structural Welding Code – Sheet Steel
Structural steel bolting	Research Council on Structural Connections Specification for Structural Joints Using High Strength Bolts, December 31, 2009
Intumescent Fire-Resistive Coating	Association of the Wall and Ceiling Industry (AWCI) Technical Manual 12-B, Second Edition; Standard Practice for the Testing and Inspection of Field Applied Thin Film Intumescent Fire-Resistive Materials; an Annotated Guide

RDPRC - Structural	RDPRC - Civil/Geotechnical	RDPRC - Mechanical
RDPRC – Electrical	RDPRC - Architect	

Owner's Acknowledgement:

Signature Date

Acceptance by Authority Having Jurisdiction:

Signature Date

Permit No.

Frequency of interim report submittals to AHJ:

☐ 1 week ☐ 2 weeks ☐ Monthly ☐ Bi-Monthly ☐ At Completion ☐ Per attached Schedule

Statement of Special Inspections
(Schedule of Inspections)

The attached tables as listed below define the applicable Special Inspections and Procedures.

Table 1 of 9	Geotechnical Special Inspections
Table 2 of 9	Structural Special Inspections
Table 3 of 9	Architectural Special Inspections
Table 4 of 9	Inspections for Special Cases
Table 5 of 9	Testing for Special Inspections
Table 6 of 9	Special Inspections for Seismic Resistance
Table 7 of 9	Testing for Seismic Resistance
Table 8 of 9	Special Inspections for Wind Resistance
Table 9 of 9	Inspection Agents

The Seismic Design Category for the project is D.

Schedule of Special Inspections - Table 1 of 9 (Geotechnical Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Soils						
Verify material below foundation is adequate to achieve design bearing capacity, free of loose, deleterious or foreign material.	1705.6	Geotechnical Report		**X** (foundation excavation complete)		
Verify excavations are extended to proper depth, proper size and material.	1705.6	Geotechnical Report		**X** (foundation excavation complete)		
Prior to placement of controlled fill, inspect subgrade and verify site is properly prepared.	1705.6	Geotechnical Report		**X** (prior to placement of fill)		
Perform classification and testing of compacted fill material.	1705.6	Geotechnical Report		**X** (during placement of fill)		
Verify materials, densities, and lift thicknesses during placement and compaction of controlled fill for foundations.	1705.6	Geotechnical Report	**X**		Note the exception of Article 1705.6.	
Driven Deep Foundation Elements NOT USED						
Cast-in-Place Deep Foundation Elements (Auger Cast Piles and Drilled Piers)						
Material verification.	1705.8	Geotechnical Report	**X**		Refer to Table 2 for material-specific requirements.	
Determine capacities of test piles and conduct additional load tests as required.		Geotechnical Report	**X**			
Drilling operations and maintain records for each pile or pier.	1705.8	Geotechnical Report	**X**			

Schedule of Special Inspections - Table 1 of 9 (Geotechnical Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Installation: Location, plumbness, diameters, bell diameter, lengths, embedment into bedrock, adequate end bearing strata capacity, record of concrete or grout volumes.	1705.8	Geotechnical Report	**X**			
Helical Pile Foundations NOT USED						
Screw Anchors NOT USED						
Mechanically Stabilized Earth (MSE) Retaining Walls NOT USED						
Tension Anchors NOT USED						
Stone Columns NOT USED						

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Structural Load-Bearing Members Fabricated in a Shop						
If registered and approved by the AHJ to perform work without special inspection, submit "Fabricator's Certificate of Compliance" at the completion of work that fabricated items were constructed in accordance with the approved construction documents.	1704.2.5.1 1704.5 1705.10			**X** (at end of fabrication)		N/A
Concrete (inspections not required for nonstructural concrete slabs supported directly on the ground)						
Reinforcing steel and prestressing tendon condition (free of oil, dirt and loose rust and that properly coated and/or sheathed) and placement. Verify size, spacing, bar clearances, cover, and adequate support to prevent displacement during concrete placement. Verify lap splices, mechanical splices, and embedment lengths. Verify dowels for work above are properly aligned and spaced to match other work.	1705.3	ACI 318 (Ch. 20) ACI 318 (25.2-25.3) ACI 318 (26.6.1-26.6.3		**X** (prior to closing of forms or delivery of concrete, for each placement)		
Cast-in-place anchor bolts prior to and during placement of concrete.	1705.3	ACI 318 (17.8.2)	**X**		All bolts visually inspected to verify anchor diameter, location, and embedment length.	
Verify use of approved mix design(s).	1705.3 1904.1	ACI 318 (Ch. 19) ACI 318 (26.4.3-26.4.4)		**X**	RDPRC to approve Design-Builder's proposed mix design prior to construction. Inspector to verify from concrete delivery ticket that the appropriate mix has been provided prior to placement.	

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Formwork shape, location, and dimensions of the concrete member being formed, construction joints properly prepared.	1705.3	ACI 318 (26.11.1.2(b)		**X** (prior to delivery of concrete for each placement)		
Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content test, and determine the temperature of the concrete.	1705.3	ASTM C31 ASTM C172 ACI 318 (26.12)		**X**	Sampling and testing frequency shall be as indicated in the cast-in-place concrete specification.	
Concrete placement.	1705.3	ACI 318 (26.5.2)	**X**		Verify that water added at the site does not exceed that allowed by the mix design. Verify conveying, depositing, and consolidation of concrete. Observe placement procedures for evidence of segregation, possible cold joints, displacement of reinforcing or forms, and proper support of embedded items, anchor bolts, etc.	
Concrete curing – maintain temperature and techniques.	1705.3	ACI 318 (26.5.3-26.5.5)		**X** (during hot, cold, and windy conditions)	For wet-curing, check at the beginning of each day during 7 day curing period	
Verification of in-situ concrete strength prior to removal of forms and shores from elevated beams and slabs.	1705.3	ACI 318 (26.11.2)		**X** (prior to form or shore removal)		
Verification of in-situ concrete strength prior to backfilling against walls.				**X** (prior to backfilling operations)		
Shotcrete NOT USED						

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Masonry for Occupancy Category I, II, or III Structures						
Verification of proportions for site-prepared mortar and grout.	1705.4	ACI 530.1 (2.1) ACI 530.1 (2.6A) ACI 530.1 (2.6B)		**X** (at beginning of masonry construction and prior to grouting)		
Verification of proportions of materials in premixed or preblended mortar and grout as delivered to the site.				**X** (at beginning of masonry construction and prior to grouting)	RDPRC to approve Design-Builder's proposed mix designs prior to construction. Inspector to verify from grout delivery ticket that the appropriate mix has been provided prior to placement.	
Verification of slump flow and VSI as delivered to the site for self-consolidating grout.	1705.4	ACI 530.1 (1.5B.1.b.3)	**X**			
Verification of f'_m and f'_{AAC} prior to construction and for every 5000 square feet during construction.	1705.4	ACI 530.1 (1.4B)		**X**	Verification by unit strength or prism testing, see masonry specification.	
Placement of masonry units and mortar joint construction.	1705.4	ACI 530.1 (3.3B)		**X** (at beginning of masonry construction, once daily for each crew, and prior to grouting)	Inspect size, layout, bonding and placement of masonry units. Inspect construction of mortar joints including tooling and filling of head joints.	

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Verification of size and location of structural elements.	1705.4	ACI 530.1 (3.3F)		**X** (at beginning of masonry construction and prior to grouting)		
Anchors grouted in masonry and anchorage of masonry to frames, structural members, and diaphragms including type, size, and location of anchors.	1705.4	ACI 530 (6.2)		**X** (at beginning of masonry construction and prior to grouting)		
Type, grade, and size of reinforcing steel.	1705.4	ACI 530 (6.1) ACI 530.1 (2.4) ACI 530.1 (3.4)		**X** (when staged and prior to installation)		
Verify grout space is clean prior to grouting.	1705.4	ACI 530.1 (3.2D) ACI 530.1 (3.2F)		**X** (prior to each grouting operation)	Verify that cells and starting beds are clean.	
Reinforcing steel and connector placement: verify size, spacing, surface condition, correct location, type of embedments.	1705.4	ACI 530 (6.1) ACI 530.1 (3.2E) ACI 530.1 (3.4)		**X** (at beginning of masonry construction and prior to grouting)	Verify dowels and inserts are secured in place, particularly at roof lines, floor lines, and intersecting wall lines.	

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
System or Material	**Inspection**				**Remarks**	**Inspection Agent No.** (see Table 9)
	Building Code Reference	**Code or Standard Reference**	**Frequency**			
			Continuous	**Periodic**		
Grout placement.	1705.4	ACI 530.1 (3.5)	**X**		Verify that the grout lift height is in conformance with the code and specifications. Verify installation of cleanout closures. Verify that grouting operations are held below the top if keying is required for subsequent lifts, as required by code and specifications. Verify mechanical vibration during placement, and later during reconsolidation. Verify that curing requirements are being followed.	
Cold/hot weather masonry protection.	1705.4 2104.3 2104.4	ACI 530.1 (1.8C) ACI 530.1 (1.8D)		**X** (at beginning of each day's work)	When temperatures are expected to be below 40 degrees F or above 90 degrees F.	
Observe preparation of required grout specimens, mortar specimens, and/or prisms.	1705.4 2105.2.2 2105.3	ACI 530.1 (1.4)		**X**	Verification by unit strength or prism testing, see masonry specification.	
Masonry for Occupancy Category IV Structures NOT USED						
Steel						
Material verification of high strength bolts: Identification markings to conform to specified ASTM standards.	1705.2.1	Applicable ASTM material specifications AISC 360 (A3.3) AISC 360 (N3)		**X** (3 bolts from each lot)	Verified at jobsite.	
Material verification of high strength bolts: Manufacturer's certificate of compliance.	1705.2.1	AISC 360 (A3.3) AISC 360 (N3)		**X** (each lot)		

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Material verification of structural steel: Identification markings to conform to specified ASTM standards.	1705.2.1 2203.1	AISC 360 (A3.1) AISC 360 (N3)		**X** (3 pieces from each lot)	Verified at fabricator's shop prior to cutting.	
Material verification of structural steel: Certified mill test reports.	1705.2.1 2203.1	AISC 360 (A3.1) AISC 360 (N3)		**X** (each mill order)		
Material verification of anchor rods and threaded rods: Manufacturer's certified test reports.	1705.2.1	AISC 360 (A3.4) AISC 360 (N3)		**X** (each lot)		
Material verification of welding consumables: Identification markings to conform to specified AWS standards.	1705.2.1	AISC 360 (A3.5) AISC 360 (N3) AWS A5 documents		**X** (3 rods from each lot)	Verified at fabricator's shop and at jobsite.	
Material verification of welding consumables: Manufacturer's certificate of compliance.	1705.2.1	AISC 360 (A3.5) AISC 360 (N3) AWS D1.1 (6.2)		**X** (each lot)		
Verify use of proper WPS's.	1705.2.1	AISC 360 (N3) AWS D1.1 (6.3)		**X** (prior to start of work)	Obtain copy of welding procedure specifications.	
Verify welder qualifications.	1705.2.1	AISC 360 (N3) AWS D1.1 (6.4)		**X** (prior to start of each welder's work)	Obtain copy of qualification records.	
Complete and partial penetration groove welds.	1705.2.1	AISC 360 (N5.4) AWS D1.1 (Section 6)	**X**		Inspect pre-heat, post-heat and surface preparation between passes.	
Multipass fillet welds.	1705.2.1	AISC 360 (N5.4) AWS D1.1 (Section 6)	**X**		Inspect pre-heat, post-heat and surface preparation between passes.	

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Single pass fillet welds greater than 5/16".	1705.2.1	AISC 360 (N5.4) AWS D1.1 (Section 6)	**X**			
Plug and slot welds.	1705.2.1	AISC 360 (N5.4) AWS D1.1 (Section 6)	**X**			
Single pass fillet welds less than or equal to 5/16".	1705.2.1	AISC 360 (N5.4) AWS D1.1 (Section 6)		**X** (observe once daily for each welder and visually inspect all welds at the completion of each weld)		
Installation of steel form decking: Verify deck type, depth, and gage.	1703.4.2 1705.1.1.3	Manufacturer's research report		**X** (when staged prior to installation, at completion, and as required by Mfr's research report)		

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Installation of steel roof decking: Verify deck depth and gage, powder actuated fasteners, screws, proprietary side seam attachments, and button punches.	1703.4.2 1705.1.1.3	Manufacturer's research report		**X** (when staged prior to installation, at completion, and as required by Mfr's research report)		
Floor and roof deck welds.	1705.2.2	SDI QA/QC inspection requirements		**X** (observe once daily for each welder and visually inspect all welds at the completion of each weld)		
Welding studs except in structural diaphragms.	1705.2.1	AWS D1.1 (Section 7.8)	**X**		Visually inspect all studs per AWS D1.1 (Section 7.8).	
Welding studs in structural diaphragms.	1705.2.1	AWS D1.1 (Section 7.8)		**X** (observe once daily for each welder and visually inspect all welds at the completion of each weld)		

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Welding stair and railing systems.	1705.2.1	AWS D1.1 (Section 6.9)		**X** (observe once daily for each welder and visually inspect all welds at the completion of each weld)	Welding of the railing system required only at the base of cantilevered rail posts.	
Observe high strength bolt preinstallation testing and calibration procedures.	1705.2.1	AISC 360 (N5.6) RCSC Specification for Structural Joints Using High-Strength Bolts (Section 7)		**X** (3 complete fastener assemblies of each combination of diameter, length, grade, and lot to be used in the work)	Test in a tension calibrator at the site. Required pretension is equal to or greater than 1.05 times that specified for installation. Verify accuracy of the tension calibrator has been confirmed through calibration within previous 12 months.	
Snug-tight high strength bolt installation: All connections visually inspected. Connected materials drawn together and properly snugged.	1705.2.1	AISC 360 (M2.5) AISC 360 (N5.6) RCSC Specification for Structural Joints Using High-Strength Bolts (Section 9)		**X** (observe once daily for each bolting crew and at completion of assembly installation)		

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Pretensioned high strength bolt installation using turn-of-the-nut method with match marking, direct tension indicator method, or twist-off type tension control bolt method: Verify installation procedure, all plies drawn together and properly snugged, visually inspect all connections. Verify that splines have separated from tension control bolts.	1705.2.1	AISC 360 (M2.5) AISC 360 (N5.6) RCSC Specification for Structural Joints Using High-Strength Bolts (Section 9)		**X** (observe once daily for each bolting crew and each assembly installation as noted in Remarks)	Turn-of-the-nut method with match marking: after pretensioning. Direct tension indicators: feeler gauge used after snugging and after pretensioning. Twist-off type tension control bolt: after pretensioning.	
Pretensioned high strength bolt installation using turn-of-the-nut method without match marking or calibrated wrench method: Verify installation procedure, all plies drawn together and properly snugged, visually inspect all connections.	1705.2.1	AISC 360 (M2.5) AISC 360 (N5.6) RCSC Specification for Structural Joints Using High-Strength Bolts (Section 9)	**X**			
Verification of frame joint details including application, component locations, bracing, and stiffening, proper application of joint details at each connection.	1705.2.1	AISC 360 (N5.7)		**X** (at 50% complete and 100% complete, for each structure)		
Proprietary moment resisting frame connection systems.	1703.4.2				Refer to welding and high strength bolting requirements.	
Open Web Steel Joists and Joist Girders NOT USED						

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Cold-Formed Steel Framing						
Material verification of weld filler metals: Identification markings to conform to specified AWS standards.		AWS D1.3 (Section 6)		**X** (3 rods from each lot)	Checked at fabricator's shop and at jobsite.	
Material verification of welding consumables: Manufacturer's certificate of compliance.		AWS D1.3 (Section 6)		**X** (each lot)		
Verify use of proper WPS's.		AWS D1.3 (Section 6)		**X** (prior to start of work)	Obtain copy of welding procedure specifications.	
Verify welder qualifications.		AWS D1.3 (Section 6)		**X** (prior to start of each welder's work)	Obtain copy of qualification records.	
Welded framing connections.		AWS D1.3 (Section 6)		**X** (observe once daily for each welder and visually inspect all welds at the completion of each weld)		

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Post-Installed Anchors – Expansion and Undercut Anchors into Concrete						
Verify anchor type, size, dimensions, location, spacing, edge distance, drill bit type, drill bit diameter, embedment depth, tightening torque, hole dimensions, hole cleaning procedure, concrete compressive strength, concrete thickness, and adherence to the manufacturer's installation instructions.	1705.3 1703.4.2 1705.1.1	Manufacturer's research report		**X**	Continuous inspection is required if mandated by manufacturer's research report.	
Post-Installed Anchors – Adhesive Anchors into Concrete						
Adhesive anchors installed in overhead, upwardly inclined, or horizontal positions: Verify anchor type, size, dimensions, location, spacing, edge distance, embedment depth, tightening torque, hole dimensions, hole cleaning procedure, concrete compressive strength, concrete thickness, adhesive identification, adhesive expiration date, and adherence to the manufacturer's installation instructions.	1705.3 1703.4.2 1705.1.1	Manufacturer's research report	**X**			

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Adhesive anchors installed in other positions: Verify anchor type, size, dimensions, location, spacing, edge distance, embedment depth, tightening torque, hole dimensions, hole cleaning procedure, concrete compressive strength, concrete thickness, adhesive identification, adhesive expiration date, and adherence to the manufacturer's installation instructions.	1705.3 1703.4.2 1705.1.1	Manufacturer's research report		**X**	Inspection required at start of job for each type and size of adhesive anchor by construction personnel on site. Subsequent installations of the same anchor type and size by the same personnel shall be inspected periodically, unless continuous inspections are mandated by the manufacturer's research report. Any change in the anchor product being installed or the personnel performing the installation shall require another initial inspection.	
Post-Installed Anchors – Expansion Anchors into Grouted Masonry						
Verify anchor type, size, dimensions, location, spacing, edge distance, drill bit type, drill bit diameter, embedment depth, tightening torque, hole dimensions, hole cleaning procedure, masonry compressive strength, masonry thickness, mortar type, and adherence to the manufacturer's installation instructions.	1703.4.2 1705.1.1	Manufacturer's research report		**X**	Continuous inspection is required if mandated by the manufacturer's research report.	
Post-Installed Anchors – Adhesive Anchors into Grouted Masonry						

Schedule of Special Inspections - Table 2 of 9 (Structural Special Inspections)						
	Inspection					
	Building Code Reference	**Code or Standard Reference**	**Frequency**		**Remarks**	**Inspection Agent No**. (see Table 9)
System or Material			**Continuous**	**Periodic**		
Verify anchor type, size, dimensions, location, spacing, edge distance, embedment depth, tightening torque, hole dimensions, hole cleaning procedure, masonry compressive strength, masonry thickness, adhesive identification, adhesive expiration date, and adherence to the manufacturer's installation instructions.	1703.4.2 1705.1.1	Manufacturer's research report		**X**	Inspection required at start of job for each type and size of adhesive anchor by construction personnel on site. Subsequent installations of the same anchor type and size by the same personnel shall be inspected periodically. Any change in the anchor product being installed or the personnel performing the installation shall require another initial inspection. Continuous inspection is required if mandated by the manufacturer's research report.	
Post-Installed Anchors – Adhesive Anchors into Hollow Masonry NOT USED						
Post-Installed Anchors – Adhesive Anchors into Unreinforced Brick Masonry NOT USED						
Aluminum NOT USED						

Schedule of Special Inspections - Table 3 of 9 (Architectural Special Inspections)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Sprayed Fire-Resistant Materials						
Surface conditions: cleanliness of steel, preparation of surface in accordance with manufacturer's instructions.	1705.14.2	Manufacturer's research report.		X (prior to application)		
Application: product name and type, material expiration date, ambient conditions, substrate minimum temperature per manufacturer's instructions, application procedures, and material thickness and density	1705.14.3	Manufacturer's research report.		X	Just prior to concealment, conduct a complete visual inspection of the fireproofed members. Verify that the sprayed fire resistant material has no voids, spalls, and delamination and that no material has been scraped or knocked off during construction.	
Mastic and Intumescent Fire-Resistive Coatings						
Surface conditions, application: cleanliness of steel, product name and type, material expiration date, ambient conditions, application procedures, and material thickness	1705.15	Manufacturer's research report., AWCI Technical Manual 12-B		X		
Exterior Insulation and Finish Systems						
Installation	1705.16		X		Not required when install over a water-resistive barrier with a means of draining moisture to the exterior or when installed over masonry or concrete walls. If the water-resistive barrier coating is installed over sheathing substrate, it requires special inspection**.**	
Fire-Resistant Penetrations and Joints						

Schedule of Special Inspections - Table 3 of 9 (Architectural Special Inspections)						
System or Material	**Inspection**				**Remarks**	**Inspection Agent No**. (see Table 9)
	Building Code Reference	**Code or Standard Reference**	**Frequency**			
			Continuous	**Periodic**		
Penetration firestops (locations indicated on drawings).	1705.17.1				Systems that are tested and listed in accordance with IBC Sections 714.3.1.2 and 714.4.2 shall be inspected in accordance with ASTM E2174.	
Fire-resistant joint systems (locations indicated on drawings).	1705.17.2				Systems that are tested and listed in accordance with IBC Sections 715.3 and 715.4 shall be inspected in accordance with ASTM E2393.	
Smoke Control Systems						
Installation	1705.18			X	Record device location(s)	

Schedule of Special Inspections - Table 4 of 9 (Inspections for Special Cases)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Pre-Engineered Structures						
Fabrication and erection	1705.1.1				Refer to Table 2 for fabricator, welding, and high strength bolting special inspection requirements	
Welded Steel Tanks						
Fabrication and erection	1705.1.1	AWWA D100, Section 11 API 650, 7.3 API 620, Section 5		**X** (per Table 2)	In addition to periodic inspection, all joints visually inspected prior to coating application. Refer to Table 2 for fabricator, welding, and high strength bolting special inspection requirements	
Mass Concrete Procedures NOT USED						

Schedule of Special Inspections - Table 5 of 9 (Testing for Special Inspections)					
	Inspection				
	Building Code Reference	Code or Standard Reference	Frequency	Remarks	Inspection Agent No. (see Table 9)
System or Material					
Geotechnical					
Classification of controlled fill material.	1705.6	ASTM D2488	One per stratum of on-site excavated material. One per common supply of off-site material.	Per Geotechnical Report and excavation and fill for structures specification.	

Schedule of Special Inspections - Table 5 of 9 (Testing for Special Inspections)					
	Inspection				
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Frequency**	**Remarks**	**Inspection Agent No**. (see Table 9)
Foundation subgrade, in-place density.	1705.6	ASTM D2922 ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASTM D2167)	One test per 1,000 SY, or as required in the excavation and fill for structures specification. Min one per foundation for foundations over 10 SY.	Per Geotechnical Report and excavation and fill for structures specification.	
Controlled fill beneath foundations, in-place density.	1705.6	ASTM D2922 ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASTM D2167)	One test per 200 CY, or as required in the excavation and fill for structures specification. Min one per foundation for foundations over 10 SY.	Per Geotechnical Report and excavation and fill for structures specification.	
Concrete					
Concrete strength.	1705.3	ASTM C31 ASTM C39 ASTM C172	See concrete specification	See concrete specification for quantity of cylinders.	
Concrete slump, air content, temperature, unit weight, water soluble chloride ion, shrinkage.	1705.3	ASTM C31 ASTM C138 ASTM C143 ASTM C157 ASTM C172 ASTM C231 ASTM C1064 ASTM C1218	See concrete specification		
Shotcrete NOT USED					
Masonry					
Unit strength.	2105.1	ASTM C140	See masonry specification		
Mortar strength.	2105.1	ASTM C270	See masonry specification		

Schedule of Special Inspections - Table 5 of 9 (Testing for Special Inspections)					
	Inspection				
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Frequency**	**Remarks**	**Inspection Agent No**. (see Table 9)
Grout strength.	2105.1	ASTM C1019	See masonry specification		
Prism strength.	2105.1	ASTM C1314	See masonry specification	Partially grouted walls require a set of tests for both the grouted and ungrouted conditions.	
Steel					
Liquid penetrant (PT), magnetic particle (MT), radiographic (RT) and ultrasonic (UT) testing of welds.	1705.2	PT – AWS D1.1 (6.10 & 6.14.5) MT - AWS D1.1 (6.10 & 6.14.4) RT – AWS D1.1 (6.12 & 6.14.1) UT - AWS D1.1 (6.13 & 6.14.3)		CJP and PJP groove welds, multipass fillet welds, single pass fillet welds larger than 5/16, and plug/slot welds**.**	
Pre-construction testing of welding studs.	1705.2	AWS D1.1 (7.7.1)	Each size and type of stud each shift		
Welding studs.	1705.2	AWS D1.1 (7.8)	All questionable studs not showing full 360° flash. Randomly test all other studs as noted: - 15% of studs welded thru deck - 5% of studs welded to bare steel	Test by bending studs to 15° from vertical, away from weld discontinuity. All ceramic welding ferrules shall be removed by Design-Builder.	
Aluminum NOT USED					
Welded Steel Tanks					
Radiographic testing (RT) of welds.		AWWA D100 (11.5 & 11.6) API 650 (8.1) API 620 (5.15.1)	At shell joints - number and spacing per the standard		

Schedule of Special Inspections - Table 5 of 9 (Testing for Special Inspections)					
	Inspection				
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Frequency**	**Remarks**	**Inspection Agent No**. (see Table 9)
Sprayed Fire-Resistant Materials					
Thickness at floor, roof, and wall assemblies.	1705.14.4.2	ASTM E605	4 measurements for each 1,000 SF of sprayed area each floor level	Tolerances per building code, 1705.13.4.	
Thickness at beams and girders.	1705.14.4.5 1707.14.4.6	ASTM E605	25% of each structural member each floor level	Tolerances per building code, 1705.13.4. Measure thickness at 9 locations around the member at each end of a 12 inch length.	
Thickness at joists and trusses.	1705.14.4.5 1707.14.4.7	ASTM E605	25% of each structural member each floor level	Tolerances per building code, 1705.13.4. Measure thickness at 7 locations around the member at each end of a 12 inch length.	
Thickness at wide-flange columns.	1705.14.4.5 1707.14.4.8	ASTM E605	25% of each structural member each floor level	Tolerances per building code, 1705.13.4. Measure thickness at 12 locations around the member at each end of a 12 inch length.	
Thickness at hollow structural section and pipe columns.	1705.14.4.5 1707.14.4.9	ASTM E605	25% of each structural member each floor level	Tolerances per building code, 1705.13.4. Measure thickness at 4 locations around the member at each end of a 12 inch length.	
Density at floor, roof, and wall assemblies.	1705.14.5	ASTM E605	For each assembly, at least one sample for every 2500 square feet (or portion thereof) of the sprayed area in each story		
Density at beams, girders, trusses, and columns.	1705.14.5	ASTM E605	For each type of structural member, at least one sample for every 2500 square feet (or portion thereof) of the floor area in each story		

Schedule of Special Inspections - Table 5 of 9 (Testing for Special Inspections)					
	Inspection				
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Frequency**	**Remarks**	**Inspection Agent No**. (see Table 9)
Bond strength at floor, roof, and wall assemblies.	1705.14.6	ASTM E736	One sample for each 2500 SF of sprayed area (or portion thereof) in each story	Minimum cohesive/adhesive bond strength: 150 psf.	
Bond strength at structural members.	1705.14.6	ASTM E736	For each type of structural member, one sample for each 2500 SF of floor area (or portion thereof) in each story	Minimum cohesive/adhesive bond strength: 150 psf.	
Intumescent Fire-Resistive Coatings					
Thickness.	1705.15	AWCI Technical Manual 12-B	Each 10,000 SF of coated area each floor level		
Smoke Control Systems					
Leakage and pressure differential and flow measurement.	1705.18.1		Determined by jurisdiction		
Detection and control verification.	1705.18.1		Determined by jurisdiction		

Schedule of Special Inspections - Table 6 of 9 (Special Inspections for Seismic Resistance)						
	Inspection					
	Building Code Reference	Code or Standard Reference	Frequency		Remarks	Inspection Agent No. (see Table 9)
System or Material			Continuous	Periodic		
Structural Steel and Structural Steel Elements Within the Seismic Force-Resisting System (systems identified on the drawings)						
Visually inspect the following before welding: material type and grade; welder identification system; fit up of groove welds including joint preparation, dimensions, cleanliness, tacking, backing type and fit; configuration and finish of access holes; fit up of fillet welds including dimensions, cleanliness and tacking.	1705.12.1	AISC 341 (J6.1)		**X** (Once daily for each individual welder)		
Visually inspect during welding: WPS followed, use of qualified welders, control and handling of welding consumables, environmental conditions, welding techniques, no welding over cracked tacks.	1705.12.1	AISC 341 (J6.1)		**X** (Once daily for each individual welder)		
Visually inspect after welding: Welds cleaned, size, length, and location of welds.	1705.12.1	AISC 341 (J6.1)		**X** (Once daily for each individual welder)		

Schedule of Special Inspections - Table 6 of 9 (Special Inspections for Seismic Resistance)						
System or Material	**Inspection**				**Remarks**	**Inspection Agent No.** (see Table 9)
	Building Code Reference	**Code or Standard Reference**	**Frequency**			
			Continuous	**Periodic**		
Visually inspect welds after welding to acceptance criteria for: crack prohibition, weld/base metal fusion, crater cross section, weld profile, weld size, undercut, and porosity.	1705.12.1	AISC 341 (J6.1)	**X**		Periodic inspection (observe once daily for each welder and visually inspect all welds at the completion of each weld) is permitted only for single pass fillet welds not exceeding 5/16" and for floor and roof deck welding.	
Visually inspect welds after welding for placement of reinforcement fillets, removal of backing bars and weld tabs and finish (where required on drawings or per specifications), and repair activities.	1705.12.1	AISC 341 (J6.1)	**X**		Periodic inspection (observe once daily for each welder and visually inspect all welds at the completion of each weld) is permitted only for single pass fillet welds not exceeding 5/16" and for floor and roof deck welding.	
Prior to high strength bolting: verify proper fasteners and bolting procedures selected for the detail, connecting elements fabricated properly including faying surface preparation and hole preparation, proper storage for bolts, nuts, washers and other components.	1705.12.1	AISC 341 (J7)		**X** (Once daily for each bolting crew)		
During high strength bolting: Fasteners assemblies properly positioned, joints snug tight prior to pretensioning, fastener component not turned by the wrench prevented from rotating, pretensioning progresses systematically from most rigid point to free edges.	1705.12.1	AISC 341 (J7)		**X** (observe once daily for each bolting crew)		

Schedule of Special Inspections - Table 6 of 9 (Special Inspections for Seismic Resistance)						
System or Material	**Inspection**				**Remarks**	**Inspection Agent No.** (see Table 9)
	Building Code Reference	**Code or Standard Reference**	**Frequency**			
			Continuous	**Periodic**		
After installation of high strength bolting, document accepted and rejected connections.	1705.12.1	AISC 341 (J7)		**X** (at completion of each connection)		
At Reduced Beam Sections (RBS), verify contour, finish, and dimensional tolerances.	1705.12.1	AISC 341 (J8)		**X** (at completion of fabrication of applicable beam)		
Verify no holes or unapproved attachments made in protected zone noted on the drawings.	1705.12.1	AISC 341 (J8)		**X** (observe once daily)		
Cold-Formed Steel Framing NOT USED						
Cold-Formed Steel Special Bolted Moment Frames NOT USED						
Architectural Components						
Anchorage of storage racks $\geq$ 8 ft in height.	1705.12.7	ASCE 7 (15.5.3)		**X** (observe once daily for each crew and visually inspect all connections at completion)		
Anchorage of access flooring.	1705.12.5.1	ASCE 7 (13.5.7)		**X** (visually inspect all connections at completion)		

Schedule of Special Inspections - Table 6 of 9 (Special Inspections for Seismic Resistance)						
System or Material	**Inspection**				**Remarks**	**Inspection Agent No**. (see Table 9)
	Building Code Reference	**Code or Standard Reference**	**Frequency**			
			Continuous	**Periodic**		
Erection and fastening of exterior cladding.	1705.12.5			**X** (observe once daily for each crew and visually inspect all connections at completion)	Not required for cladding weighing 5 psf or less or for buildings less than 30 feet in height.	
Erection and fastening of interior and exterior nonbearing walls.	1705.12.5			**X** (observe once daily for each crew and visually inspect all connections at completion)	Not required for interior nonbearing walls weighing 15 psf or less, and not required for interior or exterior nonbearing walls for buildings less than 30 feet in height.	
Placement and anchorage of interior and exterior veneer.	1705.12.5			**X** (observe once daily for each crew and visually inspect anchorage at completion)	Not required for veneer weighing 5 psf or less or for buildings less than 30 feet in height.	
Plumbing and Mechanical Components						

Schedule of Special Inspections - Table 6 of 9 (Special Inspections for Seismic Resistance)						
	Inspection					
			Frequency			
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Continuous**	**Periodic**	**Remarks**	**Inspection Agent No.** (see Table 9)
Installation and anchorage of equipment and piping for flammable, combustible, or highly toxic materials and associated mechanical units.	1705.12.6			**X** (observe once daily for each crew and completed installation of each applicable piece of equipment and piping)		
Installation and anchorage of HVAC equipment and ductwork containing hazardous materials and anchorage of such ductwork.	1705.12.6			**X** (observe once daily for each crew and completed installation of each applicable piece of equipment)		
Installation and anchorage of vibration isolation systems, where nominal clearance between equipment and support frame and restraint is 0.25 inches or less.	1705.12.6			**X** (observe once daily for each crew and completed installation of each applicable piece of equipment)		

Schedule of Special Inspections - Table 6 of 9 (Special Inspections for Seismic Resistance)						
System or Material	**Inspection**				**Remarks**	**Inspection Agent No.** (see Table 9)
	Building Code Reference	**Code or Standard Reference**	**Frequency**			
			Continuous	**Periodic**		
Electrical						
Anchorage of electrical equipment for emergency and standby power.	1705.12.6			**X** (observe completed installation of each applicable piece of equipment)	See the Meteorological and Seismic Design Criteria section (Non-Structural Components Schedule) for the specific components that must be anchored.	
Anchorage of other electrical equipment.	1705.12.6			**X** (observe completed installation of each applicable piece of equipment)	See the Meteorological and Seismic Design Criteria section (Non-Structural Components Schedule) for the specific components that must be anchored.	
Nonstructural Components						
For non-structural components that are qualified by means of shake table testing or experience data, verify that the label, anchorage, and mounting conform to the certificate of compliance furnished by the product manufacturer.	1705.12.4	ASCE 7 (13.2.2)		**X** (Each applicable piece of equipment)	See the Meteorological and Seismic Design Criteria section (Non-Structural Components Schedule) for the specific components and their anchorages that must be qualified.	
Seismic Isolation Systems NOT USED						
Energy Dissipation Systems NOT USED						

Schedule of Special Inspections - Table 7 of 9 (Testing for Seismic Resistance)					
	Inspection				
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Frequency**	**Remarks**	**Inspection Agent No**. (see Table 9)
Concrete NOT USED					
Structural Steel and Structural Steel Elements Within the Seismic Force-Resisting System (systems identified on the drawings)					
Ultrasonic (UT) of base metal thicker than 1-1/2" subject to through-thickness weld shrinkage strains. Test is for discontinuities behind and adjacent to each weld.	1705.13.1	AWS D1.1(6.13 & 6.14.3)	Each weld		
When welding doubler, continuity, or stiffener plates in the k-area of a web, test the web for cracks using magnetic particle testing (MT).	1705.13.1	AISC 341 (J6.2)	Each plate location	Inspection area shall include the k-area base metal within 3 inches of the weld. Testing shall be performed no sooner than 48 hours following completion of the welding.	
For CJP groove welds in material 5/16” thick and greater, perform ultrasonic testing (UT).	1705.13.1	AISC 341 (J6.2)	Each weld	Weld discontinuities shall be accepted or rejected on the basis of critiera of AWS D1.1 Table 6.2. In structures designed as ordinary moment frames, testing is only required for demand critical welds (locations identified on the drawings). See AISC 341 for possible reduction in testing frequency.	
For beam to column CJP groove welds, perform magnetic particle testing (MT).	1705.13.1	AISC 341 (J6.2)	25% of all such welds for each welder	In structures designed as ordinary moment frames, testing is only required for demand critical welds (locations identified on the drawings). See AISC 341 for permitted reduction in testing frequency.	

Schedule of Special Inspections - Table 7 of 9 (Testing for Seismic Resistance)					
	Inspection				
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Frequency**	**Remarks**	**Inspection Agent No.** (see Table 9)
When base metal thicker than 1-1/2" is loaded in tension in the through-thickness direction in tee and corner joints, where the connected material is greater than 3/4" thick and contains CJP welds, perform ultrasonic testing (UT) to detect discontinuities behind and adjacent to the fusion line of each weld.	1705.13.1	AISC 341 (J6.2)	Each weld	See AISC 341 for permitted reduction in testing frequency.	
For welded splices and connections, perform magnetic particle testing (MT) or liquid penetrant testing (PT) at thermally cut surfaces of beam copes and access holes when the flange thickness exceeds 1-1/2" for rolled shapes or the web thickness exceeds 1-1/2" for built-up shapes.	1705.13.1	AISC 341 (J6.2)	Each weld		
For reduced beam section (RBS) plastic hinge regions repaired by welding, or on the base metal of reduced beam section (RBS) plastic hinge region if a sharp notch has been removed by grinding, perform magnetic particle testing (MT) on the weld and the adjacent area.	1705.13.1	AISC 341 (J6.2)	Each weld or location		
For welds where weld tabs have been removed, except for continuity plate weld tabs, perform magnetic particle testing (MT) on the ends of the weld.	1705.13.1	AISC 341 (J6.2)	Each weld or location	See AISC 341 for permitted reduction in testing frequency.	
Pre-installation testing of fastener assemblies and methods used.	1705.13.1	AISC 341 (J7) RCSC Specification for Structural Joints Using High Strength Bolts (Section 7)	3 assemblies of each diameter, grade, length, and lot prior to use		

Schedule of Special Inspections - Table 7 of 9 (Testing for Seismic Resistance)					
	Inspection				
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Frequency**	**Remarks**	**Inspection Agent No.** (see Table 9)
Non-Structural Components (Architectural, Mechanical and Electrical)					
For non-structural components and their anchorage that are qualified by means of analysis, testing, or experience data, examine the certificate of compliance furnished by the product manufacturer.	1705.13.2 1705.13.3	ASCE 7 (13.2.1, part 2), ASCE 7 (13.2.2 parts 1, 2)	Each applicable piece of equipment	See the Meteorological and Seismic Design Criteria section (Non-Structural Components Schedule) for the specific components and their anchorages that must be qualified.	
Seismic Isolation Systems **NOT USED**					

Schedule of Special Inspections - Table 8 of 9 (Special Inspections for Wind Resistance) NOT USED						
	Inspection					
			Frequency			
System or Material	**Building Code Reference**	**Code or Standard Reference**	**Continuous**	**Periodic**	**Remarks**	**Inspection Agent No.** (See Table 9)

Schedule of Special Inspections - Table 9 of 9 (Inspection Agents)					
AGENT NAME	**LICENSE NO.**	**FIRM**	**ADDRESS**	**EMAIL**	**TELEPHONE NO.**
1.					( )
2.					( )
3.					( )
4.					( )
5.					( )
6.					( )
7.					( )
8.					( )
9.					( )
10.					( )

Request for Approval of Special Inspector

Project:
Project Address:
Name of Inspection/Testing Agency:
Address:
Phone Number:
Testing agency manager/supervisor responsible for this project:

Special Inspector Name:

Special Inspector Signature: _____
(as it will appear on reports)

This individual is qualified to inspect:

[ ] Verification of Soils
[ ] Earth Retaining Structure
[ ] Excavation and Filling
[ ] Piling
[ ] Drilled Piers
[ ] Testing of Concrete
[ ] Placement of Concrete
[ ] Placement of Shotcrete
[ ] Placement of Rebar
[ ] Prestressing Concrete
[ ] High Strength Bolting
[ ] Structural Welding
[ ] Steel Frame Inspection
[ ] Structural Masonry
[ ] Erection of Precast
[ ] Inspection of Fabricators
[ ] Precast Fabrication
[ ] Structural Steel
[ ] Metal Building
[ ] EIFS Inspection
[ ] Smoke Control
[ ] Seismic Resistance
[ ] Sprayed Fireproofing
[ ] Architectural Systems
[ ] Mechanical Systems
[ ] Electrical Systems

Current certifications and/or professional licenses retained by the individual:

[ ] Professional Engineer
[ ] Geotechnical Engineer
[ ] Structural Engineer
[ ] Registered Architect
[ ] Registered Geologist
[ ] EI/EIT (min. of 1 yr. related experience)
[ ] GIT (min. of 1 yr. related experience)
[ ] ACI Concrete Field Testing Technician Grade 1
[ ] ACI Concrete Construction Inspector
[ ] ACI Laboratory Testing Technician, Grade 1 or 2
[ ] ACI Strength Testing Technician
[ ] AWS Certified Welding Inspector
[ ] AWS/AISC Certified Structural Steel Inspector
[ ] ASNT NDT Technician Level II or III
[ ] ICC Building Inspector
[ ] ICC Structural Masonry
[ ] ICC Structural Steel and Welding
[ ] ICC Spray-Applied Fire Proofing
[ ] ICC Prestressed Concrete
[ ] ICC Reinforced Concrete
[ ] ICC Structural Steel and Bolting
[ ] ICC Structural Welding
[ ] NCMA Concrete Masonry Testing Technician
[ ] NICET Concrete Technician Level II, III, or IV
[ ] NICET Soils Technician Level II, III, or IV
[ ] NICET Geotechnical Engineering Technician Level II, III, or IV
[ ] EDI EIFS
[ ] Other _____

Copies of current certifications and/or professional licenses and a resume showing the special inspector's work experience are attached.

I hereby certify that in my judgment the individual is qualified to inspect and/or test the items indicated above.

Special Inspection Agency:

Signed:_____Date:_____
(Testing agency manager/supervisor responsible for this project)

Request for Approval to Provide Special Inspection of Non-Local Fabrication

Project:
Project Address:

Testing / Inspection Agent:
Testing / Inspection Agent Address:
Scope of Testing / Inspections:

We propose to have the following testing agency provide special inspection of fabrication of:

Fabricator name:
Fabricator address:

Name of Testing Agency:
Address:
Phone Number:
Testing agency manager/supervisor responsible for this project:
Primary special inspector for this project:

Copies of the Request for Approval of Special Inspector, resumes, and certifications are attached.

The fabrication inspections to be performed are:

The undersigned hereby acknowledge that they have read, understand and will properly enforce the inspection and testing requirements for the above referenced project, as specified in the Code-Required Special Inspections and Procedures section. Further, the undersigned acknowledge that they have no interest (financial, personal or otherwise) in the performance or management of the above identified Fabricator.

Signature of Primary Special Inspector	Date
Signature of Responsible Agency Manager/Supervisor	Date
Signature of Responsible Manager for Approved Agency employed by the Owner	Date

Design-Builder's Statement of Responsibility

Each Fabricator, Contractor, or Supplier responsible for the construction or fabrication of a system or component designated in the Statement of Special Inspections shall submit this Statement of Responsibility.

Project:
Contractor's or Supplier's Name:
Address:
License No.:

Description of designated building systems and components included in the Statement of Responsibility:

Acknowledgment of Special Requirements

I hereby acknowledge that I have received, read, and understand the Code Required Special Inspections and Tests program and the Schedule of Special Inspections.

I hereby acknowledge that control will be exercised to obtain conformance with the construction documents approved by the Authority Having Jurisdiction.

Signature Date

Title

Provisions for Quality Control

Procedures for exercising control within the Fabricator's, Contractor's, or Supplier's organization, the method and frequency of reporting and the distribution of reports are attached to this Statement.

Identification and qualifications of the person(s) exercising such control and their position(s) in the organization are attached to this Statement.

Fabricator's Certificate of Compliance

Each approved fabricator that is exempt from Special Inspection of shop fabrication and implementation procedures per the governing building code shall submit this *Fabricator's Certificate of Compliance* at the completion of fabrication.

Project:
Fabricator's Name:
Address:
Certification or Approval Agency:
Certification Number:
Date of Last Audit or Approval:

Description of structural members and assemblies that have been fabricated:

I hereby certify that items described above were fabricated in strict accordance with the approved construction documents.

Signature

Date

Title

Attach copies of fabricator's certification or building code evaluation service report and fabricator's quality control manual.

Final Report of Special Inspections

Project:
Project Address:

Testing / Inspection Agent:
Testing / Inspection Agent Address:
Scope of Testing / Inspections:

To the best of my information, knowledge, and belief, the special inspections or testing required for this project, and designated for this Agent in the Statement of Special Inspections submitted for permit, have been completed in accordance with the contract documents. Based upon my personal observations and written reports, it is my judgment that the inspected work was performed, to the best of my knowledge, in accordance with the building department approved design drawings, specifications, approved change orders, and applicable workmanship provisions of the governing building code.

Interim reports submitted prior to this final report and numbered _____ to _____, form a basis for, and are to be considered an integral part of this final report.

The following discrepancies that were outstanding since the last interim report dated
have been corrected:

Items not in conformance, unresolved items or any discrepancies in inspection coverage (i.e., missed inspections, periodic inspections when continuous was required, etc.) are as follows:

Prepared By:

Type or print name

Signature Date

Special Inspector's Seal

(Licensed Professional)

Section 01 61 00

GENERAL EQUIPMENT STIPULATIONS

1. SCOPE. When an equipment specification section in this Contract references this section, the equipment shall conform to the general stipulations set forth in this section, except as otherwise specified in other sections.

2. COORDINATION. The equipment suppliers and vendors shall coordinate all details of their equipment and packages with other related parts of the Work, including verification that all structures, piping, wiring, and equipment components are compatible with the overall Balance of Plant. The equipment suppliers and vendors are responsible for pointing out where their equipment deviates from the Design-Builder procurement package, drawings and specifications.

3. MANUFACTURER'S EXPERIENCE. Unless specifically named in the Specifications, a manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years.

4. WORKMANSHIP AND MATERIALS. The equipment suppliers shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests.

Except where otherwise specified, structural and miscellaneous fabricated steel used in equipment shall conform to AISC standards. All structural members shall be designed for shock or vibratory loads. Unless otherwise specified, all steel which will be submerged, all or in part, during normal operation of the equipment shall be at least 1/4 inch thick. When dissimilar metal components are used, consideration shall be given to prevention of galvanic corrosion.

5. STRUCTURAL DESIGN REQUIREMENTS. All equipment, including non-structural components and non-building structures as defined in ASCE 7, and their anchorage, shall be designed and detailed in accordance with the Meteorological and Seismic Design Criteria section.

6. LUBRICATION. Equipment shall be adequately lubricated by systems which require attention no more frequently than weekly during continuous operation. Lubrication systems shall not require attention during startup or shutdown and shall not waste lubricants.

Lubricants of the types recommended by the equipment manufacturer shall be provided in sufficient quantities to fill all lubricant reservoirs and to replace all consumption during testing, startup, and operation prior to acceptance of equipment by Design-Builder. Lubricants for equipment where the lubricants may come in contact with water before or during a potable water treatment process or with potable water, shall be food grade lubricants. This includes lubricants for equipment not normally in contact with water, but where accidental leakage of the lubricants may contaminate the water.

Lubrication facilities shall be convenient and accessible. Oil drains and fill openings shall be easily accessible from the normal operating area or platform. Drains shall allow for convenient collection of waste oil in containers from the normal operating area or platform without removing the unit from its normal installed position.

7. ELEVATION. The elevation of the site shall be as indicated in the Meteorological and Seismic Design Criteria section. All equipment furnished shall be designed to meet stipulated conditions and to operate satisfactorily at the specified elevation.

8. ELECTRIC MOTORS. Unless otherwise specified, motors furnished with equipment shall meet the requirements specified in Common Motor Requirements for Process Equipment section or specified in specific equipment sections.

9. DRIVE UNITS. The nominal input horsepower [kW] rating of each gear or speed reducer shall be at least equal to the nameplate horsepower [kW] of the drive motor. Drive units shall be designed for 24 hour continuous service.

9.01. Gearmotors. The use of gearmotors sharing an integral housing or cutgears into the motor output shaft, or that require removal of lubricant from the gear reducer to change out the motor will not be acceptable.

9.02. Gear Reducers. Each gear reducer shall be a totally enclosed unit with oil or grease lubricated, rolling element, antifriction bearings throughout.

Unless superseded by individual specification requirements each helical, spiral bevel, combination bevel-helical, and worm gear reducers shall have a service factor of at least 1.50 based on the nameplate horsepower [kilowatts] of the drive motor. Cycloidal gear reducers shall have a service factor of at least 2.0 based on the nameplate horsepower [kW] of the drive motor. Shaft-mounted and flange-mounted gear reducers shall be rated AGMA Class III. Helical gear reducers shall have a gear strength rating to catalog rating of 1.5. Each gear reducer shall be designed and manufactured in compliance with applicable most current AGMA standards.

The thermal horsepower rating of each unit shall equal or exceed the nameplate horsepower of the drive motor. During continuous operation, the maximum sump oil temperature shall not rise more than 100°F above the ambient air temperature in the vicinity of the unit and shall not exceed 200°F.

Each grease lubricated bearing shall be installed in a bearing housing designed to facilitate periodic regreasing of the bearing by means of a manually operated grease gun. Each bearing housing shall be designed to evenly distribute new grease, to properly dispose of old grease, and to prevent overgreasing of the bearing. The use of permanently sealed, grease lubricated bearings will not be acceptable in large sized reducers. In small reducers, similar to basin equipment, permanently sealed grease lubricated bearings may be provided at the manufacturer's option. An internal or external oil pump and appurtenances shall be provided if required to properly lubricate oil lubricated bearings. A dipstick or a sight glass arranged to permit visual inspection of lubricant level shall be provided on each unit.

Gear reducers which require the removal of parts or the periodic disassembly of the unit for cleaning and manual regreasing of bearings will not be acceptable.

9.03. Variable Speed Drives. Each mechanical variable speed drive shall have a service factor of at least 1.75 at maximum speed based on the nameplate horsepower of the drive motor. A spare belt shall be provided with each adjustable speed drive unit employing a belt for speed change. Unless specifically permitted by the detailed equipment specifications, bracket type mounting will not be acceptable for variable speed drives.

9.04. V-Belt Drives. Each V-belt drive shall include a sliding base or other suitable tension adjustment. V-belt drives shall have a service factor of at least 1.75 at maximum speed based on the nameplate horsepower of the drive motor.

10. SAFETY GUARDS. All belt or chain drives, fan blades, couplings, and other moving or rotating parts shall be covered on all sides by a safety guard. Safety guards shall be fabricated to a thickness as required per Cal-OSHA, galvanized, aluminum-clad sheet steel, or stainless sheet steel or from 1/2 inch mesh galvanized expanded metal, or pultrusion molded UV resistant materials. Each safety guard shall be reinforced or shaped to provide suitable strength to prevent vibration and deflection and shall comply with Cal-OSHA. Each guard shall be designed for easy installation and removal. All necessary supports and accessories shall be provided for each guard. Supports and accessories, including bolts, shall be galvanized. All safety guards in outdoor locations shall be designed to prevent the entrance of rain and dripping water.

11. ANCHORAGE AND ANCHOR BOLTS. Equipment suppliers shall design and detail suitable anchor bolts for each item of equipment. Anchor bolts shall be designed for all operating conditions of the equipment, including wind, vibration and seismic loadings. Wind and seismic loads shall be as indicated in the Meteorological and Seismic Design Criteria section. Anchor bolt design shall be sealed by a registered professional engineer licensed in the State of California.

Requirements for anchor bolt type, material, and minimum diameter shall be as indicated in the Anchorage in Concrete and Masonry section.

Anchor bolts templates and/or setting drawings shall be submitted early to permit purchase of the anchor bolts by the Design-Builder and to permit setting the anchor bolts when the structural concrete or masonry grout is placed.

Unless otherwise indicated or specified, anchor bolts for items of equipment mounted on baseplates shall be long enough to permit 1-1/2 inches of grout beneath the baseplate and to provide adequate anchorage into structural concrete.

12. EQUIPMENT BASES. Unless otherwise indicated or specified, all equipment shall be installed on concrete bases at least 6 inches high by the Design-Builder. Cast iron or welded steel baseplates shall be provided for pumps, compressors, and other equipment. Each unit and its drive assembly shall be supported on a single baseplate of neat design. Baseplates shall have pads for anchoring all components, and adequate grout holes. Baseplates for pumps shall have a means for collecting leakage and a threaded drain connection. Baseplates shall be anchored to the concrete base with suitable anchor bolts and the space beneath filled with grout as specified in the Grouting section by the Design-Builder.

13. SPECIAL TOOLS AND ACCESSORIES. Equipment requiring periodic repair and adjustment shall be furnished complete with all special tools, instruments, and accessories required for proper maintenance. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices.

14. SHOP PAINTING AND COATING. All iron and steel surfaces of the equipment shall be protected with suitable protective coatings applied in the shop. Surfaces of the equipment that will be inaccessible after assembly shall be protected for the life of the equipment. Coatings shall be suitable for the environment where the equipment is installed. Exposed surfaces shall be finished, thoroughly cleaned, and filled as necessary to provide a smooth, uniform base for painting. All shop fabricated equipment shall be provided with final coating in the shop.

Electric motors, speed reducers, starters, and other self-contained or enclosed components shall be shop primed and shop finished with an epoxy or polyurethane enamel or universal type primer suitable for top coating with an aliphatic polyurethane system.

Machined, polished, and nonferrous surfaces which are not to be painted shall be coated with rust-preventive compound as recommended by the equipment manufacturer.

15. LABELING AND TAGGING. Equipment labeling and tagging shall be in accordance with the Equipment and Valve Identification section.

16. PREPARATION FOR SHIPMENT. Equipment shall be prepared for shipment as specified in the Supplementary Terms and Conditions section.

17. STORAGE. Handling and storage of equipment once on site shall be as specified in the Product Storage and Handling Requirements section.

18. INSTALLATION AND OPERATION. Installation and operation shall be as specified in respective equipment sections and the Startup Requirements section.

19. OBSERVATION OF PERFORMANCE AND ACCEPTANCE TESTS. Performance and Acceptance tests shall be coordinated and observed or witnessed by the Design-Builder where indicated in the Specifications.

End of Section

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Section 01 67 00

METEOROLOGICAL AND SEISMIC DESIGN CRITERIA

1. SCOPE. Buildings, non-structural components and non-building structures shall be designed in accordance with this section. In the event of conflict with requirements in other sections, the more stringent criteria shall be followed.

2. DESIGN CRITERIA. Buildings, non-structural components, non-building structures including anchorage of such items, shall be designed in accordance with the following criteria.

General Design Data:

Building code and references	CBC 2016, ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures", AISC 360 "Specification for Structural Steel Buildings", AISC 341 "Seismic Provisions for Structural Steel Buildings"
Site elevation, above mean sea level (ft)	75 to 135
Design flood elevation, DFE (ft)	Not within WRF boundary
Design groundwater elevation (ft below surface)	13 to 18
Minimum ambient air temperature, °F	23.1
Maximum ambient air temperature, °F	110.6

Wind Design Data:

Ultimate design wind speed, V_{ult} (mph)	115
Nominal design wind speed, V_{asd} (mph)	89
Exposure category	C
Risk Category	III

Building enclosure classification	Varies

Seismic Design Data

Mapped MCE short period spectral response acceleration, S_S	1.135
Mapped MCE one second period spectral response acceleration, S_1	0.421
Design short period spectral response acceleration, S_{DS}	0.757
Design one second period spectral response acceleration, S_{D1}	0.387
Risk Category	III
Building Importance factor, I	1.25
Building Seismic Design Category	D
Non-Structural Components Importance factors, I_P	As indicated in the Non-Structural Component Schedule
Non-Structural Components Seismic Design Category	D
Non-Builidng Structures Importance factors, I	As indicated in the Non-Building Structure Schedule or in the applicable reference documents, whichever is greater.

3. WIND ANCHORAGE. Equipment that is to be located outdoors shall have anchor bolts designed for the effects of wind forces, as determined in accordance with ASCE 7, Chapters 26-31. Design of anchorage into concrete shall be in accordance with ACI 318 Chapter 17, shall consider concrete to be cracked, and shall not include the strengthening effects of supplementary reinforcement or anchor reinforcement unless approved by the Structural Engineer of Record. Design of anchorage into masonry shall be in accordance with ACI 530. Post-installed anchors into concrete or masonry may be used only when approved by the Structural Engineer of Record, and shall be designed in accordance with the anchor manufacturer's research report. Shop drawings shall include full anchor bolt details, and shall be sealed by a professional engineer licensed in the state of the project. Calculations shall be furnished when requested by the Structural Engineer of Record.

4. SEISMIC DESIGN.

4-1. General. Structural systems shall provide continuous load paths, with adequate strength and stiffness to transfer all seismic forces from the point of application to the point of final resistance.

4-2. Pre-Engineered Buildings. Pre-engineered buildings shall have sufficient strength and ductility to resist the specified seismic effects defined for buildings and shall meet all of the design, proportioning, detailing, inspection, and quality assurance provisions of the specified building code.

"W" for buildings shall include the total dead load, the total operating weight of permanent equipment and the effective contents of vessels, and applicable portions of other loads, as required by the specified building code.

4-3. Non-Structural Components. Non-structural components are architectural, mechanical, and electrical items that are permanently attached to and supported by a structure but are not part of the structural system, as indicated in Chapter 13 of ASCE 7. The Non-Structural Components Schedule identifies the components that require seismic design. The requirements of this paragraph are applicable only to the items listed in the Non-Structural Components Schedule.

4-3.01. General. Design of non-structural components shall be in accordance with all applicable provisions of ASCE 7, Chapter 13. "W_p" shall include the total operating weight of the component or system, including, but not limited to, any insulation, fluids, and concentrated loads such as valves, condensate traps, and similar components.

4-3.02. Anchorage Design. Every component in the Non-Structural Components Schedule shall have its anchorage to the supporting structure designed in accordance with ASCE 7, Chapter 13. Design of anchorage into concrete shall be in accordance with ACI 318 Chapter 17, shall consider concrete to be cracked, and shall not include the strengthening effects of supplementary reinforcement or anchor reinforcement unless approved by the Structural Engineer of Record. Design of anchorage to concrete shall also include the overstrength factors indicated in ASCE 7, Tables 13.5-1 and 13.6-1. Design of anchorage into masonry shall be in accordance with ACI 530. Post-installed anchors into concrete or masonry may be used only when approved by the Structural Engineer of Record, and shall be designed in accordance with the anchor manufacturer's research report.

Components shall be attached so that seismic forces are transferred to the structural system. Curbs that support roof-mounted equipment shall be designed to transfer forces from the equipment into the main structural roof members. All

structural attachments shall be bolted, welded, or otherwise positively fastened. Frictional resistance due to gravity shall not be considered in evaluating the required resistance to seismic forces.

4-3.03. Component Design. Components indicated in the Non-Structural Components Schedule to require design of the component itself, as opposed to an anchorage design alone, shall be designed in accordance with ASCE 7, Chapter 13.

Components shall have sufficient strength and ductility to resist the specified seismic effects, and shall meet all of the design, proportioning, detailing, inspection, and quality assurance provisions of the specified building code and other referenced codes. Components shall be designed to be operable during and following a design level seismic event without collapsing, breaking away from supports, creating an ignition hazard, or releasing any contents.

Seismic effects that shall be analyzed in the design of piping systems include the dynamic effects of the piping system, contents, and supports. The interaction between piping systems and the supporting structures, including other mechanical and electrical equipment, shall also be considered. Where pipe supports are to be designed by system supplier and/or vendor, as required by the Pipe Supports section, both the piping and support systems shall be designed to meet the applicable requirements of ASCE 7, Chapter 13.

4-3.04. Submerged Components. Components that are to be submerged in water shall be designed to withstand loads from the effects of water sloshing during the seismic event. The calculation of the sloshing effects shall be in accordance with the latest edition of ACI 350.3.

4-3.05. Seismic Certification. Design of components and their anchorage shall be certified by one of the following methods.

1. Analysis and design by a design professional registered in the state of the project.

2. Shake table testing based upon a nationally recognized testing standard procedure, such as ICC-ES AC 156, acceptable to the authority having jurisdiction.

3. Experience data, based upon nationally recognized procedures acceptable to the authority having jurisdiction.

Components indicated in the Non-Structural Components Schedule to require special seismic certification shall be certified only by methods 2 or 3 above, except that certification for containment of hazardous materials may be by any of the three methods.

4-3.06. Construction Documents. Construction documents (fabrication or shop drawings) of non-structural components and anchorage design shall be sealed by a design professional that is registered in the state of California. Documents shall be sealed whether the basis for certification is analysis and design, shake table testing, or experience data. The sealing method shall clearly indicate that the anchorage system, and the component itself when applicable, have been designed for the code required seismic forces.

4-3.07. Submittals. The construction documents, structural design calculations, shake table certification, and experience data certification, as applicable, shall be submitted in accordance with the Submittal Procedures section.

4-4. Non-Building Structures. Non-building structures are the items described as such in Chapter 15 of ASCE 7. The Non-Building Structures Schedule identifies the items that require seismic design. The requirements of this paragraph are applicable only to the items listed in the Non-Builiding Structures Schedule.

4-4.01. General. Design of non-building structures shall be in accordance with all applicable provisions of ASCE 7, Chapter 15. Design of anchorage into concrete shall be in accordance with ACI 318 Chapter 17, shall consider concrete to be cracked, and shall not include the strengthening effects of supplementary reinforcement or anchor reinforcement unless approved by Design-Builder. Post-installed anchors into concrete may be used only when approved by Design-Builder, and shall be designed in accordance with the anchor manufacturer's research report.

"W" shall include the total dead load and shall also include all normal operating contents of tanks, vessels, bins, and piping.

Non-building structures shall provide sufficient strength and ductility to resist the specified seismic effects, and shall meet all of the design, proportioning, detailing, inspection, and quality assurance provisions of the specified building code and other referenced codes.

The seismic design of non-building structures shall provide sufficient stiffness, strength and ductility to resist the effects of seismic ground motions during the design level earthquake.

Non-building structures shall be designed to be operable during and following a design level seismic event, without collapsing, breaking away from supports, creating an ignition hazard, or releasing any contents.

4-4.02. Construction Documents. Construction documents (fabrication or shop drawings) depicting all seismic force resisting elements of non-building structures

shall be sealed by a design professional that is registered in the state of the project.

4-4.03. Submittals. The construction documents shall be submitted in accordance with the Submittal Procedures section.

End of Section

Non-Structural Components Schedule					
Component		Applicable Specification Section	Importance Factor (I_p)	Component Design Required	Special Seismic Certification Required
Metal Partition Walls		05 40 00	1.0		
Weir Plates and Scum Baffles		06 82 00	1.0		
Odor Control Covers		06 82 00	1.0		
Steel Doors and Frames		08 11 14			
Overhead Coiling Steel and Fire Doors		08 33 23.23			
Aluminum Entrances and Assemblies		08 41 14			
Aluminum Windows		08 51 13			
Glass Glazing		08 81 00			
Acoustical Panel Ceilings		09 51 13			
Plastic Toilet Compartments		10 21 13.19			
Louvers and Vents		08 90 00			
Metal Lockers		10 51 13			
Horizontal End Suction Centrifugal Pumps		43 21 13.13	1.0		
Submersible Pumps		43 21 39.11	1.0		
Horizontal Submersible Propeller Pumps		43 21 39.23	1.0		
Rotary Lobe Pumps		43 23 58	1.0		
Mechanically Cleaned Bar Screens		46 21 12	1.0		
Vortex Grit Removal Equipment		46 22 23	1.0		
Grit Separation and Classification Equipment		46 22 64	1.0		
Packaged Odor Control System		44 31 19	1.0		
Odor Control Fans		43 11 21	1.0		
Submersible Mixers		46 41 23	1.0		
Fine Pore Diffused Aeration Equipment		46 51 31	1.0		
Coarse Bubble Diffusers		46 51 21	1.0		
Rotary Positive Displacement Blowers		43 11 17	1.0		
Dry Screw Positive Displacement Blower		43 11 15	1.0		
Compressed Air Equipment – Base Mounted Compressors		43 12 32	1.0		
Rotary Screw Air Compressors		43 12 24	1.0		
Engine Generators		26 32 13	1.5	x	x

Non-Structural Components Schedule					
Component		Applicable Specification Section	Importance Factor (I_p)	Component Design Required	Special Seismic Certification Required
Laboratory Furniture		12 56 53			
MBR		46 61 35	1.0		
Low Pressure Reverse Osmosis/Nano Filtration Equipment		46 63 25	1.0		
Fiberglass Reinforced Plastic Chemical Storage Tanks		43 41 45.13	1.5	x	x
Ammonia Storage Tanks		43 42 22	1.5	x	x
Aboveground Fuel Storage Tanks		33 56 13	1.5	x	x
Panels, Consoles, and Appurtenances		40 67 00	1.0		
Fire Sprinkler Systems		21 13 00	1.5	x	
Screw Conveyors		41 12 13.36	1.0		
Traveling Bridge Cranes		41 22 13.13	1.0		
Piping Systems and Related Pipe Supports		40 05 07.13			
All above ground pipes.			1.0		
Plumbing		22 00 00	1.0		
Water Heaters		22 00 00	1.0		
HVAC Equipment		23 00 00	1.0		
Gas Vent Systems		23 00 00	1.0		
Air-Side HVAC Air Handling Units, Furnaces, Makeup Air Units, Fans, Heaters, and Other Mechanical Components Constructed of Sheet Metal Framing		23 00 00	1.0		
Ductwork Including Inline Components		23 00 00	1.0		
Wet-Side HVAC Air Separators, Chemical Feed Pots, Expansion Tanks, Pumps, and Other Mechanical Components Constructed of High-Deformability Materials		23 21 11	1.0		
Piping, Tubing, and Inline Components		23 21 11	1.0		
Heating Systems Equipment		23 50 13	1.0		
Heaters, and Other Mechanical Components Constructed of Sheet Metal Framing		23 50 13	1.0		
Wet-Side HVAC Boilers and Other Mechanical Components Constructed of High-Deformability Materials		23 50 13	1.0		
Refrigeration Systems		23 70 00	1.0		

Non-Structural Components Schedule					
Component		Applicable Specification Section	Importance Factor (I_p)	Component Design Required	Special Seismic Certification Required
Condensing Units, Heat Pumps, Packaged Air Conditioning Units and Heat Pumps and Other Mechanical Components Constructed of Sheet Metal Framing		23 70 00	1.0		
Wet-Side HVAC Chillers and Other Mechanical Components Constructed of High-Deformability Materials		23 70 00	1.0		
Dehumidification Systems		23 84 21	1.0		
Air Distribution Systems		23 30 13	1.0		
Air-Side HVAC Air Handling Units, Furnaces, Makeup Air Units, Fans, Air Distribution Boxes, and Other Mechanical Components Constructed of Sheet Metal Framing		23 30 13	1.0		
Ductwork Including Inline Components		23 30 13	1.0		
Lighting Fixtures		26 05 11	1.0		
Lighting Panels		26 05 11	1.0		
Power Panels		26 05 11	1.0		
Surge Protection Device		26 05 11	1.0		
Separately Enclosed Motor Starters		26 05 11	1.0		
Separately Enclosed Manual Starters		26 05 11	1.0		
Control Stations		26 05 11	1.0		
Separately Enclosed Circuit Breakers		26 05 11	1.0		
Disconnect Switches		26 05 11	1.0		
Lighting and Auxiliary Power Transformers		26 05 11	1.0		
Power Centers		26 05 11	1.0		
Power Factor Correction Capacitors		26 05 11	1.0		
Lighting Contactors		26 05 11	1.0		
Photoelectric Controls		26 05 11	1.0		
Relay Enclosures		26 05 11	1.0		
Alarm Horn and Beacon		26 05 11	1.0		
Adjustable Frequency Drives		26 29 24	1.0		
Common Motor Requirements for Process Equipment		40 05 93	1.0		
Low Voltage Switchgear		26 23 00	1.0		
Switchboards		26 24 13	1.0		

Non-Structural Components Schedule					
Component		Applicable Specification Section	Importance Factor (I_p)	Component Design Required	Special Seismic Certification Required
600 Volt Class Motor Control Centers		26 24 23	1.0		
Bypass Isolation Automatic Transfer Switch		26 36 26	1.0		
Lightning Protection Systems		26 41 13	1.0		
Fire Detection and Alarm Systems		28 31 16	1.5	x	
Fire Detection and Signaling System		28 31 19	1.5	x	

Note: Some specification sections listed in the Non-Structural Components Schedule cover multiple items. Within those sections, some components may be exempt from seismic design based on their weight and/or their height above the floor. Reference ASCE 7, Paragraph 13.1.4 for specific conditions of the exemptions. Some ductwork and piping systems may also be exempt from seismic design based on criteria in their respective paragraphs in ASCE 7, Chapter 13.

Non-Building Structures Schedule			
Structure		Applicable Specification Section	Importance Factor (I)
Steel Water Storage Reservoir		33 16 13.13	1.25

Section 01 68 00

EQUIPMENT AND VALVE IDENTIFICATION

PART 1 – GENERAL

1-1. SCOPE. This section covers the furnishing and installation of nameplates and tags for identification of equipment, valves, panels, and instruments.

1-2. GENERAL. Except as otherwise specified in equipment, valve, and instrumentation sections, nameplates and tags shall be as specified herein. Nameplates or tags shall be provided for all equipment, valves, operator interfaces, control and electrical panels, cabinets, instruments, and instrument racks that have been named and/or tagged on the Drawings.

1-3. SUBMITTALS. Drawings and data shall be submitted in accordance with the requirements of the Submittals Procedures section for each type of tag provided including materials, colors, sizes, letter sizes, and installation instructions.

PART 2 - PRODUCTS

2-1. EQUIPMENT NUMBER PLATES. All equipment tagged on the drawings, shall be provided with number plates bearing the equipment tag number identified on the Drawings. Number plates shall be bevelled, 1/8th inch thick laminated black phenolic plastic engraving stock with white core. Lettering on number plates shall be capitalized block letters ¾ inch high. Number plate height shall be twice the letter height. Number plate length shall be as needed, with suitable margins all around. Lettering shall be placed in one row where practicable; however, where necessary due to excessive length, lettering shall be placed on more than one row and centered.

Number plates shall be attached with stainless steel panhead screws, rivets, or drive screws.

When a number plate cannot be installed due to the physical size, space, or mounting surface geometry of the equipment, the Contractor shall provide a 12 gauge stainless steel tag with engraved or imprinted equipment tag number. Lettering on tags shall be ¼ inch high. Tags shall be rectangular with smooth edges and shall be fastened to the equipment with stainless steel mechanical fasteners or with a stainless steel chain.

2-2. EQUIPMENT INFORMATION PLATES. Equipment shall be provided with engraved or stamped equipment information plates securely affixed with mechanical fasteners to the equipment in an accessible and visible location. Equipment information plates shall be in addition to the number plates specified. Equipment information plates shall indicate the manufacturer's name, address, product name, catalog number, serial number, capacity, operating and power characteristics, labels of tested compliances, and any other pertinent design data. Equipment information plates listing the distributing agent only will not be acceptable.

2-3. VALVE AND GATE TAGS.

2-3.01. Temporary Tags. Each valve and gate with an identifying number indicated on the Drawings or listed in the valve or gate schedule, shall be tagged or marked in the factory with the identifying number.

2-3.02. Permanent Tags. All valves and gates, except buried or submerged valves, that have been assigned a number on the Drawings or in the valve or gate schedule, shall be provided with a permanent number plate. Tags shall be permanently attached to valves and gates with stainless steel mechanical fasteners or with stainless steel chains. Numerals shall be ¾ inch high and shall be black baked enamel on an anodized aluminum plate.

All buried valves shall be tagged with a brass plate cast into a 6-inch by 6 inch concrete pad at grade next to the valve box. The valve number shall be engraved in the brass plate with lettering and numerals at least 1 inch high.

2-4. PANEL NAMEPLATES. Nameplates shall be provided on the face of each panel and cabinet. Panel identification nameplates shall be mounted at the top of the panel shall include the panel descriptive name and tag number as indicated on the Drawings, in two or three lines of text. Lettering shall be ¾ inch high.

Nameplates for devices mounted on or in the panel shall be inscribed with the text as indicated on the Drawings. Where nameplate information is not indicated on the Drawings, inscriptions shall be in accordance with information in the supplier's submittal drawings as guided by information in the relevant specification section. Panel device nameplates shall have engraved letters 3/16 inch high.

Nameplate material and size shall be as specified above for equipment number plates. Nameplates shall be secured to the panel with stainless steel panhead screws.

2-5. INSTRUMENT TAGS.

2-5.01. Temporary Tags. Where instruments are not provided with permanent tags furnished from the factory, instruments shall be tagged or marked in the factory with the instrument tag number indicated on the Drawings.

2-5.02. Permanent Tags. Instruments shall be tagged with the instrument tag number indicated on the Drawings. Tags shall be 12 gauge stainless steel with engraved or imprinted symbols. Lettering on tags shall be ¼ inch high. Tags shall be rectangular with smooth edges, and shall be fastened to the instrument with stainless steel mechanical fasteners or with a stainless steel chain.

PART 3 – EXECUTION

Not used.

End of Section

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Section 01 73 19

EQUIPMENT INSTALLATION

PART 1 - GENERAL

1-1. SCOPE. This section covers general installation requirements of new equipment units that have been purchased by Design-Builder as part of this Work. Equipment specific installation requirements are covered in the equipment sections.

1-2. GENERAL. Equipment installed under this section shall be erected and placed in proper operating condition in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

1-2.01. Coordination. When manufacturer's field services are provided by the equipment manufacturer, Design-Builder shall coordinate the services with the equipment manufacturer.

Flanged connections to equipment including the bolts, nuts, and gaskets are covered in the appropriate pipe specification section.

PART 2 - PRODUCTS

2-1. MATERIALS. Materials shall be as follows:

Grout	As specified in the Grouting section.
Anti-Seize thread lubricant for SS bolts	As specified in the Anchorage in Concrete and Masonry section.

PART 3 - EXECUTION

3-1. INSTALLATION. Equipment shall not be installed or operated except by, or with the guidance of, qualified personnel having the knowledge and experience necessary to obtain proper results as specified in the Startup Requirements section.

Each equipment unit shall be leveled, aligned, and shimmed into position. Installation procedures shall be as recommended by the equipment manufacturer and as required herein. Shimming between machined surfaces will not be permitted.

Anti-seize thread lubricant shall be liberally applied to the threaded portion of all stainless steel bolts during assembly. For equipment installed in drinking water facilities, the anti-seize lubricant shall meet requirements of NSF-61.

When specified in the equipment sections, the equipment manufacturer will provide installation supervision and installation checks. For installation supervision, the manufacturer's field representative will observe, instruct, guide, and direct Design-Builder's erection or installation procedures as specified in the equipment specifications. For installation checks, the manufacturer's field representative will inspect the equipment installation immediately following installation by Design-Builder, and observe the tests indicated in the Startup Requirements section. The manufacturer's representatives will revisit the site as often as necessary to ensure installation satisfactory to Owner.

All equipment shall be protected after installation, prior to final acceptance by Owner. Protection provisions shall be as recommended by the manufacturer, and shall include provisions to prevent rust, mechanical damage, and foreign objects entering the equipment.

3-2. STARTUP AND TESTING. Startup requirements, and tests associated with startup shall be as indicated in the Startup Requirements section. Other field tests shall be as indicated in the specific equipment sections. Startup and tests required shall occur in the order listed in the following paragraphs. Tests shall not begin until any installation supervision and installation checks by the equipment manufacturer have been completed, except where noted below.

3-2.01. Preliminary Field Tests. Preliminary field tests shall be conducted on all equipment by Design-Builder as indicated in the Startup Requirements section. When an installation check is specified in the equipment sections, the equipment manufacturer's representative will participate in these tests to the extent described in the Startup Requirements section and in the equipment sections.

3-2.02. Field System Operation Tests. Field system operation tests shall be conducted on all equipment by Design-Builder as indicated in the Startup Requirements section. When an installation check is specified in the equipment sections, the equipment manufacturer's service personnel will participate in these tests to the extent described in the Startup Requirements section and in the equipment sections.

3-2.03. Field Demonstration Tests. Field demonstration tests will be conducted by the equipment manufacturer on equipment as indicated and as specified in the equipment sections.

3-2.04. Field Performance Tests & Distribution Tests. Field performance tests or distribution tests will be conducted by the equipment manufacturer on equipment as indicated and as specified in the equipment sections.

3-2.05. Field Baseline Performance Tests. Field baseline performance tests shall be conducted by Design-Builder on the equipment indicated in the equipment sections, and the tests shall be performed as indicated. When indicated in the equipment sections, the equipment manufacturer will participate in these tests. This test shall not be considered an acceptance test, but rather a test to determine initial performance curves and efficiency just prior to the equipment entering service.

End of Section

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Section 01 79 00

DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.01 DESCRIPTION. This section contains requirements for training the Owner's personnel in the proper operation and maintenance of the equipment and systems installed under this contract. Additional training requirements may be provided in individual specification sections.

1.02 GENERAL. Where indicated in the specifications, the manufacturer's representative shall provide on-the-job training of the Owner's personnel. The training sessions shall be conducted by qualified, experienced, factory trained representatives of the various equipment manufacturers. Training shall include instruction in both operation and maintenance of the subject equipment.

1.03 SUBMITTALS. The following information shall be submitted to the Engineer in accordance with the provisions of the Submittals section. The material shall be submitted not less than 4 weeks prior to the provision of training.

1. Lesson plans, training manuals, handouts, visual aids, and other reference materials for each training session to be conducted by the manufacturer's representatives.

2. Subject of each training session, identity and qualifications of individuals to be conducting the training, and tentative date and time of each training session.

PART 2 – PRODUCTS

2.01 GENERAL. Where specified, the Supplier shall conduct training sessions for the Owner's personnel to instruct staff on the proper operation, care, and maintenance of the equipment and systems installed under this contract. Training shall take place at the site of the work and under the conditions specified in the following paragraphs. Approved operation and maintenance manuals shall be available at least 30 days prior to the date schedule for the individual training session.

2.02 LOCATION. Training sessions shall take place at the site of the work at a location designated by the Owner.

2.03 TIMING. The training of the Owner's personnel shall be at such times

as requested by the Owner.

2.03 LESSON PLANS. Formal written lesson plans shall be prepared for each training session. Lesson plans shall contain an outline of the material to be presented along with a description of the visual aids to be utilized during the sessions. Each plan shall contain time allocation for each subject.

One complete set of originals of the lesson plans, training manuals, handouts, visual aids and reference materials shall be the property of the Owner and shall be suitable bound for proper organization and easy reproduction. The Supplier shall furnish ten copies of necessary training manuals, handouts, visual aids, and reference materials at least 1 week prior to each training session.

2.04 FORMAT AND CONTENT. Each training session shall include classroom and time at the location of the subject equipment or system. As a minimum, training sessions shall cover the following subjects for each item of equipment or system:

1. Familiarization

    a. Review catalog, parts lists, drawings, etc, which have been previously provided for the plan files and operation and maintenance manuals.
    b. Guided inspection of the subject equipment.
    c. Demonstration of the subject equipment and how operation in accordance with the specified requirements.

2. Safety

    a. Review and demonstration of safety procedures and related documentation.
    b. Inspection and discussion of hazardous components of the subject equipment.

3. Operation

    a. Review of subject equipment operations literature and theory of operation.
    b. Overview of equipment operation and function.
    c. Explanation and demonstration of all modes of operation including start up, shut down, normal, and emergency operation, and manual and automatic operation through the plant control system.
    d. Explanation of all hardwired interlocks.
    e. Explanation and demonstration of equipment related valves and their purpose.

f. Explanation of all equipment related instruments including primary element, instrument indicator, purpose, and interpretation of information.
g. Check out of Owner's personnel on proper use of the equipment.

4. Preventive maintenance

    a. Review preventative maintenance documentation and discussion of maintenance require at various intervals; e.g. daily, weekly, monthly, annually.
    b. Demonstrate performance of each preventive maintenance task.
    c. Identification of indicators of equipment problems.
    d. Discussion of corrosion protection and lubrication requirements.
    e. Requirements for periodic exercise of equipment and demonstration of equipment exercise where required.
    f. Identification of inspection points and demonstration of inspection covers removal and routine disassembly and assembly of equipment.

5. Corrective Maintenance and Equipment Repair

    a. Discussion of common repairs and identification of special problems.
    b. Explanation and demonstration of equipment inspection and troubleshooting.
    c. Demonstration of calibration procedures.
    d. Demonstration of repair procedures where practical.

6. Parts

    a. Discussion of the parts list and ordering of parts.
    b. Review of spare parts provided with the equipment and identification of other recommended spare part.

7. Local Representatives

    a. Name, address, telephone of local representative.
    b. Review of contact information for providers of routine and emergency repair and operational assistance.

8. Operation and Maintenance Manuals

    a. Review of O&M manual content and organization.
    b. Update O&M material as required.

2.05 VIDEO RECORDING. The Design-Builder shall record each training session and shall give the Owner exclusive rights to each training session recording. The Design-Builder shall advise all manufacturers providing training sessions that the material will be recorded.

PART 3 – EXECUTION

Training shall be conducted in conjunction with the operational testing and commissioning periods. Classes shall be scheduled so that training is performed when equipment is available for operation. The Design-Builder shall arrange to have the training conducted on consecutive days, with no more than 6 hours of class scheduled for any one day. Concurrent classes will not be permitted.

Additional training requirements specific to various equipment may be provided in the separate technical specifications.

End of Section

Section 03 01 26.66

CONCRETE CRACK REPAIR

PART 1 - GENERAL

1-1. SCOPE. This section covers the repair of concrete and shotcrete cracks and joints.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values expressed in inch-pound units shall govern.

1-1.01. General Crack Repair. General crack repair is applicable only to new construction, and shall include the following:

a. Sealing of all cracks and crack networks that are wider than 10 mils (0.01 inch) [250 µm] as measured at the exposed surface.

b. All necessary repairs to structures that have failed a tightness test, including sealing of construction joints.

All costs for general crack repair shall be included in the Contract Price. General crack repair work is expected to be necessary due to cracks that commonly develop during concrete construction.

1-1.02. Engineer-Directed Crack Repair. Engineer-directed crack repair is applicable only to new construction, and shall only be performed when instructed by the Structural Engineer of Record. The work shall include, but is not limited to, the following:

a. Sealing of construction joints that are not otherwise required to be sealed as the result of a failure of a leakage test.

b. Sealing of cracks and crack networks with a width of 10 mils (0.01 inch) [250 µm] or less as measured at the exposed surface.

Design-Builder shall include 150 linear feet [50 linear meters] of Engineer-directed crack repair in the Contract Price. The Engineer-directed crack repair may be either epoxy resin or foam resin, as determined by the Structural Engineer of Record.

1-1.03. Pre-Defined Crack Repair. Pre-defined crack repair is applicable only to existing structures, and the extent of this type of repair is indicated on the Drawings.

Prior to beginning the repair work Design-Builder shall field verify and provide clear bright colored marking to the cracks to be repaired. Crack repair work shall not begin until marking is complete and has been approved by the Structural Engineer of Record.

1-2. SUBMITTALS. Specifications and data covering physical properties, mixtures, application procedures, and curing procedures of the materials proposed shall be submitted in accordance with the Submittals Procedures section. Submittals shall include the approvals from the material manufacturer.

1-3. QUALITY ASSURANCE.

1-3.01. Manufacturer's Field Services. The material manufacturer shall provide engineering field services to review the Work and the material application prior to any preparation; to approve the applicator, the material used, and the procedure to be used; to observe surface preparation; to approve surface preparation; and to observe application. The field representative of the material manufacturer shall submit, in writing through Design-Builder, approvals of proposed material, application procedures, applicator, and surface preparation. The field representative shall be an employee of the material manufacturer.

1-3.02. Applicator. The applicator shall submit through Design-Builder a satisfactory experience record including references from previous application of the specified materials to structures of similar design and complexity.

1-3.03. Pre-Construction Meeting. At least 30 days prior to concrete crack repairs, Design-Builder shall conduct a meeting to review the detailed requirements for rehabilitation work. Site conditions, surface preparation, proposed equipment, procedures, material mixing, placing procedures, and curing methods shall be discussed and approved by the Structural Engineer of Record and by the manufacturer’s field representative. Design-Builder shall require the attendance of all involved parties, including but not limited to Design-Builder’s superintendent, repair contractor, manufacturer’s field representative and proposed equipment supplier representative. Minutes of the meeting shall be recorded, typed and printed by Design-Builder and distributed to all parties within 5 days after the meeting.

1-3.04. Quality Assurance Certification. Material manufacturers shall be ISO 9001/9002 registered or shall provide proof of documented quality assurance. The documented quality assurance system shall be obtained through an independent auditing registrar.

1-4. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

PART 2 - PRODUCTS

2-1. PERFORMANCE AND DESIGN REQUIREMENTS. Unless otherwise specified or authorized, repairs shall conform to the requirements specified herein. Types of repairs not specified herein shall be as specified in other sections, as indicated on the Drawings, or, in the absence of any definite requirement, as recommended by the manufacturer's representative and subject to acceptance by the Structural Engineer of Record. The following types of repairs shall be performed as required.

2-1.01. Pressure-Injected Epoxy Resin. Unless indicated otherwise on the drawings, pressure-injected epoxy resin shall be used to seal joints and cracks that are not intended to permit movement.

2-1.02. Pressure-Injected Foam Resin. Unless indicated otherwise on the drawings, pressure-injected foam resin shall be used to seal joints that are intended to permit movement.

2-1.03. Crack Sealant. Crack sealant shall be used to seal cracks in structures prior to pressure injection of resin.

2-2. ACCEPTABLE PRODUCTS. Repair products/materials shall be as specified herein. Equivalent products of other manufacturers regularly producing high quality concrete crack repair products/materials, providing engineering field services, and meeting the specified quality assurance requirements may be furnished subject to review and acceptance by the Structural Engineer of Record.

2-3. MATERIALS. Materials shall be approved by the manufacturer for the type of application, including temperature and moisture conditions encountered.

Pressure-Injected Epoxy Resin	ASTM C881, Type I or Type IV, moisture tolerant or moisture insensitive.
Crack Sealant	As recommended by the manufacturer of the pressure-injected epoxy resin product.
Pressure-Injected Foam Resin	Hydrophilic polyurethane foam; Prime Resins “Prime-Flex 900 XLV”, DeNeef "Sealfoam PURe", or Avanti “AV-333 Injectaflex”.

Foam Resin Accelerator	As recommended by foam resin manufacturer.
Water	Clean and free from deleterious substances.

PART 3 - EXECUTION

3-1. INSPECTION. Prior to the placement of the repair materials, the crack to be repaired shall be inspected by the material manufacturer to assure that preparation and conditions are correct for the type of repair and the product/material being used as specified herein.

3-2. PREPARATION. All cracks and surfaces around the cracks shall be free of objectionable substances and shall conform to the requirements of the material manufacturer. Concrete and shotcrete to be repaired shall be cleaned by methods acceptable to the material manufacturer so that the cracks are free of dirt, oil, grease, laitance, and other foreign matter. All loose and deteriorated existing concrete and shotcrete shall be removed down to sound materials. All concrete and shotcrete surfaces shall be checked for delamination to ensure that all surfaces are sound. All edges shall be square cut to avoid feather edges.

Any other preparation recommended by the material manufacturer shall be brought to the Structural Engineer of Record's attention and may be incorporated into the work if acceptable.

Concrete and shotcrete surfaces in the area of a crack to be repaired shall be cleaned by wire brushing, blasting, or other acceptable methods.

Wall surfaces shall be sandblasted clean to expose crack networks and construction joints. If there is active water seepage in the repair area, the seepage shall be stopped as recommended by the injection material manufacturer and as acceptable to the Structural Engineer of Record. Injection ports shall be installed, when recommended by the injection material manufacturer.

3-2.01. Injected Epoxy Resin. Preparation for injected epoxy resin shall include sealing the surface at the crack, on both sides when possible, with crack sealant as recommended by the material manufacturer and as acceptable to the Structural Engineer of Record for the pressure injection work. Injection ports for epoxy resin shall penetrate through the crack sealant into the cracks at spacings recommended by the material manufacturer.

3-2.02. Injected Foam Resin. Preparation for injected foam resin shall include drilling offset injection holes at an angle that will intersect the crack, joint, or crack network at approximately one-half the thickness of the concrete or shotcrete up

to a thickness of 36 inches [900 mm]. Spacing of injection ports shall be determined as recommended by the injection material manufacturer and as acceptable to the Structural Engineer of Record. When the injection material manufacturer certifies, in writing, that spacing of injection ports and installation procedures are acceptable, the injection ports may be installed directly into the crack, subject to review by the Structural Engineer of Record.

3-3. APPLICATION. Concrete and shotcrete repair work shall be performed in accordance with the following requirements.

3-3.01. Crack Sealant. Crack sealant shall be trowel-applied to a minimum dried thickness of 1/8 inch [3 mm], or thicker if directed by manufacturer's literature. The concrete surface where the sealant is applied shall be smooth, uniform, and free from irregularities. Crack sealant shall be removed after the injection of resin is completed, except for portions of wall faces that will be at least 12 inches below the finished grade.

3-3.02. Pressure-Injected Resin. The injected areas shall be prepared as specified and as recommended by the manufacturer. Pressure-injected resin shall be suitable for penetration of joints, cracks, and crack networks 2 mils (0.002 inch) [50 µm] wide and larger.

After the joints and cracks are prepared and before the injection of the resin, the joints shall be flushed with water. The water flush shall be terminated when the turbidity of the expelled water is equal to that of the flush water. Unless otherwise acceptable to resin manufacturer and Structural Engineer of Record, cracks shall be dry prior to injecting resin.

The pumping equipment used for the pressure injection of resin shall have pressure metering. Written procedures for use and quality control of the injection equipment shall be furnished to the Structural Engineer of Record for review and acceptance. The pump shall be electric. The material and process used for the pressure injection of the resin shall have been in use a minimum of 5 years.

The joints and crack networks shall have a minimum of 90 percent penetration of resin into the joint or crack network. Core samples may be taken at the Structural Engineer of Record's discretion.

3-3.02.01. Epoxy Resin. Epoxy resin shall be injected into the structure in accordance with the material manufacturer's recommendations and as acceptable to the Structural Engineer of Record. Epoxy resin shall be injected until the resin appears at the next injection port.

3-3.02.02. Foam Resin. Foam resin shall be premixed and injected into the structure in accordance with the material manufacturer's recommendations and as acceptable to the Structural Engineer of Record. Foam resin shall be injected into the structure until the resin appears at the next injection port.

Surfaces of cracks and joints may need to be sealed with crack sealant.

3-3.03. Cold Weather. When ambient temperatures below 40°F [4°C] are expected during the curing period, the repair materials shall be maintained at a temperature of at least 50°F [10°C] for 14 days or 75°F [24°C] for 7 days after placement. Sudden cooling of the repair materials shall not be permitted.

3-4. PROTECTION. Post-placement curing and protection shall be as specified herein and in accordance with the manufacturer's recommendations.

3-5. CLEANING. Work areas shall be cleaned each day in accordance with the Project Requirements section. Upon completion of the final cleanup, Design-Builder shall restore all areas affected by the grouting procedures to their original condition, leaving no trace of material piles or other wasted materials.

End of Section

Section 03 08 13

TIGHTNESS TESTING OF STRUCTURES

PART 1 - GENERAL

1-1. SCOPE. This section covers hydrostatic tightness testing of concrete structures.

Tightness testing, cleaning, and disinfection of steel storage reservoirs and tanks, elevated steel tanks, and piping systems are covered in other sections.

1-2. GENERAL. Unless otherwise specified, testing shall be completed after the entire concrete structure has been constructed, cured, and has attained its design strength, but prior to placement of backfill, cleaning and disinfection, and prior to the installation of equipment in the structure.

All testing work shall be performed by Design-Builder.

1-2.01. Testing Schedule and Procedure. A testing schedule and procedure shall be prepared by the Design-Builder not less than 30 days prior to commencement of testing. The schedule shall indicate the proposed time and sequence of testing for each structure. The procedure shall indicate the limits of the area to be tested, define the method of isolation, the position and use of valves during testing, the location of temporary bulkheads, the process for introducing water and air into the structure, the method of measuring water and air losses, any correction methods required due to evaporation and precipitation, the method and location for disposal of testing water, and any other activities relevant to the testing.

Design-Builder shall notify Owner's Representative at least five days in advance of the time that testing of any individual structure will begin.

1-2.02. Water. Water for testing will be furnished as stipulated in the temporary facilities section. Water shall be conserved through collection and reuse in subsequent tests. Following completion of testing work, the water shall be disposed of in a manner acceptable to Owner and shall not be allowed to enter other parts of the system.

PART 2 - PRODUCTS

2-1. TEST EQUIPMENT. All necessary connections between the structure to be tested and the water source or other test medium, together with pumping equipment, any necessary metering devices, pressure or vacuum gauges, and all

other equipment, materials, and facilities required to perform the specified tests and dispose of the test medium after completion of testing, shall be provided by Design-Builder. Design-Builder shall provide all required temporary flanges, valves, bulkheads, bracing, blocking, and other sectionalizing devices that may be necessary to perform the testing. All temporary devices shall be removed upon satisfactory completion of testing.

2-2. STRUCTURES TO BE TESTED. The structures to be tested are indicated in the Tightness Testing of Structures schedule.

2-3. ALLOWABLE WATER LOSS. The maximum allowable water loss and the test duration shall be as specified in the Tightness Testing of Structures schedule.

Adjustments for evaporation and precipitation shall be required when indicated in the schedule. A partially filled plastic pan or tub having dimensions proportionately similar to those of the basin shall be placed in the basin and monitored to account for evaporation or rainfall.

Each leak which is discovered during the correction period shall be located and repaired to the satisfaction of Owner by and at the expense of Design-Builder.

PART 3 - EXECUTION

3-1. HYDROSTATIC TEST PROCEDURES. The hydrostatic test shall consist of both a visual inspection and a water loss measurement.

Unless otherwise specified, tightness testing shall be performed after all pipe sleeves have been installed but before backfilling or the interior waterproofing material or coating has been applied or exterior dampproofing material has been applied.

Paint that has been applied to piping, valves, or other items shall be permitted to dry in accordance with the paint manufacturer's instructions prior to introducing test water into the tank.

Exposed concrete surfaces of the structure, including the floor, shall be cleaned of all foreign material and debris prior to the test. Standing water in or outside the structure that would interfere with observation of the exposed concrete surfaces shall be removed. The concrete surfaces and concrete joints shall be thoroughly inspected for potential leakage points. Areas of potential leakage shall be repaired prior to filling the tank with water.

Adjacent structures having common walls shall be tested individually at different

times to permit examination of the dividing walls for leaks.

Pipe connections or openings to structures, if not provided with drip tight valves, shall be temporarily plugged during testing. Where slide gates, sluice gates or similar devices are located, Design-Builder shall provide bulkheads or the means to make them drip tight, and measure any leakage.

Unless otherwise specified, each structure to be tested shall be filled with potable water at a uniform rate not to exceed a depth of 4 feet per hour to the level specified in the Tightness Testing of Structures schedule. The water shall be allowed to stand for at least three days prior to tightness testing in order to stabilize the absorption rate of the concrete and the water temperature. During this period, sufficient water shall be added to maintain the water level to the elevation specified.

3-1.01. Visual Inspection. All structures to be tested shall be free from visible leaks. Damp spots on exterior wall surfaces shall be considered visible leaks if moisture can be picked up on a dry hand. Damp spots on tops of wall footings will be permitted unless the water can be observed to be flowing. Repairs shall be made to visible leaks regardless of the water loss test results. All visible leaks which have not spontaneously plugged or demonstrated a definite decrease in the rate of leakage over a maximum period of 28 days shall be located and repaired by and at the expense of Design-Builder. The structure shall be retested to confirm that the repairs are satisfactory.

3-1.02. Water Loss Measurement. Measurements of water level and loss will be taken by Design-Builder each day over the test period. If the measured drop in water level, adjusted for evaporation and precipitation when applicable, exceeds the allowable amount specified in the Tightness Testing of Structure schedule and does not show a definite decreasing trend during the following 7 day period, the structure shall be drained, repaired, cleaned, refilled, and retested to the satisfaction of Engineer.

Testing shall be considered void and the basin shall be retested in the event of excessive evaporation or precipitation that results in an empty or overflowing pan.

3-1.03. Structure-Specific Requirements. Not used.

3-1.04. Disposal of Test Water. Design-Builder shall confirm that Owner intends to dispose of the test water. If the water is to be disposed of, Design-Builder shall verify there is no residual chlorine or other undesirable product in the test water to be discharged. If necessary a neutralizing chemical treatment shall be provided to condition the water prior to disposal. Design-Builder shall be responsible to determine a suitable location and method for disposing of the used

test water. Water discharged to overland disposal or to a sewer system shall be discharged at flow rates and locations acceptable to the local governing agencies and in compliance with applicable rules and regulations.

3-2. PNEUMATIC TEST PROCEDURES FOR OZONE CONTACT BASINS. Not used.

3-2.01. Visual Inspection. While maintaining the pressure, the basin top slab and the walls above the water surface and the top slab, shall be visually observed for leaks. A leak detection solution shall be applied to all potential leakage areas, including the entire roof slab, and the appearance of bubbles shall be used to indicate leakage. All locations where leakage occurs shall be repaired prior to performing the pressure loss measurement.

The leak detection solution shall be a non-contaminating solution suitable for summer or winter use as appropriate. The leak detection solution for summer use shall be “Sherlock” Type CG manufactured by Winton Products Co. The leak detection solution for winter use shall be “No. OX-65-C (-65°F to +35°F)” as manufactured by American Gas and Chemicals Co.

3-2.02. Pressure Loss Measurement. After acceptance of the visual inspection, a pressure loss measurement test shall be performed. The basin shall be filled with potable water to the elevation specified for hydrostatic testing. The basin shall then be pressurized to 14 inches water column utilizing the procedure previously described.

The test duration shall be as indicated in the Tightness Testing of Structures schedule. At the end of the test period the pressure within the basin shall be recorded. The pressure loss shall not exceed the allowable pressure loss specified in the Tightness Testing of Structures schedule. If the pressure loss exceeds the allowable pressure loss, leaks shall be identified and sealed and the basin retested.

End of Section

Schedule 03 08 13-S01

TIGHTNESS TESTING OF STRUCTURES

Structure	Hydrostatic Testing			
	Water Surface Elevation	Allowable Water Surface Drop	Test Duration	Consider Evaporation and Precipitation
	ft	inches	days	(Y/N)
SAFE Diversion Box	133.96	0.60	5	N
BNR Basins Deox Box	128.69	0.48	4	Y
BNR Basins Splitter Chimney	128.69	0.48	4	Y
BNR Basins Anoxic and Aeration Zones (2 trains)	128.69	0.48	4	Y
BNR Mixed Liquor Channels (2 trains)	127.50	0.36	3	Y
MBR Cassette Tanks	130.84	0.36	3	Y
MBR RAS Channels	130.84	0.36	3	Y
Sludge Holding Tanks (2 trains)	133.00	0.36	3	Y
Chemical Containment Facility	104.00	0.125	3	Y

End of Section

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Section 03 11 00

CONCRETE FORMING

PART 1 - GENERAL

1-1. SCOPE. This section covers formwork for cast-in-place concrete.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values expressed in inch-pound units shall govern.

1-2. GENERAL. All forms shall be accurately and properly placed so cast-in-place concrete may be placed as indicated on the Drawings and as specified. The forms shall produce a smooth concrete finish free from offsets or irregularities.

1-3. SUBMITTALS. All submittals of catalog data sheets, manufacturers' certificates of compliance and other data shall be in accordance with the Submittals Procedures section.

A manufacturer's certificate of compliance, which includes the name of the project and, when requested, copies of independent test results confirming compliance with specified requirements, shall be submitted for the following materials:

Form Coating
Form Ties

PART 2 – PRODUCTS

2-1. MATERIALS.

Forms

Prefabricated	Simplex "Industrial Steel Frame Forms", Symons "Steel Ply", or Universal "Uni-form".
Plywood	Product Standard PS1, waterproof, resin-bonded, exterior type Douglas fir, face adjacent to concrete Grade B or better.

Fiberboard	ANSI/AHA A135.4, Class 1, tempered, water-resistant, concrete form hardboard.
Lumber	Straight, uniform width and thickness, and free from knots, offsets, holes, dents, and other surface defects.
Chamfer Strips	Clear white pine, surface against concrete planed.
Form Coating	Nonstaining and nontoxic after 30 days. Product shall not exceed VOC limits established by the federal, state, or local regulatory agency having jurisdiction over the project site.

2-2. FORMS. Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions indicated on the Drawings. Forms shall conform to ACI 347R and the following additional requirements.

Stay-in-place metal formwork will not be permitted.

Form-facing materials shall be selected in accordance with ACI 347.3R, based upon the applicable formed concrete surface category. Formed concrete surface categories vary by structure and application, and shall be as indicated in the Concrete Finishing section. Other types of forming materials, such as steel or unlined wood, may be used where plywood or lined forms are not required, and may be used as backing for form linings. Forms for exposed surfaces shall be laid out in a regular and uniform pattern with the long dimension of panels vertical and all joints aligned. The forms shall produce finished surfaces that are free from offsets, ridges, waves, and concave or convex areas, within the tolerances specified herein.

All vertical concrete surfaces above footings shall be formed.

Flat segmented forms not more than 24 inches [600 mm] wide may be used for forming curved surfaces 25 feet [7600 mm] in diameter or larger.

2-2.01. Design. Forms shall be substantial and sufficiently tight to prevent leakage of mortar. Forms shall be braced or tied to maintain the desired position, shape, and alignment during and after concrete placement. Walers, studs, internal ties, and other form supports shall be sized and spaced so that permissible working stresses are not exceeded.

Beams and slabs supported by concrete columns shall be formed so that the column forms may be removed without disturbing the supports for the beams or slabs.

Wherever the top of a wall will be exposed to weathering, the forms on at least one side shall not extend above the top of the wall and shall be brought to true line and grade. At other locations, forms shall be brought to a true line and grade, or a wooden guide strip shall be placed at the proper location on the forms so that the concrete surface can be finished with a screed or template to the specified elevation, slope, or contour. At horizontal construction joints in walls, the forms on one side shall not extend more than 2 feet [600 mm] above the joint.

Temporary openings shall be provided at the bottom of column and wall forms and at other points where necessary to facilitate cleaning and inspection.

2-2.02. Form Ties. Form ties shall have removable end and permanently embedded body, and shall have sufficient strength and rigidity to support and maintain the form in proper position and alignment without the use of auxiliary spreaders. Cones shall be provided on the outer ends of each tie, and the permanently embedded portion shall be at least 1 inch [25 mm] back from the concrete face. Form ties for liquid-containing walls shall be provided with water stop washers located on the permanently embedded portions of the ties at the approximate center of the wall. The ties shall be smooth at the location of the water stop washer; continuously threaded systems will not be acceptable. Permanently embedded portions of form ties without threaded ends shall be constructed so that the removable ends are readily broken off without damage to the concrete. Through-wall tapered removable ties will not be acceptable. The type of form ties used shall be acceptable to Structural Engineer of Record.

Form ties in exposed surfaces shall be uniformly spaced and aligned in horizontal and vertical rows.

2-2.03. Edges and Corners. Chamfer strips shall be placed in forms to bevel all salient edges and corners, except the top edges of walls and slabs which are to be tooled and edges which are to be buried. Equipment bases shall have formed beveled salient edges for all vertical and horizontal corners, unless specifically indicated otherwise on the Drawings. Unless otherwise noted, bevels shall be 3/4 inch [19 mm] wide.

PART 3 – EXECUTION

3-1. PLACEMENT. The limits of each concrete pour shall be determined by Design-Builder and acceptable to the Structural Engineer of Record.

Before concrete is placed, forms shall be rigidly secured in proper position; all dirt, mud, water, and debris shall be removed from the space to be occupied by concrete; all surfaces encrusted with dried concrete from previous placements shall be cleaned; and the entire installation shall be acceptable to the Structural Engineer of Record. Remove all frost, ice, and snow from within the formwork before concrete is placed.

3-2. TOLERANCES. Tolerances for cast-in-place concrete work shall be as indicated in ACI 347.3R, based upon the relevant formed concrete surface category.

3-3. FORM COATING. All concrete forms shall have form release agent applied to them before placement of concrete.

3-4. FORM REMOVAL. Forms shall not be removed from structures until the concrete in the structures has sufficient strength to support the weight of the structure and any superimposed load, including loads from construction operations. Design-Builder shall be responsible for limiting any applied loadings. There shall be no evidence of damage to concrete and no excessive deflection or distortion of members due either to the removal of forms or to loss of support.

Supporting formwork (soffit material only) for horizontal members shall not be removed until the concrete has attained at least 75 percent of the specified 28 day compressive strength as determined by cylinders made and cured in the field. Shoring systems for horizontal members shall not be removed until the concrete has attained the full specified 28 day compressive strength, but may be temporarily removed for the purpose of removing the soffit material as permitted above. Shoring shall be left in place and reinforced as necessary to carry any construction equipment or materials placed thereon.

When forms are removed before the specified curing is completed, measures shall be taken to immediately continue curing and to provide adequate thermal protection for the concrete.

End of Section

Section 03 15 19

CONCRETE JOINTS AND ACCESSORIES

PART 1 – GENERAL

1-1. SCOPE. This section covers concrete accessories including construction, contraction and expansion joints for cast-in-place concrete.

Dovetail anchor slots shall be as specified in the Masonry section.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values expressed in inch-pound units shall govern.

1-2. GENERAL. All accessories shall be accurately placed and all joints shall be accurately and properly constructed so cast-in-place concrete can be placed as specified and as indicated on the Drawings.

1-3. DRAWINGS AND DATA. All submittals of manufacturers' certificates of compliance, test data, reports, catalog data sheets and other data shall be in accordance with the Submittals Procedures section.

PART 2 - PRODUCTS

2-1. MATERIALS.

PVC Waterstops	Extruded, virgin, elastomeric, polyvinyl chloride (PVC), white (no pigment), ribbed, 3/8 inch [9.5 mm] min thick. Reclaimed material will not be acceptable. Provide hog rings or grommets spaced at 12 inches [300 mm] on center entire length.
6 inches wide, at construction joints	Greenstreak “679” or Vinylex “R638”.
9 inches wide, at construction joints	Greenstreak “646” or Vinylex “R938”.
6 inches wide, at control joints	"O" bulb closed center section; Greenstreak "732" or Vinylex "RB638H".

9 inches wide, at control joints	"O" bulb closed center section; Greenstreak "735" or Vinylex "RB938H".
Expansion joint materials	
Filler	Preformed sponge rubber, ASTM D1752, Type I.
Filler adhesive	As recommended by manufacturer.
Sealant	As specified in the Joint Sealants section.
Polyethylene film	NBS Product Standard PS17 or ASTM D4397, 6 mils [0.152 mm] or thicker.
Vapor retarder and seam tape	Polyolefin membrane, 15 mil [0.38 mm] min, ASTM E1745, Class A, with maximum water vapor permeance of 0.02 perms. Stego Industries “Stego Wrap 15 Mil”, Raven Industries “Vaporblock 15”, Reef Industries “Griffolyn 15 Mil Green”, W.R. Meadows “Perminator 15”, Insulation Solutions “Viper VaporCheck II”. Manufacturer recommended seam tape and pipe boots.
Bearing pads	Preformed cotton duck reinforced pads, at least 1/4 inch [6 mm] thick; JVI "Capralon" or Voss Engineering "Sorbtex".
Epoxy bonding agent	As specified in Concrete Placing section.
Wedge inserts	Malleable iron, with galvanized askew-head bolts, nuts, and washers; Hohmann and Barnard "HW", Richmond "Peerless", or Weston "WC50".

PART 3 - EXECUTION

3-1. CONSTRUCTION JOINTS. Construction joints shall be made at locations indicated on the Drawings or where specified. Construction joints shall not be made at other locations without the concurrence of the Structural Engineer of Record.

3-1.01. Location. Construction joints shall be located as follows:

a. In Columns and Walls. At the underside of beams, girders, haunches, drop panels, and column capitals, and at floor levels. All haunches, drop panels, and column capitals shall be considered part of the supported floor or roof and shall be placed monolithically therewith. Column bases will not be required to be monolithic with the floor beneath. Walls shall be divided into sections not to exceed 60 feet [18 m], except at corners which shall be as indicated on the Drawings. Walls supporting beams shall have pockets blocked out so that the full beam cross section penetrates the full thickness of the wall. Where waterstops are required in the joint, the wall pocket shall be widened and deepened to prevent interference between the waterstop and the beam reinforcement.

b. In Beams and Girders. Within the middle third of the span, unless a beam intersects a girder at this point, in which case the joint in the girder shall be offset by twice the width of the beam. Provisions for the transfer of shear and other forces through the construction joint shall be acceptable to the Structural Engineer of Record. Members shall be divided into pour sections not greater than 60 feet [18 m] in length.

c. In Suspended Slabs. At or near the center of the span in flat slab or T-beam construction. No joint will be permitted between a slab and a concrete beam or girder unless specifically required by the Drawings. Suspended floor systems shall be divided by construction joints into approximately square sections not to exceed 60 feet [18 m] in their longest dimension.

d. In Bottom Slab. Each bottom slab shall be divided into approximately square sections not to exceed 60 feet [18 m] in their longest dimension.

Construction joints in beams, girders, joists, and slabs shall be perpendicular to the planes of their surfaces.

3-1.02. Watertight Joints. Construction joints in the following locations shall be watertight and shall be provided with continuous waterstops.

a. For liquid-containing structures, provide in slabs below the liquid surface elevation, and in all perimeter walls to their full height.

b. For liquid-containing structures, provide in divider walls where it is possible for one side or “cell” to be out of service while the other remains liquid-containing.

c. For filters and clear water reservoirs, provide in all walls, base slabs, and top slabs.

d. Provide in other locations specifically indicated on the Drawings.

3-2. EXPANSION AND CONTRACTION JOINTS. Expansion joint filler shall be firmly bonded to the previously poured joint face with a suitable adhesive, and the new concrete shall be poured directly against the joint filler. Accessible edges of each expansion and contraction joint shall be sealed as specified in the caulking section.

3-3. WATERSTOPS.

3-3.01 Placement. Each waterstop shall be continuous throughout the length of the joint in which it is installed. Waterstops shall be clean, free from coatings, and shall be maintained in proper position until surrounding concrete has been deposited and compacted. Waterstop embedment shall be equal on both sides of the joint.

Expandable waterstops shall be located as nearly as possible to the center of the joint and shall not be installed when air temperature falls outside the manufacturer's recommended range.

3-3.02. Storage and Handling. Expansion joint filler and elastomeric (PVC or TPV) waterstops shall be stored in a cool place protected from direct sunlight.

Metal waterstops shall be handled, transported, delivered, and stored in a manner which will prevent bends, dents, or corrosion.

3-3.03. Splices. Junctions between adjacent sections of metal waterstops shall be lapped 5 inches [130 mm] and securely bolted, screwed, or spot welded together.

Junctions between adjacent sections of elastomeric (PVC or TPV) waterstops shall be spliced in strict conformity with the recommendations of the manufacturer. Directional changes and intersections shall be factory fabricated by the waterstop manufacturer prior to delivery to the Site. Field splices will be acceptable only in straight sections.

Expandable waterstops shall be contact lapped a minimum distance of 8 inches [200 mm]. Voids shall be filled with sealant.

Where an expandable waterstop is used in combination with metal or PVC water stops, the expandable water stop shall be placed in contact and shall overlap a minimum distance of 12 inches [300 mm]. Voids shall be filled with sealant.

3-4. PLACEMENT. The limits of each concrete pour shall be determined by Design-Builder and shall be acceptable to the Structural Engineer of Record.

3-5. EMBEDMENTS. Anchor bolts, castings, steel shapes, conduits, sleeves, masonry anchors, and other objects that are to be embedded in the concrete shall be accurately positioned in the forms and securely anchored.

Unless installed in pipe sleeves, anchor bolts shall have sufficient threads to permit a nut to be placed on the concrete side of the form or template. A second nut shall be placed on the other side of the form or template, and the two nuts shall be so adjusted that the bolt will be held rigidly in proper position.

3-6. DUCT BANK JOINTS. Hardened surfaces that are to receive additional concrete shall be prepared by removing all loose particles, scum, and laitance so that the aggregate is exposed. The hardened surface shall then be thoroughly wetted and a thin coating of neat cement mortar shall be spread over the entire surface just before the fresh concrete is placed. The fresh concrete shall be puddled and spaded to eliminate any honeycomb or lack of mortar near the joint.

3-7. PLACEMENT AGAINST SUBGRADE. Where concrete is placed against rock, all loose pieces of rock shall be removed and the exposed surface cleaned with a high-pressure water spray.

3-7.01. Polyethylene Film. Where concrete is placed against gravel or crushed rock which does not contain at least 25 percent material passing a No. 4 [4.75 mm] sieve, such surfaces shall be covered with polyethylene film. Joints in the film shall be lapped at least 6 inches [152 mm] and taped.

3-7.02. Vapor Retarder. Vapor retarder shall be installed at the locations indicated on the Drawings. Installation shall be in accordance with ASTM E1643 and the manufacturer's recommendations. Joints in the retarder shall be sealed with waterproof sealing tape. Care shall be exercised to avoid tearing or puncturing the retarder. Any damage shall be promptly repaired, and the retarder shall be inspected for damage immediately before the concrete is placed.

3-8. BEARING PADS. Wherever a concrete beam is supported by a concrete bracket, a bearing pad shall be placed in the joint between the beam and the bracket.

End of Section

Section 03 20 00

CONCRETE REINFORCING

PART 1 – GENERAL

1-1. SCOPE. This section covers reinforcement for cast-in-place concrete.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values expressed in inch-pound units shall govern.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. All submittals of drawings, manufacturers' certificates of compliance, certification of reinforcement, reinforcement bar lists, placement drawings, test data, catalog data sheets and other data shall be in accordance with the Submittals Procedures section.

Bar lists and drawings for the fabrication and placing of reinforcement shall be submitted for review and shall have sufficient plans, elevations, and sections to adequately detail and label all reinforcement. The bar lists and drawings shall also include a reference to the structure in which the reinforcement will be installed and to the Drawing showing the reinforcement.

1-2.02. Manufacturer's Certificate of Compliance. A manufacturer's certificate of compliance, which includes the name of the project and, when requested, copies of independent test results confirming compliance with specified requirements, shall be submitted to Owner’s Representative for the following materials:

Mechanical connectors

PART 2 – PRODUCTS

2-1. MATERIALS.

Bars, Except Weldable	ASTM A615 or A706, Grade 60, deformed. Shear bars shall be Grade 60, smooth.

Bars, Weldable	ASTM A706 or A615, Grade 60, deformed, with maximum carbon equivalent of 0.55%.
Column Spirals	ASTM A1064, cold drawn wire.
Welded Wire Fabric	ASTM A1064, Grade 70.
Bar Supports	CRSI Class 1, plastic protected; or Class 2, stainless steel protected. Precast concrete bricks shall not be used without approval of the Structural Engineer of Record.
Mechanical Connectors	Splicing system meeting Type 2 tensile requirements of ACI 318. Products shall have a current evaluation report verifying testing per ICC-ES AC 133.
Threaded Type	Dayton Superior “DBDI Splice System”, or Barsplice Products “Grip-Twist” system,
Locking Type	Dayton Superior “Bar-Lock Coupler” system, or Barsplice Products “Zap Screwlock Type 2 Mechanical Connector” system,
Protective Tape Wrap	Tapecoat "Tapecoat 20".

2-2. REINFORCEMENT. Reinforcement shall be accurately formed and shall be free from loose rust, scale, concrete splatter, and contaminants which reduce bond. Unless otherwise indicated on the Drawings or specified herein, the details of fabrication shall conform to ACI SP-66 and ACI 318. Reinforcement shall not be bent in the field without approval of the Structural Engineer of Record.

2-2.01. Splices. Splices shall conform to the details indicated on the Drawings. Splices at locations other than those indicated on the Drawings shall be submitted to the Structural Engineer of Record for review and concurrence.

2-2.02. Mechanical Connectors. Mechanical connectors shall be used only as indicated on the Drawings. Connections in adjacent bars shall be spaced at least 30 inches [760 mm] apart.

2-2.03. Welding. Except where indicated on the Drawings, welding or tack welding of reinforcement is not permitted. Preheating and welding shall conform to AWS D1.4. Reinforcement which has been welded improperly or without the Structural Engineer of Record's concurrence shall be removed and replaced.

2-2.04. Repair of Epoxy Coating. When epoxy-coated reinforcing bars are specified, before placing epoxy-coated reinforcement in the work, Design-Builder shall repair all damaged epoxy coatings and shall check the coating for holidays in accordance with the procedures set forth in ASTM A775. All reinforcement shall be free of holidays prior to placement in the work.

Damaged epoxy coating shall be repaired as recommended by the manufacturer using patching material provided by the manufacturer.

Coatings damaged by handling and placing after onsite testing shall be repaired as specified. The maximum amount of damaged coating shall not exceed 0.5 percent of the surface area of each bar.

After completion of welding on epoxy-coated reinforcement, when acceptable to the Structural Engineer of Record, damage to the coating shall be repaired as specified. All welds and steel splice members, including mechanical connections when used to splice bars, shall be coated with the same material as used to repair coating damage.

PART 3 – EXECUTION

3-1. STORAGE AND HANDLING. Reinforcing steel shall be carefully handled and shall be stored on supports which prevent the steel from touching the ground.

Epoxy-coated reinforcement shall be handled using equipment with protected contact areas. Bundles or stacks of epoxy-coated reinforcement shall be lifted at multiple points to prevent abrasion from sags. Epoxy-coated reinforcement shall not be dropped or dragged and shall be stored on protective cribbing. Faded or chalking coating will not be cause for rejecting epoxy-coated reinforcement.

3-2. PLACEMENT. Reinforcement shall be accurately positioned on supports, spacers, hangers, or other reinforcement, and shall be secured in place with wire ties or suitable clips. Tolerances shall be as stipulated in ACI 117 and ACI 318 unless otherwise indicated.

Reinforcement at the bottom of concrete slabs and mats shall not be supported from contact with subgrade by the use of metal supports or bent reinforcement.

Where reinforcement in beams is placed in two or more layers, the bars in the upper layer shall be placed directly above the bars in the lower layer.

Reinforcement for beams or slabs which are supported by concrete columns shall not be installed until after the concrete for the column has been placed.

Before concrete is placed, reinforcement shall be rigidly secured in proper position. All surfaces encrusted with dried concrete from previous placements shall be cleaned and the entire installation shall be acceptable to the Structural Engineer of Record. Remove all frost, ice, and snow before concrete is placed.

Epoxy-coated reinforcement shall be fastened with nylon, epoxy, or plastic-coated tie wire.

3-3. PLACING CONCRETE. Concrete shall be placed and compacted in wall or column forms before any reinforcement is placed in the system to be supported by such walls or columns.

3-4. DUCT BANKS. All reinforcement and other magnetic materials installed in duct banks shall be installed parallel to the individual ducts, unless they enclose all the ducts of the duct bank.

End of Section

Section 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1-1. SCOPE. This section covers procurement of all cast-in-place concrete, including concrete materials, limiting requirements, mixture design, and performance requirements, and delivery to the Site through discharge at the end of the delivery truck chute.

Work beyond the end of the delivery truck chute is covered in the Concrete Forming, Concrete Joints and Accessories, Concrete Reinforcing, Concrete Placing, Concrete Finishing, and Concrete Curing sections.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values expressed in inch-pound units shall govern.

1-2. GENERAL. All cast-in-place concrete shall conform to the limiting requirements of this specification including Table 1.

1-2.01. Concrete Classifications. Concrete classifications shall be defined and used as indicated for the following classes:

Concrete Classifications

Class	Class Description
A.	Structural Concrete
A1.	Concrete for Liquid-Containing Structures. Concrete for liquid-containing environmental structures, liquid-containing tanks, interior suspended slabs in high humidity areas, headwalls, chemical storage or containment areas, below grade structures exposed to groundwater under normal conditions, and all other concrete not otherwise indicated.

Class Class Description

A2. Small Aggregate Concrete; Congested Areas. Structural small aggregate concrete shall be used in all areas (including liquid-containing structures) where the clear distance between reinforcement, conduit, or embedded items is less than the largest dimension of coarse aggregate particles in the structural concrete.

A3. Concrete for Non-Liquid-Containing Structures. Concrete for footings, foundations, manholes, catch basins, pan-formed joists, and all other structural concrete other than for liquid-containing structures.

A4. Mortar Puddle. Placed in a lift 2 inches or more deep at the bottom of forms for walls and columns immediately before structural concrete is placed.

A5. Drilled Pier Concrete. Placed in drilled piers, lined or unlined. Not to be used as grout for pressure-grouted augured piles.

B. Exterior Flatwork Concrete. Concrete for exterior slabs on grade, plant pavement, sidewalks, curbs and gutters, and small equipment pads.

C. Architectural Concrete. Concrete whose appearance is of higher importance; which may have coloring or a special surface texture.

D. Miscellaneous Concrete

D1. Ductbanks, Pipe Blocking, Concrete Fill, and Pipe Encasement Concrete. Concrete used in ductbanks, pipe blocking, concrete fill and pipe encasements.

D2. Underwater Concrete. Concrete used for underwater sealing, tremie slabs, underwater work slabs, underwater concrete fill, or cofferdam ballast. Unless otherwise permitted by the Structural Engineer of Record, concrete shall not be deposited underwater.

D3. Mass Concrete. Concrete areas with unusually thick sections that may be subject to detrimental thermal effects during hydration and curing.

D4. Pan Stairs Concrete. Concrete used to fill architectural, steel pan stair treads.

Class	Class Description

D5. Wash Water Trough Concrete. On-site placement of concrete wash water troughs.

D6. Composite Topping Concrete. Concrete placed as a cap over a properly prepared concrete subsurface, placed as a topping over precast hollowcore or double tee sections, or used for repair, leveling, raising a finished surface elevation.

D7. Lean Concrete. Used as a fill material for over-excavations or for mud slabs below foundations. Controlled Low-Strength Material (CLSM) used as an easily removable fill material is covered in the Excavation and Fill for Structures section.

1-3. SUBMITTALS. All data shall be submitted in accordance with the Submittals Procedures section, unless otherwise specified herein.

The required submittal data for each Class of concrete shall be as indicated in Tables 2A, 2B, and 2C.

1-3.01. Preliminary Review of Materials. Reports covering the source and quality of concrete materials proposed for the work shall be submitted to the Structural Engineer of Record for review within 30 days after the preconstruction conference.

A manufacturer's certificate of compliance, which includes copies of independent test results confirming compliance with specified requirements, shall be submitted for the following materials:

Cement.

Admixtures.

Fly Ash.

Slag Cement.

Fibers.

1-3.02. Proposed Mixture Proportions. Data indicating the proposed material quantities in each Class of concrete shall be submitted to the Structural Engineer of Record for review within 30 days after the preconstruction conference (no less than 7 days prior to placement).

1-3.03. Field Test Record Data. Concrete mixture field test record performance data shall be submitted to the Structural Engineer of Record for review and acceptance. Field test record data shall be acceptable only for the Classes of concrete indicated as such in Table 2C.

1-3.04. Laboratory Trial Mixture Test Results. Laboratory trial mixture testing shall not begin until materials and proposed mixture proportions have been reviewed and are acceptable to the Structural Engineer of Record. Trial mixture testing shall be performed for all Classes of concrete where field test record data is not acceptable as a means of qualifying the mixture.

1-4. STORAGE AND HANDLING. Cement, slag cement and fly ash shall be stored in suitable moistureproof enclosures. Cement, slag cement and fly ash which have become caked or lumpy shall not be used.

Aggregates shall be stored so that segregation and the inclusion of foreign materials are prevented. The bottom 6 inches [150 mm] of aggregate piles in contact with the ground shall not be used.

PART 2 - PRODUCTS

2-1. LIMITING REQUIREMENTS. Unless otherwise specified, each concrete mixture shall be designed and controlled, within the following limits, to provide a dense, durable concrete suitable for the expected service conditions.

Concrete materials shall be selected and concrete shall be proportioned, batched, mixed, and delivered in a manner that will minimize shrinkage and cracking as specified herein, and in accordance with Chapters 3 and 8 of ACI 224R. Concrete temperatures shall be controlled before and until delivery at the end of the delivery truck chute to minimize cracking. Any rise in concrete temperature caused by environmental conditions that will be conducive to excessive shrinkage shall be controlled.

For each class of concrete, each concrete mixture shall be designed and concrete shall be controlled within the limits in the specification and in Table 1.

2-1.01. Cementitious Material Content Limits. The minimum quantity of Portland cement in the concrete shall be as indicated in Table 1.

The cementitious material content shall not be increased beyond the Table 1 values more than necessary to achieve the required f'_{cr}.

Design-Builder may substitute fly ash for Portland cement within the percentage ranges indicated in Table 1, on the basis of 1.0 lbs [1.0 kg] of fly ash added for each lb [kilogram] of Portland cement reduction.

Design-Builder may substitute slag cement for Portland cement within the percentage ranges indicted in Table 1 on the basis of 1.0 lbs [1.0 kg] of slag cement added for each lb [kilogram] of Portland cement reduction.

Mixtures using slag cement in combination with fly ash will not be acceptable.

2-1.02. Maximum Water-Cementitious Material Ratio. The maximum water-cementitious material ratio shall be on a cement mass basis, or, if fly ash or slag cement is used, the combined mass of cement plus fly ash or slag cement shall be used to determine the water-cementitious materials ratio. Limiting maximum water-cementitious material ratios are indicated in Table 1.

2-1.03. Aggregates. Aggregates shall comply with ASTM C33 except as specified herein. Fine aggregate shall be clean natural sand. Artificial or manufactured sand shall not be used unless acceptable to the Structural Engineer of Record. Coarse aggregate shall be crushed rock, washed gravel, or other inert granular material, meeting Class 4S requirements, except that clay and shale particles shall not exceed values indicated in Table 1.

Gradation of coarse aggregate shall conform to maximum nominal size grading requirements of ASTM C33. When a combination of two or more sizes is used, the combined gradation shall meet ASTM C33 requirements.

Aggregates used in concrete shall have a combined aggregate distribution similar to the aggregates used in the concrete trial mixtures. Reports of individual aggregates shall include sieve sizes 1-1/2 inch, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, No. 4, No. 8, No. 16, No. 30, and No. 50 [38 mm, 25 mm, 19 mm, 12.5 mm, 9.5 mm, 4.75 mm, 2.36 mm, 1.118 mm, 600 µm, and 300 µm] in accordance with ASTM E11.

Specified sand equivalent for fine aggregate shall be not less than indicated in Table 1 for an average of 3 samples tested in accordance with ASTM D2419.

To comply with the specified concrete shrinkage test requirements, the clay and shale content of the aggregates may need to be reduced by washing the aggregate.

2-1.04. Ratio of Fine to Total Aggregates. The ratio of fine to total aggregates, based on solid volumes (not weights), shall be as follows:

Maximum Nominal Coarse Aggregate Size	Minimum Ratio	Maximum Ratio
3/8 inch [9.5 mm]	0.45	0.60
1/2 inch [12.5 mm]	0.40	0.55
3/4 inch [19 mm]	0.35	0.50
1 inch [25 mm]	0.30	0.46
1-1/2 inch [37.5 mm]	0.25	0.40

2-1.05. Slump. Concrete slump shall be kept as low as possible, consistent with proper handling and thorough consolidation. Prior to the addition of admixtures, slump shall be at least 2 inches [50 mm] and shall not exceed the maximum slump as indicated in Table 1.

When superplasticizer is dispensed at the ready-mix plant, the concrete mixture design shall be based on a maximum slump as indicated in Table 1. When superplasticizer is dispensed at the Site, the slump of the concrete delivered shall not exceed the maximum slump as indicated in Table 1 before superplasticizer is added.

2-1.06. Initial Set. The initial set, as determined by ASTM C403, shall be attained 5-1/2 hours ±1 hour after the water and cementitious materials are added to the aggregates for each concrete mixture. The quantity of retarding admixture shall be adjusted to compensate for variations in temperature and job conditions.

2-1.07. Total Air Content. The total volumetric air content of concrete after placement shall be as indicated in Table 1, and within ±1.5 percent. Air-entraining admixture may be omitted from concrete for interior slabs which are to be steel trowel finished.

2-1.08. Admixtures. Only approved or specified admixtures shall be used.

Unless otherwise acceptable to the Structural Engineer of Record, all admixtures shall be from one manufacturer and shall be compatible. Admixtures that are compatible with other admixtures and concrete materials shall not have an

adverse effect on the required properties of the concrete nor the specified limiting requirements. The admixture content, batching method, and time of introduction to the mixture shall comply with these specifications and with the manufacturer's recommendations for minimum shrinkage. The admixture manufacturer shall provide qualified field services as necessary, at no additional cost to Owner.

Admixtures used in the concrete shall be reviewed and accepted by the Structural Engineer of Record prior to conducting the laboratory trial mixture testing and the shrinkage testing. No calcium chloride nor admixture containing chloride from sources other than residual impurities in admixture ingredients will be permitted.

Combination of admixtures which cause premature or local dehydration or post-compaction settlement of the concrete surface shall not be used. If any such undesirable characteristics are observed, the use of the mixture shall be discontinued and an alternate mixture design used.

All liquid-containing (Class A1) concrete, and small aggregate (Class A2) concrete that is placed in liquid-containing structures, shall include a high-range water reducing admixture (superplasticizer). Water-reducing admixtures are not required for Classes D1 and D7, but may be included at Design-Builder’s option. For all other non-liquid-containing concrete, a water-reducing admixture shall be used.

Superplasticizer may be dispensed into the concrete at the plant or on the Site and shall be mixed in accordance with the admixture manufacturer's recommendations. Each superplasticizer dose, when dispensed at the Site, shall be easily verifiable and recorded on the delivery ticket. The superplasticizer for each load shall be accurately proportioned into a separate container prior to dispensing the admixture into the concrete. When truck-mounted dispensers are used, the system shall not be flushed or cleaned with water until after the entire load of concrete has been discharged. When permitted by the Structural Engineer of Record, redosing of concrete with superplasticizer shall be done only once. Redosing procedures shall be as recommended by the admixture manufacturer.

A shrinkage reducing admixture may be added to Class A1 concrete. It shall replace an equal volume of mixing water or as otherwise recommended by the admixture manufacturer. The quantity of air entrainment admixture shall be adjusted as required by the admixture manufacturer to keep mixture air content within specified limits.

2-1.09. Fiber Concrete. Fiber concrete shall be used only where noted on the Drawings. Polypropylene micro fibers shall be added to the concrete materials at

the time the materials are batched at the rate of 1.5 lbs/cu yd [0.90 kg/m ^{3}]. Batching and mixing procedures shall be in accordance with the manufacturer's recommendations. Fibers shall be randomly oriented and uniformly distributed throughout the concrete.

2-1.10. Strength. In addition to the other limiting requirements to achieve durability and minimize shrinkage, the minimum acceptable compressive strengths of concrete tested at the end of the delivery truck chute, as determined by ASTM C39, shall be as indicated in Table 1.

Adequate test cylinders taken at the point of placement shall also be made to verify that Design-Builder's concreting procedures comply with applicable industry standard procedures.

2-1.11. Pumped Concrete. Coarse aggregate size for pumped concrete mixtures shall be limited to a nominal maximum of 1-1/2 inch [37.5 mm].

2-1.12. Water-Soluble Chloride. Maximum water-soluble chloride ion concentrations in hardened concrete at an age of 28 days shall not exceed the limits expressed as a percentage of mass of cementitious materials as indicated in Table 1.

Test results shall be reported as the percentage of water-soluble chloride ions in the concrete and as a percentage of chloride ion relative to the mass of cementitious materials in the concrete.

Testing of the concrete components for water-soluble chloride ions may be done at the discretion of Design-Builder. Copies of the reports on such tests shall be furnished to the Structural Engineer of Record.

The hardened concrete and each gradation of aggregate used in the concrete shall be tested each time a chloride ion test is conducted on a concrete mixture.

2-1.13. Laboratory Shrinkage Limits. Based on the modified ASTM C157 test procedures as specified herein, the shrinkage limits of concrete shall be the average drying shrinkage of each set of three test specimens cast in the laboratory from a trial mixture as measured at the 21 days drying age, and shall not exceed the values in Table 1.

2-1.14. NSF 61 Compliance. Not used.

2-1.15. Mineral Colored Concrete. Mineral colored concrete shall be used where indicated on the Drawings. The color of the concrete shall be as noted on the Drawings. The quantity of mineral coloring admixture added shall be as recommended by the color admixture manufacturer for a deep, intense color tone.

2-1.16. Cold Weather Concrete. Except as modified herein, cold weather concrete shall comply with ACI 306.1. The temperature of concrete at the point of delivery at the end of the delivery truck chute shall be not less than that indicated in ACI 306.1 for corresponding outdoor temperature (in shade) at the time of placement.

When delivered, heated concrete shall be not warmer than 80°F [26°C].

2-1.17. Hot Weather Concrete. Except as modified herein, hot weather concrete shall comply with ACI 305.1. At air temperatures of 90°F [32°C] or above, concrete shall be kept as cool as possible before and during delivery. The temperature of the concrete at the time of delivery at the end of the delivery truck chute shall not exceed the values indicated in Table 1.

2-2. MATERIALS.

Cement	ASTM C 150, Type V or Type II/V. Low Alkali.
Fly Ash	ASTM C618, except that loss on ignition shall not exceed 4 percent. Class F or Class C are acceptable, but Class C shall also be qualified for moderate sulfate resistance as described in ASTM C618, Table 3, Procedure A. The test for sulfate resistance shall be in accordance with ASTM C1012.
Slag Cement	ASTM C989, Grade 100 or Grade 120.
Aggregates, Fine and Coarse	As specified in Limiting Requirements paragraph.
Water	Potable. Water from concrete production operations shall not be used.
Admixtures	

Water Reducing/Normal Set	ASTM C494, Type A, except as otherwise specified herein.
Water Reducing/Retarding	ASTM C494, Type D, except as otherwise specified herein.
Air-Entraining	ASTM C260.
High Range Water Reducing/Normal Set	ASTM C494, Type F, extended slump life type, except as otherwise specified herein.
High Range Water Reducing/Retarding	ASTM C494, Type G, extended slump life type, except as otherwise specified herein.
Shrinkage Reducing Admixture	GCP Applied Technologies (Grace) “Eclipse 4500”, Euclid “Eucon SRA”, or BASF “MasterLife SRA 035”. These admixtures may not be usable in mixtures that require NSF 61 certification.
Mineral Coloring	Nonfading mineral coloring unaffected by sunlight or free alkali; Davis Colors "Mix-Ready", L.M. Scofield "Chromix", or Euclid “Super Concentrated Mortar Color”.
Fibers	Collated, fibrillated, polypropylene fibers; Propex “Fibermesh”, Forta “Mighty-Mono”, or GCP Applied Technologies (Grace) “MicroFiber”.

2-3. MIXTURE DESIGN AND TESTING. As stipulated in the Quality Control section, all reports and tests required for preliminary review of materials and for laboratory trial mixtures shall be made by an independent testing laboratory at the expense of Design-Builder. Mixtures shall be adjusted in the field as necessary, within the limits specified, to meet the requirements of these specifications. If the source of any concrete materials is changed during the contract, concrete work shall pause until the new materials and the new mixture design are tested in accordance with the specified requirements.

2-3.01. Preliminary Review of Materials. The tests and reports required shall be as indicated in Table 2A. Review of these reports shall be for general acceptability only, and continued compliance with all contract provisions shall be required.

Aggregate reports shall be no more than 90 days old at time of submittal.

Alkali-aggregate reactivity potential shall be determined by one of the following procedures. A satisfactory service record evaluation as described in ASTM C33 will not be acceptable.

1 Test fine and coarse aggregates in accordance with ASTM C1260. Aggregates which are classified as innocuous may be used without further testing. Aggregates which are not innocuous shall be further tested in accordance with ASTM C227 or C1105 (as appropriate), using a cement containing less than 0.6 percent alkalies.

2 Test fine and coarse aggregates in accordance with ASTM C1567, using a single aggregate with all cementitious materials selected for the Project. The fine and coarse aggregates shall not be combined and used in a single test. This test may only be used for mixtures that contain slag cement or fly ash, and those products shall not have an alkali content greater than 4.0 percent sodium oxide equivalent. Combinations of cementitious materials and aggregate which do not indicate a potential for alkali reactivity may be used without further testing. Mixture combinations which indicate a potential for alkali reactivity shall have the ingredients and/or proportions modified and then the test shall be repeated.

3 Test fine and coarse aggregates in accordance with ASTM C1293. Concrete mixtures containing only portland cement (without pozzolan or slag cement) shall be tested accordingly and have a measured expansion of 0.04 percent or less at one year duration. Concrete mixtures containing pozzolan or slag cement shall be tested with those ingredients in proportions matching that of the proposed mixture, and shall have a measured expansion of 0.04 percent or less at two years duration.

At the discretion of the Structural Engineer of Record, testing in addition to that indicated herein or in Appendix X1 of ASTM C33 may be performed on potentially reactive aggregates. Nonreactive aggregates shall be imported if, in the opinion of the Structural Engineer of Record, local aggregates exhibit unacceptable potential reactivity.

2-3.02. Proposed Mixture Proportions. Proposed proportions for each Class of concrete shall meet the limiting requirements indicated herein.

2-3.03. Mixture Testing. Test results on each Class of concrete shall be submitted for review and shall be acceptable to the Structural Engineer of Record before concrete work is started. The reports shall include the information indicated in Table 2C.

2-3.03.01. Field Test Record Data. If indicated as acceptable in Table 2C, concrete mixtures may be qualified based upon field test record performance data in lieu of laboratory trial mixtures. Field test data records shall be from the production facility being used on the current Project and shall have been performed in the past 12 months. Field test records shall represent a single group of at least 10 consecutive strength tests for one mixture, using the same materials, under the same conditions, and encompassing a period of not less than 45 days.

2-3.03.02. Laboratory Trial Mixture Testing. Trial mixtures shall be tested in the laboratory for each size and combined gradation of aggregates and for each consistency as indicated and intended for use on the work and as specified.

Concrete ingredients shall be measured and mixed in the laboratory. Concrete test specimens shall be made, cured, and stored in accordance with ASTM C192 and tested in accordance with ASTM C39.

Concrete proportions shall be established based on laboratory trial mixtures that meet the following requirements:

a. The combination of materials shall be as proposed for use in the work.

b. Mixtures shall conform with the limiting requirements specified herein.

c. The required average compressive strength, f'_{cr}, of the trial mixture shall exceed the specified minimum acceptable compressive strength, f'_{cr}, as required in Table 1.

d. Trial mixtures of the proportions and consistencies specified for the work shall be prepared. When a three point curve is required by Table 2C, the three concrete trial mixtures shall reflect the cement content proposed for the Project and for the indicated concrete class at three water-cementitious material ratio contents at or lower than indicated in Table 1. The compressive strength of the cylinders made from the three trial mixtures shall produce a range of compressive strengths exceeding or encompassing the f'_{cr} required for the work.

e. For each proposed concrete mixture that is required to be tested as indicated in Table 2C, compressive strength test cylinders shall be made for each testing age. Each change in the water-cementitious materials ratio shall be considered a new concrete mixture. Each mixture shall be tested at the ages of 7 days and 28 days.

f. When a three point curve is required in Table 2C, the results of the cylinder tests for each water-cementitious materials ratio at each age shall be plotted as a curve showing the relationship between compressive strength (along y-axis) and the water-cementitious materials ratio (along x-axis). The water-cementitious materials ratio and the associated average compressive strength for the Project concrete mixture shall be selected from the 28 day curve. The maximum water-cementitious materials ratio specified in the limiting requirements shall still apply even if the curve indicates that the concrete strength would be adequate at a higher ratio. The cement content and mixture proportions to be used shall be such that the selected water-cementitious materials ratio will not be exceeded at specified maximum slump. These concrete mixture proportions shall be submitted for review in accordance with the Submittals Procedures section.

g. When a shrinkage reducing admixture is proposed, trial mixtures shall be prepared with and without the shrinkage reducing admixture.

2-3.03.03. Testing Procedures. Concrete mixture testing procedures shall be as specifier herein, and reports for these tests shall be prepared specifically for this Project.

Aggregates shall be sampled and tested in accordance with ASTM C33. The bulk specific gravity of each aggregate shall be determined in accordance with ASTM C127 and ASTM C128.

Slump shall be determined in accordance with ASTM C143. Unit weight (mass) shall be determined in accordance with ASTM C138. Total air content shall be determined in accordance with ASTM C231 and verified in accordance with ASTM C138. Concrete temperature shall be determined in accordance with ASTM C1064.

Initial set tests shall be made at ambient temperatures of 70°F and 90°F [21°C and 32°C] to determine compliance with the specified time for initial set. The test at 70°F [21°C] shall be made using concrete containing the specified normal set/water-reducing admixture and, when required, air-entraining admixture. The test at 90°F [32°C] shall be made using concrete containing the specified

retarding/water-reducing admixture and, when required, air-entraining admixture. Initial set shall be determined in accordance with ASTM C403.

Cylinders shall be 6 inches [150 mm] diameter by 12 inches [300 mm] high for concrete mixes using a maximum nominal aggregate size of 1 inch [25 mm] or larger. Cylinders may be either 6 inches [150 mm] diameter by 12 inches [300 mm] high, or 4 inches [100 mm] diameter by 8 inches [200 mm] high for concrete mixes using a maximum nominal aggregate size of less than 1 inch [25 mm]. The average compressive strength shall be determined from the results of at least three cylinders when using 4 inch [100 mm] diameter cylinders, and at least two cylinders when using 6 inch [150 mm] diameter cylinders. All tests for a particular class of concrete shall be performed using the same sized cylinders for the duration of the work.

Water-soluble chloride ion shall be determined in accordance with ASTM C1218.

A drying shrinkage test shall be conducted on the trial mixture with the maximum water-cementitious materials ratio used to qualify each proposed concrete mixture design using the concrete materials, including admixtures, that are proposed for the Project. Three test specimens shall be prepared for each test. Drying shrinkage specimens shall be 4 inch by 4 inch by 11 inch [100 by 100 by 275 mm] prisms with an effective gauge length of 10 inches [250 mm], fabricated, cured, dried, and measured in accordance with ASTM C157 except with the following modifications:

Specimens shall be removed from the molds at an age of 23 hours ±1 hour after batching, shall be placed immediately in water at 73°F ±3°F [23°C ±2°C] for at least 30 minutes, and shall be measured within 30 minutes thereafter to determine original length and then submerged in lime-saturated water as specified in ASTM C157. Measurement to determine expansion expressed as a percentage of original length shall be taken at age 7 days. The length at 7 days shall be the base length for drying shrinkage calculations ("zero" days drying age). Specimens then shall be stored immediately in a humidity controlled room maintained at 73°F ±3°F [23°C ±2°C] and 50 percent ±4 percent relative humidity for the remainder of the test. Measurements to determine shrinkage expressed as a percentage of the base length shall be reported separately for 7, 14, and 21 days ±4 hours of drying from "zero" days after 7 days of moist curing for a total of 28 days from the date of casting.

Drying shrinkage deformation for each specimen shall be computed as the difference between the base length (at "zero" days drying age) and the length after drying at each test age. Results of the shrinkage test shall be reported to the nearest 0.001 percent. If drying shrinkage of any specimen deviates from the average for that test age by more than 0.004 percent, the results for that specimen shall be disregarded.

The average drying shrinkage of each set of 4 inch by 4 inch by 11 inch [100 by 100 by 275 mm] test specimens made in the laboratory from a trial mixture shall not exceed the values required in Table 1.

PART 3 – EXECUTION

3-1. BATCHING, MIXING, AND DELIVERY. Concrete shall be furnished by an acceptable ready-mixed concrete supplier, and shall conform to ASTM C94 except as indicated otherwise in this specification.

3-1.01. Delivery Tickets. A delivery ticket shall be prepared for each load of ready-mixed concrete and a copy of the ticket shall be provided by the truck operator at the time of delivery. Tickets shall indicate the name and location of Design-Builder, the project name, the mixture identification, the quantity of concrete delivered, the quantity of each material in the batch, the outdoor temperature in the shade, the time at which the cementitious materials were added, and the numerical sequence of the delivery.

3-1.02. Mixing Water. Mixing water shall not be added in transit. Any amount of water withheld from the truck mixer shall be clearly indicated on the delivery ticket. Water added at the site shall not exceed the amount withheld, and shall not be added without oversight by Owner's on site inspector.

3-1.03. Consistency. The consistency of concrete shall be suitable for the placement conditions. Aggregates shall flow uniformly throughout the mass, and the concrete shall flow sluggishly when vibrated or spaded. The slump shall be kept uniform.

3-2. DESIGN-BUILDER'S ON GOING MATERIAL CONTROL TESTING. The following tests and test reports are required during the progress of the work and shall be made at the expense of Design-Builder. The frequency specified herein for each field control test is approximate and subject to change as determined by the Structural Engineer of Record.

3-2.01. Aggregate Gradation. Each 200 tons [180 Mg] of fine aggregate and each 400 tons [360 Mg] of coarse aggregate shall be sampled and tested in accordance with ASTM D75 and C136, for verification that the gradations continue to meet ASTM C33 requirements. If lesser quantities of aggregates are used, the sampling and testing shall occur at least once every 6 months.

3-2.02. Sand Equivalent. The sand equivalent test shall be conducted each time the sand gradation tests are conducted.

3-2.03. Fly Ash. Each 400 tons [360 Mg] of fly ash shall be sampled and tested in accordance with ASTM C618 and C311. Design-Builder shall supply the Structural Engineer of Record with certified copies of supplier's (source) test reports showing chemical composition and physical analysis for each shipment delivered to Design-Builder and certifying that the fly ash complies with the specifications. The certificate shall be signed by the fly ash supplier.

3-2.04. Cement. Each 1500 tons [1350 Mg] of cement shall be sampled and tested in accordance with ASTM C150. Design-Builder shall supply the Structural Engineer of Record with certified copies of supplier's (source) test reports showing chemical composition and physical analysis, and certifying that the cement complies with ASTM C150 and these specifications. The certificate shall be signed by the cement manufacturer.

3-2.05. Slag Cement. Each 800 tons [720 Mg] of slag cement shall be sampled and tested in accordance with ASTM C989. Design-Builder shall supply the Structural Engineer of Record with certified copies of supplier's (source) test reports showing chemical composition and physical analysis, and certifying that the slag cement complies with ASTM C989 and these specifications. The certificate shall be signed by the slag cement manufacturer.

3-3. OWNER'S FIELD CONTROL TESTING. Field control tests, including slump, air content, and making compression test cylinders, shall be performed by Owner's testing laboratory personnel, at the expense of Owner. Design-Builder shall provide access to all facilities and the services of one or more employees as necessary to assist with the field control testing.

The frequency specified herein for each field control test is approximate and subject to change as determined by the Structural Engineer of Record.

The Structural Engineer of Record may require field testing prior to the addition of superplasticizer at the Site to determine compliance with the specifications. Field testing after the addition of superplasticizer shall be conducted as specified and as needed to determine that the concrete is in compliance with the specifications. Air content tests shall be conducted whenever field tests are conducted.

3-3.01. Slump. A slump test shall be made for each 100 cubic yards [80 m^3] of concrete. Slump shall be determined in accordance with ASTM C143.

3-3.02. Air Content. An air content test shall be made on concrete from one of the first three batches mixed each day and on concrete from each batch of concrete from which concrete compression test cylinders are made. Air content shall be determined in accordance with ASTM C231 and verified in accordance with ASTM C138.

3-3.03. Unit Weight. A unit weight test shall be made on concrete from each batch of concrete from which concrete compression test cylinders are made. Unit weight shall be determined in accordance with ASTM C138.

3-3.04. Concrete Temperature. A concrete temperature test shall be made on concrete from the first batch of concrete mixed each day and on concrete from each batch of concrete from which concrete compression test cylinders are made. During hot or cold weather concreting operations, temperature shall be checked not less than once per hour. Concrete temperature shall be determined in accordance with ASTM C1064.

3-3.05. Water-Soluble Chloride Ion. Water-soluble chloride ion testing shall be performed once for each 1,000 cubic yards [764 m^3] of concrete in accordance with ASTM C1218.

3-3.06. Compression Tests. One set of concrete compression test cylinders shall be made not less than once each day concrete is placed, not less than once for each 100 cubic yards [80 m^3] of each class of concrete, and not less than once for each 5000 square feet [465 m^2] of surface area for slabs or walls. Half of the cylinders of each set shall be tested at an age of 7 days and the remaining cylinders shall be tested at an age of 28 days.

Test cylinders shall be made, cured, stored, and delivered to the laboratory in accordance with ASTM C31 and tested in accordance with ASTM C39.

Cylinders shall be 6 inches [150 mm] diameter by 12 inches [300 mm] high for concrete mixes using a maximum nominal aggregate size of 1 inch [25 mm] or larger. Cylinders may be either 6 inches [150 mm] diameter by 12 inches [300 mm] high, or 4 inches [100 mm] diameter by 8 inches [200 mm] high for concrete mixes using a maximum nominal aggregate size of less than 1 inch [25 mm]. The average compressive strength shall be determined from the results of at least three cylinders when using 4 inch [100 mm] diameter cylinders, and at least two cylinders when using 6 inch [150 mm] diameter cylinders. All tests for a particular mixture class shall be performed using the same sized cylinders for the duration of the work and shall match the cylinder size used for the trial mixtures.

Each set of compression test cylinders shall be marked or tagged with the date and time of day the cylinders were made, the location in the work where the concrete represented by the cylinders was placed, the number of the delivery truck or batch, the air content, the slump, the unit weight, and the concrete temperature.

3-3.07. Shrinkage Tests. Concrete shrinkage tests shall be performed once for each 1,000 cubic yards [764 m^3] of concrete with controlled shrinkage that is placed and shall be made on concrete from a batch of concrete from which concrete compression test cylinders are made. Shrinkage testing shall be conducted as specified for the preliminary trial mixtures.

The average drying shrinkage of each set of test specimens cast in the field from concrete delivered to the Site and sampled at the end of the delivery truck chute, as measured at the 21 days drying age, shall not exceed the values indicated in Table 1.

3-3.08. Test Reports. Five copies of each test report shall be prepared and distributed by the testing laboratory to the Owner, Resident Project Representative (two copies), Structural Engineer of Record, and Design-Builder, in accordance with the Quality Control section.

3-4. EVALUATION AND ACCEPTANCE OF CONCRETE. Concrete will be evaluated for compliance with all requirements of the specifications. Concrete strength will be only one of the criteria used for evaluation and acceptance of the concrete. The results of all tests performed on the concrete and other data and information concerning the procedures for handling, placing, and curing concrete will be used to evaluate the concrete for compliance with the specified requirements.

Compression tests will be evaluated in accordance with ACI 318 and as specified herein. A strength test shall be the average of the compressive strengths of two 6 inch [150 mm] diameter cylinders or three 4 inch [100 mm] diameter cylinders, made from the same concrete sample tested at 28 days.

3-4.01. Compression Test Evaluation. Compressive strength test results will be evaluated for compliance with the specified strength requirements. The strength level of the concrete will be considered satisfactory when the averages of all sets of three consecutive strength tests equal or exceed the specified compressive strength, f'_c, and no individual strength test result falls below the specified compressive strength by more than 500 psi [3.5 MPa].

3-4.02. Inspection of Concrete Supplier. Both scheduled and unscheduled visits by inspectors on days of concrete pours shall be accommodated. Inspectors shall be allowed access to delivery tickets and mixture proportions.

TABLE 1 – LIMITING REQUIREMENTS															
	Concrete Class	**A1**	**A2**	**A3**	**A4**	**A5**	**B**	**C**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
1.	**Minimum Cement Content**, lbs/cubic yard; based on maximum slump and maximum water-cementitious material ratio.														
	Maximum Nominal Aggregate Size, ASTM C33 aggregate														
	Size No. 467 (1-1/2")	---	---	489	---	440	464	---	---	600*	**	---	---	---	380
	Size No. 57 (1")	536	---	514	---	460	489	514	460	620*	**	---	---	---	400
	Size No. 67 (3/4")	564	---	526	---	480	514	526	480	640*	**	---	---	526	420
	Size No. 7 (1/2")	---	601	555	---	500	526	555	500	660*	**	---	584	555	440
	Size No. 8 (3/8")	---	636	564	---	520	555	564	520	680*	**	636	601	564	460
	Fine Aggregate, (Sand)	---	---	---	750	---	---	---	---	---	---	---	---	---	---
2.	**Compressive Strength**, minimum; psi														
	Field, 7 days;	3375	3375	3375	3000	3000	3000	3000	2250	3000	**	3000	3000	3000	1500
	Field, 28 days; f'_c	4500	4500	4500	4000	4000	4000	4000	3000	4000	**	3000	4000	4000	2000
	Laboratory, 28 days; f'_{cr}	5700	5700	5700	5200	5200	5200	5200	3200	5200	**	4200	5200	5200	2000
3.	**Maximum water-cementitious material ratio**	0.42	0.42	0.45	0.45	0.45	0.48	0.45	0.65	0.45	**	0.45	0.45 0.40[a]	0.42	0.75
4.	**Maximum nominal coarse aggregate size, inches**	1	1/2	1-1/2	Sand	1-1/2	1-1/2	1	1	1-1/2	**	3/8	1/2	3/4	1-1/2
5.	**Maximum slump**, inches														

TABLE 1 – LIMITING REQUIREMENTS														
	Concrete Class	**A1**	**A2**	**A3**	**A4**	**A5**	**B**	**C**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
	Slump before super-plasticizer added	3	3	4	6	6	4	3	5	6	**	4	4	4	6
	Slump after adding superplasticizer	8	8	8	8	8	8	8	8	9	**	8	8	8	10
6.	**Total air content**, percent, (± 1.5 %)	6	6	6	6	6	6	6	---	---	**	---	6	6	---
7.	**Fly ash replacement, percent range**	15-25	15-25	15-25	15-25	15-30	15-25	15-25	15-30	15-25	**	15-30	15-35	15-25	15-30
8.	**Slag cement replacement, percent range**	25-50	25-50	25-50	0	25-50	25-30	0	25-50	0	**	0	0	25-50	25-50
9	**Testing limits**														
	Sand equivalent, min. percent	75	75	75	75	75	75	75	---	75	**	75	75	75	---
	Chloride ion, max. percent	0.10	0.10	0.15	0.10	0.30	0.15	0.10	0.30	0.30	**	---	0.15	0.15	---
	Shrinkage, max. percent; based 4 x 4 x 11 inch specimen														
	Laboratory	0.036	0.036	0.048	---	---	0.048	0.048	---	0.048	**	---	---	0.048	---
	Field	0.048	0.048	0.064	---	---	0.064	0.064	---	0.064	**	---	---	0.064	---
	Coarse Aggregate: Clay and shale combined particles shall not exceed, max. percent	1	1	1	1	1	3	2	10	1	**	3	1	2	3

TABLE 1 – LIMITING REQUIREMENTS															
	Concrete Class	**A1**	**A2**	**A3**	**A4**	**A5**	**B**	**C**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
10	**Concrete temperature at time of delivery and placement, max. °F**	85	85	90	85	90	95	85	95	95	**	90	85	85	95

NOTES:
* "D2" (Underwater concrete) - Limit aggregate to 3/4" for reinforced concrete, up to 1-1/2" for unreinforced concrete.
** "D3" (Mass Concrete) limiting requirements shall be as indicated in the Mass Concrete section.
[a] "D5" Wash water trough top edge water-cementitious ratio, 100 percent sand passing No. 8 sieve.

TABLE 2A – SUBMITTAL REQUIREMENTS (PRELIMINARY REVIEW OF MATERIALS)															
	Concrete Class	**A1**	**A2**	**A3**	**A4**	**A5**	**B**	**C**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
1	**Aggregate reports** (ASTM C33)														
	Fine aggregate														
	Source and type	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	---	**X**	**X**	---
	Gradation	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	---	**X**	**X**	---
	Deleterious materials	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	---	**X**	**X**	---
	Fineness modulus	**X**	**X**	**X**	**X**	**X**	**X**	**X**	---	**X**	**	**X**	**X**	**X**	---
	Alkali-aggregate reactivity	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	---	**X**	**X**	**X**
	Sand equivalent	**X**	**X**	**X**	**X**	**X**	**X**	**X**	---	**X**	**	**X**	**X**	**X**	---
	Coarse aggregate														
	Source and type	**X**	**X**	**X**	---	**X**	**X**	**X**	**X**	**X**	**	**X**	**X**	**X**	**X**
	Gradation	**X**	**X**	**X**	---	**X**	**X**	**X**	**X**	**X**	**	**X**	**X**	**X**	**X**

TABLE 2A – SUBMITTAL REQUIREMENTS (PRELIMINARY REVIEW OF MATERIALS)															
	Concrete Class	**A1**	**A2**	**A3**	**A4**	**A5**	**B**	**C**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
	Deleterious materials	**X**	**X**	**X**	---	**X**	**X**	**X**	**X**	**X**	**	**X**	**X**	**X**	---
	Abrasion loss	**X**	**X**	**X**	---	**X**	**X**	**X**	---	**X**	**	---	**X**	**X**	---
	Soundness test	**X**	**X**	**X**	---	**X**	**X**	**X**	---	**X**	**	**X**	**X**	**X**	---
	Alkali-aggregate reactivity	**X**	**X**	**X**	---	**X**	**X**	**X**	**X**	**X**	**	---	**X**	**X**	**X**
	Combined aggregate gradation	**X**	**X**	**X**	---	**X**	**X**	**X**	**X**	---	**	**X**	---	---	---
2	**Cement**, mill report	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	**X**	**X**	**X**	**X**
3	**Cementitious material**, type, data sheet, and test report (fly ash, slag cement)	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	**X**	**X**	**X**	**X**
4	**Admixtures**														
	Data sheets and certifications	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	**X**	**X**	**X**	**X**
	Manufacturer's approval letter	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	**X**	**X**	**X**	**X**

TABLE 2B – SUBMITTAL REQUIREMENTS (PROPOSED MIXTURE PROPORTIONS)															
	Concrete Class	**A1**	**A2**	**A3**	**A4**	**A5**	**B**	**C**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
5	**Mixture proportions**, reports	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**	**X**	**X**	**X**	**X**

TABLE 2C – SUBMITTAL REQUIREMENTS (MIXTURE TESTING)															
	Concrete Class	**A1**	**A2**	**A3**	**A4**	**A5**	**B**	**C**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
6	**Type of testing**														
	Field test records acceptable	---	---	---	---	---	---	---	**X**	---	**	**X**	**X**	**X**	**X**
	Trial mixtures required	**X**	**X**	**X**	**X**	**X**	**X**	**X**	---	**X**	**	---	---	---	---

TABLE 2C – SUBMITTAL REQUIREMENTS (MIXTURE TESTING)															
	Concrete Class	**A1**	**A2**	**A3**	**A4**	**A5**	**B**	**C**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
7	**Test Reports Required**														
	Confirmation of materials tested														
	Cement brand, type, composition, quantity	X	X	X	X	X	X	X	X	X	**	X	X	X	---
	Fly ash brand, type, composition, quantity	X	X	X	X	X	X	X	X	X	**	X	X	X	X
	Specific gravity of each aggregate	X	X	X	X	X	X	X	X	X	**	X	X	X	X
	Ratio of fine to total aggregates	X	X	X	---	X	X	X	---	---	**	---	X	X	---
	Water content	X	X	X	X	X	X	X	X	X	**	X	X	X	---
	Water-cementitious materials ratio	X	X	X	X	X	X	X	X	X	**	X	X	X	---
	Slump	X	X	X	X	X	X	X	---	X	**	X	X	X	---
	Unit weight	X	X	X	---	X	X	X	---	X	**	---	X	X	---
	Air content	X	X	X	---	X	X	X	---	---	**	---	X	X	---
	Temperature	X	X	X	X	X	X	X	---	X	**	---	---	---	---
	Time of initial set at 70°F and 90°F.	X	X	X	X	X	X	X	---	X	**	---	---	---	---
	Three point curves	X	X	X	---	---	---	X	---	X	**	---	---	---	---
	Compressive strength at 7 and 28 days	X	X	X	X	X	X	X	X	X	**	X	X	X	X
	Water-soluble chloride ion	X	X	X	X	X	X	X	X	X	**	---	X	X	---
	Drying shrinkage	X	X	X	---	---	X	X	---	X	**	---	---	X	---

NOTES:
** "D3" (Mass Concrete) submittal requirements shall be as indicated in the Mass Concrete section.

End of Section

Section 03 30 13

CONCRETE PLACING

PART 1 – GENERAL

1-1. SCOPE. This section covers placing of cast-in-place concrete.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values in inch-pound units govern.

1-2. GENERAL. All cast-in-place concrete shall be properly placed as indicated on the Drawings and as specified herein.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. All submittals of test data, manufacturers' certificates of compliance, reports, catalog data sheets and other data shall be in accordance with the Submittals Procedures section.

1-3.02. Manufacturer's Certificate of Compliance. A manufacturer's certificate of compliance, which includes the name of the project and, when requested, copies of independent test results confirming compliance with specified requirements, shall be submitted to the Structural Engineer of Record for the following materials:

Epoxy bonding agent.

1-3.03. Lift Drawings. Concrete lift drawings shall be submitted in accordance with the Submittals Procedures section. Content of the lift drawings shall include, but not be limited to, the following.

Construction joint locations and pour sequences.

Concrete dimensions, joint details, and location of embedded items required by electrical, mechanical, and electrical design.

A bill of materials indicating all items to be included in each placement. The bill of materials shall list descriptions, quantities, weights, and other relevant information such as tag numbers or purchase order numbers for specialty items.

Location of any blockouts required where needed to work around late delivery of items to be embedded.

PART 2 - PRODUCTS

2-1. LIMITING REQUIREMENTS. Concrete shall be handled and placed in a manner that will minimize shrinkage and cracking as specified herein. Concrete temperatures shall be controlled both before and after placement to minimize cracking.

2-2. MATERIALS.

Epoxy Bonding Agent	ASTM C881, Type V, moisture insensitive, 100 percent solids; Dayton Superior “Sure Bond J58”, Euclid "Euco #452", or Prime Resins “Prime Bond 3000”.

2-3. ARCHITECTURAL CONCRETE. Not used.

PART 3 - EXECUTION

3-1. RECEIVING. Design-Builder shall check each delivery ticket to verify the concrete class delivered to the jobsite is in compliance with the concrete requested and is suitable for Design-Builder's handling, placing, finishing, and curing procedures. Owner’s Representative will collect the delivery tickets from the truck operator.

3-2. PLACEMENT. The limits of each concrete pour shall be determined by Design-Builder and shall be acceptable to the Structural Engineer of Record. All concrete within the predetermined limits shall be placed in one continuous operation.

Before concrete is placed, forms, reinforcement, water stops, anchor bolts, and embedments shall be rigidly secured in proper position; all dirt, mud, water, and debris shall be removed from the space to be occupied by concrete; all surfaces encrusted with dried concrete from previous placements shall be cleaned; and the entire installation shall be acceptable to the Structural Engineer of Record. Remove all frost, ice, and snow from within the formwork before concrete is placed.

Design-Builder shall inform the Structural Engineer of Record at least 48 hours in advance of any concrete placement.

3-2.01. Bonding to Hardened Concrete. The surface of hardened concrete upon which fresh concrete is to be placed shall be rough, clean, sound, and damp. Before placement of plastic concrete, the hardened surface shall be cleaned of all laitance and foreign substances (including curing compound), washed with clean water, wetted thoroughly, and the surface made free of standing water.

Surface profile of the hardened concrete after surface preparation shall be as required for good bond.

Coarse aggregate shall be omitted from the first batch or batches of concrete placed on hardened concrete in wall or column forms. The mortar puddle, Class A4 concrete, shall cover the hardened concrete by at least 2 inches [50 mm] at every point.

3-2.02. Conveying Concrete. Methods of conveying concrete to the point of final deposit shall prevent segregation or loss of ingredients. After placement in the forms, concrete shall not be moved laterally more than 5 feet [1500 mm]. Concrete's free fall should not exceed 4 feet [1200 mm].

3-2.03. Pumping Concrete. The slump of concrete, with or without a superplasticizer, which is discharged into the pump may exceed the specified maximum slump value by the amount of slump loss in the pumping system, up to a maximum of 1 inch [25 mm]. The slump loss shall be determined by tests made at each end of the pumping system. If tests indicate a slump loss greater than 1 inch [25 mm] in the pumping system, Design-Builder shall modify the pumping system as required to reduce the slump loss to 1 inch [25 mm] or less.

3-2.04. Placing Concrete. For proper compaction, concrete shall be placed in approximately horizontal layers not to exceed 24 inches [600 mm]. Each layer of concrete shall be plastic when covered with the following layer, and the rate of vertical rise of the concrete in the forms shall not be less than 24 inches [600 mm] per hour. Vertical construction joints shall be provided as necessary to comply with these requirements.

Concrete shall be placed and compacted in wall or column forms before any reinforcement is placed in the system to be supported by such walls or columns. The height of any portion of a wall or column placed monolithically with a floor or roof slab shall not exceed 6 feet [1800 mm]. Concrete in walls or columns shall be in place at least 2 hours before concrete is placed in the structural systems to be supported by such walls or columns.

Concrete shall be thoroughly settled in wall forms before top finishing. All laitance, debris, and surplus water shall be removed from concrete surfaces at tops of forms by screeding, scraping, or other effective means. Wherever the top of a wall will be exposed to weathering, the forms shall be overfilled and after the concrete has settled, the excess shall be screeded off.

Concrete for piers or caissons shall be carefully deposited to avoid contact with forms, reinforcement, and earth sides until completion of the drop. Necessary precautions shall be taken during concrete placement to prevent earth or other material from falling into excavations and to avoid dislocation of reinforcement. Concrete shall be placed continuously to the top of each pier or caisson at a rate of not less than 2 feet [600 mm] of vertical rise per hour. Forms above grade

shall be of cylindrical steel or fiber acceptable to the Structural Engineer of Record.

3-2.05. Compaction. During and immediately after placement, concrete shall be thoroughly compacted and worked around all reinforcement and embedments and into the corners of the forms. Mechanical vibrators shall maintain at least 14,000 cycles per minute when immersed in the concrete. The number and type of vibrators shall be acceptable to the Structural Engineer of Record. The use of "jitterbug" tampers to compact concrete flatwork will not be permitted.

3-2.06. Cold Weather Concreting. Except as modified herein, cold weather concreting shall comply with ACI 306.1.

Massive embedded items identified on the drawings shall be above 32°F [0°C] when the concrete is placed.

When placed, heated concrete shall not be warmer than 80°F [26°C].

3-2.07. Hot Weather Concreting. Except as modified herein, hot weather concreting shall comply with ACI 305.1.

At air temperatures of 90°F [32°C] or above, concrete shall be kept as cool as practicable during placement. The temperature of the concrete when placed in the work shall not exceed the values indicated in the Cast-in-Place Concrete section.

Plastic shrinkage cracking due to rapid evaporation of moisture shall be prevented. Concrete shall not be placed when the evaporation rate (actual or anticipated) equals or exceeds 0.2 lb per square foot per hour [1 kg/m^2/h], as determined using the nomograph in Appendix A of ACI 305.1.

3-2.08. Placement Sequence. To minimize the effect of shrinkage in producing cracks, the following structures shall be constructed using a placement sequence:

a. Treatment Area (BNR Basins and MBR System)
b. Residuals Area (Sludge Holding and SAFE Settle Tanks)

For these structures, concrete shall be placed as follows:

a. Bottom Slab. Each bottom slab shall be divided into sections by the construction joints indicated on the Drawings and, when not indicated on the Drawings, into approximately square sections not greater than 60 feet [18 m] in their longest dimension. Bottom slabs with radial and circumferential reinforcement patterns may be divided into pie-shaped segments with the longest dimension not greater than 60 feet [18 m]. A section near the center of each

structure shall be placed first. Sections shall be placed alternately, first on one side and then on the other side of previously placed sections. Placement shall be scheduled so that two adjacent sides of each section are free, except at closures.

b. Walls. Walls shall be divided into sections by the construction joints indicated on the Drawings and, when not indicated on the Drawings, into sections not greater than 60 feet [18 m] in length. A section near the center of each wall shall be placed first. Sections shall be placed alternately, first on one side and then on the other side of the previously placed section. Placement shall be scheduled so that one end of each section is free, except at corner closures.

c. Top Slab. Each top slab shall be placed in the manner described for the bottom slab.

No two abutting sections shall be placed within a period of 48 hours, unless otherwise authorized by the Structural Engineer of Record.

3-2.09. Duct Banks. Duct bank concrete shall be compacted by rodding or spading only. Mechanical vibrators shall not be used. Concrete shall be worked around reinforcement and embedments and into the corners of the forms.

3-3. PAN STAIRS. Not used.

3-4. COMPOSITE TOPPING CONCRETE. Composite topping concrete (Class D6) shall be placed in the locations indicated on the Drawings.

3-4.01. Surface Preparation. Before topping is applied, the underlying hardened concrete surface shall be scrubbed clean. Grease or oil shall be completely removed by cleaning the surface in accordance with ASTM D4258 and abrading the surface in accordance with ASTM D4259 by chipping or grinding. The cleaned surface shall be rinsed with clean water and kept saturated for the 24 hour period immediately preceding the application of topping. Immediately before topping is applied, the hardened concrete shall be coated with epoxy bonding agent or with neat portland cement slurry having the consistency of paint.

3-4.02. Composite Topping. Composite topping concrete shall be applied over the precast or cast-in-place concrete roof areas indicated on the Drawings. Topping shall be spread and compacted with suitable concrete tools. Topping shall be accurately placed to the elevations and slopes indicated.

3-5. CLEANING EMBEDMENTS. Embedments shall be clean when installed.

End of Section

Section 03 35 00

CONCRETE FINISHING

PART 1 – GENERAL

1-1. SCOPE. This section covers finishing of cast-in-place concrete.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values in inch-pound units govern.

1-2. GENERAL. All cast-in-place concrete shall be properly finished as indicated on the Drawings and as specified herein.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. All submittals of test data, manufacturers' certificates of compliance, reports, catalog data sheets and other data shall be in accordance with the Submittals Procedures section.

1-3.02. Manufacturer's Certificate of Compliance. A manufacturer's certificate of compliance, which includes the name of the project and, when requested, copies of independent test results confirming compliance with specified requirements, shall be submitted for the following materials:

Floor sealer.

PART 2 - PRODUCTS

2-1. MATERIALS.

Concrete Surface Coloring/Hardener	Mineral aggregate dry-shake colored hardener for concrete flatwork. ChemSystems, Inc. “CSI Heavy-Duty Color Hardener”, Euclid “Surflex”, or Dayton Superior “Quartz Tuff”.
Evaporation Reducer	Dayton Superior "AquaFilm Concentrate J74", Euclid "Eucobar", L&M Chemical "E-Con", BASF "MasterKure ER50", or Sika "SikaFilm".

Nonslip Aggregate	Aluminum oxide aggregate, L&M Chemical "Grip It", BASF "MasterTop 120SR", or Dayton Superior “Emery Non-Slip”.
Floor Sealer	ASTM C1315, Type I, Class A, minimum 25 percent solids, acrylic, non-yellowing, unit moisture loss 0.40 kg/m^2 maximum in 72 hours. Product shall not exceed VOC limits established by the federal, state, or local regulatory agency having jurisdiction over the project site.

PART 3 - EXECUTION

3-1. FINISHING UNFORMED SURFACES. Buried and permanently submerged concrete blocking and encasement will require no finishing except as necessary to obtain the required surface elevations or contours. The unformed surfaces of all other concrete shall be screeded and given an initial float finish followed by additional floating, and troweling where required.

3-1.01. Screeding. Screeding shall produce a concrete surface conforming to the proper elevation and contour, with all aggregates completely embedded in mortar.

3-1.02. Application of Evaporation Reducer. Concrete flatwork subject to rapid evaporation due to hot weather, drying winds, and sunlight shall be protected with an evaporation reducer. The evaporation reducer shall form a continuous film on the surface of fresh, plastic concrete to reduce evaporation.

Immediately following screeding, evaporation reducer shall be sprayed over the entire surface of fresh, plastic concrete flatwork at a rate of not less than 200 square feet per gallon [4 m^2/L], in accordance with the manufacturer's recommendations. The spray equipment shall have sufficient capacity to continuously spray the product at approximately 40 psi [275 kPa] with a suitable nozzle as recommended by the manufacturer.

The sprayable solution shall be prepared as recommended by the manufacturer.

Under severe drying conditions, additional applications of evaporation reducer may be required following each floating or troweling, except the last finishing operation.

3-1.03. Floating. Screeded surfaces shall be given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse

aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a finish of uniform texture and color, and unless additional finishing is specifically required, shall produce the completed finish for unformed surfaces.

Floating shall be done with hand floats or suitable mechanical compactor-floats.

3-1.04. Finishing Surfaces for Bonding. All surfaces to be covered with concrete or topping shall be float finished. All laitance, surface mortar, and unsound material shall be removed by brushing or air blasting at the time of initial set. Surfaces shall be rough, clean, and sound. Floors and other flat surfaces to receive composite topping (Class D6) shall be given a broom finish or raked finish with at least a 1/4 inch profile.

3-1.05. Troweling. Interior floor surfaces which will be exposed after construction is completed; surfaces to be covered with resilient floor coverings, thinset terrazzo, or seamless floor covering; exposed top surfaces of equipment bases and interior curbs; and other surfaces designated on the Drawings shall be steel trowel finished. Surfaces to be covered with elastomeric deck covering shall be lightly troweled but not burnished. Trowel finishing will not be required for floors which are normally submerged. Troweling shall be performed after the second floating when the surface has hardened sufficiently to prevent an excess of fines being drawn to the surface. Troweling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

3-1.06. Edging. Unless specified to be beveled, exposed edges of floated or troweled surfaces shall be edged with a tool having at least a 1/8 inch [3 mm] corner radius.

3-1.07 Broom Finish. Concrete surfaces indicated below shall be given a light broom finish to produce a nonslip surface. Brooming shall be done after the second floating and at right angles to the normal direction of traffic.

Broom finish shall be provided at the following locations:

a. exterior docks
b. exterior stairs

3-1.08. Nonslip Aggregate Finish. Tread surfaces of indicated stairs shall be surfaced with nonslip aluminum oxide aggregate. Aggregate shall be uniformly distributed during steel troweling at the rate of 1/4 lb per square foot, in accordance with the manufacturer's recommendations and as acceptable to Design-Builder.

Nonslip aggregate finish shall be provided at the following locations:

a. TBD

3-1.09. Pavement Finishing. The surface of pavements shall not vary more than 1/8 inch [3 mm] under a 10 foot [3 m] straightedge placed parallel to the center line.

Following placement and consolidation, and the disappearance of bleed water, the concrete surface shall be drag finished, using a seamless strip of damp burlap over the full width of the surface. The burlap drag shall consist of sufficient layers of burlap and shall have sufficient length in contact with the concrete to slightly groove the surface. The drag shall be moved forward with a minimum bow of the lead edge. The drag shall be kept damp, clean, and free of particles of hardened concrete. When acceptable to Design-Builder, carpet, artificial turf, or cotton fabric may also be used.

Following placement and consolidation, and the disappearance of bleed water, the concrete surface shall be broom finished with a broom acceptable to Design-Builder. The broom shall be not less than 18 inches [460 mm] wide and made from good quality bass or bassine fibers not more than 5 inches [125 mm] long. The broom finishing shall produce regular corrugations not over 1/8 inch [3 mm] deep. The broom shall be pulled square across the surface, from edge to edge, with adjacent strokes slightly overlapped, and shall not tear the concrete surface.

3-1.10. Curb and Gutter Finishing. Curb and gutter shall be finished to the shape indicated on the Drawings. After the forms have been removed, all exposed edges shall be rounded, using an edging tool with at least a 1/8 inch [3 mm] corner radius. Exposed surfaces shall be float finished and given a light broom finish applied at right angles to the curb at the time of initial set, using a horsehair type broom.

3-1.11. Sidewalk Finishing. Concrete surfaces shall be screeded to the proper elevation and contour. All aggregates shall be completely embedded in mortar. Screeded surfaces shall be given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be

removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface. Initial floating shall be followed by a second floating at the time of initial set.

Floated surfaces shall be given a light broom finish, using a horsehair broom, to provide a nonslip surface. Brooming shall be done at right angles to the length of the walk.

Sidewalks shall be edged using a 3 or 4 inch [75 or 100 mm] wide edging tool with a 1/8 inch [3 mm] corner radius. Edger lap marks at corners of each slab shall be carefully removed. False joints shall be provided at right angles to the length of the walk, using a grooving tool with 1/8 inch [3 mm] radius. The finished edge on each side of the joint shall be the same width as the edging tool used. False joints shall divide each sidewalk into square sections.

The finished surface of all sidewalks shall be neat in appearance, shall be sloped to drain, and shall not pond water.

3-2. CONCRETE SURFACE COLORING/HARDENER. Where concrete surface coloring/hardener is required, a dry-shake coloring material shall be worked into the freshly screeded concrete surface.

3-2.01. Duct Bank Finishing. After screeding and before final floating, a red concrete surface coloring shall be dusted onto the fresh concrete surface at the rate recommended by the manufacturer.

3-2.02. Floor Finishing. Where concrete surface coloring/hardener is required on the Drawings, the coloring material shall be applied at the rate of 50 lbs per 100 square feet [244 kg/100 m^2] in strict accordance with the manufacturer's recommendations. The color of the concrete surface shall be as required on the Drawings.

Concrete floors with surface coloring shall be protected from damage until acceptance by Design-Builder. Areas which are subject to traffic or over which equipment or materials are to be moved shall be covered with hardboard or plywood. Just before final inspection, the colored floors shall be thoroughly cleaned and then waxed with colored wax furnished by the manufacturer of the coloring material.

3-3. MINERAL COLORED CONCRETE. Floors and walls that have colored concrete shall be protected from damage until accepted by Design-Builder. Areas which are subject to traffic or over which equipment or materials are to be moved shall be covered with hardboard or plywood. Just before final inspection, the floors shall be thoroughly cleaned and then sealed with liquid floor sealer. Walls that have colored concrete shall receive a brush-blasted finish.

3-4. FLOOR SEALER. All concrete floors in interior locations which are to remain as exposed concrete or will be covered with carpet shall be given two coats of clear floor sealer in addition to any which may have been applied as a membrane curing compound. Floor sealer shall not be applied to concrete floors that are to be stained or etched, covered with chemical resistant linings, covered with additional concrete, or indicated in the Architectural drawings to be covered with a finish flooring material. Prior to application of each coat of sealer, the floor shall be thoroughly cleaned of dirt, grease, and other foreign matter. The first coat shall be applied at the end of the curing period and before any traffic is permitted on the floor. The second coat shall be applied in preparation for substantial completion of the work. Floor sealer shall be applied in accordance with the manufacturer's recommendations.

3-5. REPAIRING DEFECTIVE CONCRETE. Defective concrete shall be defined as any surface with undesirable visible effects in excess of that permitted by the relevant formed concrete surface category (CSC), except as indicated otherwise herein.

Defects in formed concrete surfaces shall be repaired to the satisfaction of the Structural Engineer of Record within 24 hours of form removal. Surface repair work shall conform to Article 5.3.7 of ACI 301 and shall be performed in a manner that will not interfere with thorough curing of the surrounding concrete. Surface repair material shall be adequately cured.

Defects in concrete that are more than 3 inches deep shall be brought to the attention of the Structural Engineer of Record prior to any repair work. Design-Builder shall submit a proposed repair material and procedure for review by the Structural Engineer of Record. The repair material and procedure required by the Structural Engineer of Record may be more extensive than the process described in Article 5.3.7 of ACI 301.

3-6. FINISHING FORMED SURFACES. Formed concrete surfaces shall meet all criteria of the relevant formed concrete surface category (CSC), as defined in ACI 347.3R, except as indicated otherwise herein. Surfaces shall be assigned to CSC's as indicated.

Formed Concrete Surface Category	Applicable Surfaces	Mockup Required
CSC1	Formed concrete surfaces that will be in permanent contact with earth backfill.	No
CSC2	All other formed concrete surfaces not designated otherwise.	No

CSC3	None.	Yes
CSC4	None.	Yes

3-6.01. Tie Holes. All tie holes in formed surfaces, regardless of the relevant CSC, shall be cleaned, wetted, and filled with patching mortar. The patches shall be finished flush and cured and shall match the texture and color of the adjacent concrete.

3-6.02. Mockups. Not used.Not used.

3-6.03. Grout Cleaning. The surfaces noted on the Drawings shall be finished by grout cleaning.

Grout-cleaned finish shall conform to Paragraph 5.3.3.4.b of ACI 301. Grout cleaning shall not result in an overall plastering of the concrete surfaces, but shall produce a smooth, uniform surface free of marks, voids, surface glaze, and cement dust.

3-7. TOLERANCES. Tolerances for cast-in-place concrete work shall be as stipulated in ACI 117, unless otherwise indicated.

3-7.02. Ringwall Tolerances. The top of the foundation ringwall for each steel reservoir shall be accurately constructed within the following tolerances:

a. In any 30 foot [9,000 mm] length, the top of the wall shall not vary from level by more than 1/4 inch [6 mm] peak to valley.

b. No two points on the top of the wall shall differ in elevation by more than 1/2 inch [12.5 mm].

Levels will be checked on the top of the foundation wall, and any variations exceeding the specified tolerances shall be corrected prior to erection of the reservoir.

3-8. CONCRETE WASH WATER TROUGHS. Not used.

3-9. PAN STAIRS. Pan stair treads and landings shall be given a nonslip finish.

After the concrete has hardened, all droppings and dust shall be removed from the adjacent areas, and the work shall be left clean and suitable for painting.

3-10. COMPOSITE TOPPING CONCRETE. Composite topping shall be screeded and floated with suitable concrete tools. Topping shall be given a float finish.

3-11. CLEANING EMBEDMENTS. After placement of concrete, surfaces of embedments not in contact with concrete shall be cleaned of concrete spatter and other foreign substances.

End of Section

Section 03 39 00

CONCRETE CURING

PART 1 – GENERAL

1-1. SCOPE. This section covers curing of cast-in-place concrete.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values in inch-pound units govern.

1-2. GENERAL. All cast-in-place concrete shall be properly cured as indicated on the Drawings and as specified herein.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. All submittals of test data, manufacturers' certificates of compliance, reports, catalog data sheets and other data shall be in accordance with the Submittals Procedures section.

1-3.02. Manufacturer's Certificate of Compliance. A manufacturer's certificate of compliance, which includes the name of the project and, when requested, copies of independent test results confirming compliance with specified requirements, shall be submitted to for the following materials:

Membrane curing compound.

PART 2 - PRODUCTS

2-1. LIMITING REQUIREMENTS. Concrete shall be cured in a manner that will minimize shrinkage and cracking as specified herein.

2-2. MATERIALS.

Membrane Curing Compound	ASTM C1315, Type I, Class A, minimum 25 percent solids, acrylic, non-yellowing, unit moisture loss 0.40 kg/m^2 maximum in 72 hours. Product shall not exceed VOC limits established by the federal, state, or local regulatory agency having jurisdiction over the project site.

PART 3 - EXECUTION

3-1. GENERAL.

3-1.01. Cold Weather Concreting. Except as modified herein, cold weather concreting shall comply with ACI 306.1.

The concrete surface shall be maintained at a temperature of at least 50°F [10°C] for 5 days or 70°F [21°C] for 3 days, after placement. Concrete temperature shall be recorded at least six times for each 24 hour period. Concrete and adjacent form surfaces shall be kept continuously moist. Sudden cooling of concrete shall not be permitted.

3-1.02. Hot Weather Concreting. Except as modified herein, hot weather concreting shall comply with ACI 305.1.

At air temperatures of 90°F [32°C] or above, concrete shall be kept as cool as practicable during curing.

Plastic shrinkage cracking due to rapid evaporation of moisture shall be prevented.

3-2. CURING. Concrete shall be protected from loss of moisture for at least 7 days after placement unless indicated otherwise. Curing of concrete shall be done by methods which will keep the concrete surfaces adequately wet for the specified curing period.

3-2.01. Water Curing. Water curing shall be performed for concrete in liquid-containing structures and for all concrete containing slag cement. Other forms of curing will not be acceptable in these applications. Water curing shall be in accordance with ACI 308.1 except as modified herein.

Water saturation of concrete surfaces shall begin as soon as possible after initial set. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water to walls may be interrupted for grout cleaning only over the areas being cleaned at the time, and the concrete surface shall not be permitted to become dry during such interruption.

Water curing shall continue for 14 days for concrete containing slag cement, and for 7 days for other types of concrete. However, when concrete is being protected from low temperatures, the duration of water curing may be shortened to 1 day less than the duration of cold weather protection.

When forms are removed before the specified curing duration is completed, measures shall be taken to immediately continue water curing and to provide adequate thermal protection for the concrete.

3-2.02. Membrane Curing. Unless otherwise specified, membrane curing compound may be used instead of water curing on concrete in non-liquid-containing structures which will not be stained or etched, covered with chemical resistant linings, covered with additional concrete, or indicated in the Architectural drawings to be covered with a finish flooring material.

Membrane curing compound shall be evenly sprayed at a coverage rate of not more than 300 square feet per gallon [7.3 m^2/L]. The spray equipment shall have sufficient capacity to continuously spray curing compound at approximately 40 psi [275 kPa] with a suitable nozzle as recommended by the manufacturer. Unformed surfaces shall be covered with the first coat of curing compound within 30 minutes after final finishing. A second coat of curing compound shall be applied when the first coat has become tacky to the touch and shall be applied at right angles to the first coat.

Curing compound shall be suitably protected against abrasion during the curing period.

3-2.03. Film Curing. Unless otherwise specified, film curing with white polyethylene sheeting may be used instead of water curing on concrete in non-liquid-containing structures which will be covered later with mortar or additional concrete, or which will otherwise not be exposed to view.

Film curing shall begin as soon as possible after initial set of the concrete. The concrete surfaces shall be completely covered with polyethylene sheeting. Sheeting shall overlap the edges of the concrete for proper sealing and anchorage, and joints between sheets shall be sealed. All tears, holes, and other damage shall be promptly repaired. Covering shall be anchored continuously at edges and as necessary to prevent billowing on the surface.

End of Section

Section 05 40 00

COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions section, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Load-bearing wall framing.
2.
3. Interior non-load-bearing wall framing exceeding height limitations of standard, nonstructural metal framing.
4.
5. Ceiling joist framing.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for miscellaneous steel shapes, and connections used with cold-formed metal framing.
2. Section 092116.23 "Gypsum Board Shaft Wall Assemblies" for interior non-load-bearing, metal-stud-framed, shaft-wall assemblies, with height limitations.
3. Section 092216 "Non-Structural Metal Framing" for standard, interior non-load-bearing, metal-stud framing, with height limitations and ceiling-suspension assemblies.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layout, spacings, sizes, thicknesses, and types of cold-formed steel framing; fabrication; and fastening and anchorage details, including mechanical fasteners.
2. Indicate reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachment to adjoining work.

C. Delegated-Design Submittal: For cold-formed steel framing.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Welding certificates.

C. Product Certificates: For each type of code-compliance certification for studs and tracks.

D. Product Test Reports: For each listed product, for tests performed by a qualified testing agency.

1. Steel sheet.
2. Expansion anchors.
3. Power-actuated anchors.
4. Mechanical fasteners.
5. Vertical deflection clips.
6. Horizontal drift deflection clips
7. Miscellaneous structural clips and accessories.

E. Evaluation Reports: For nonstandard cold-formed steel framing, post-installed anchors and power-actuated fasteners, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

B. Product Tests: Mill certificates or data from a qualified independent testing agency indicating steel sheet complies with requirements, including base-metal thickness, yield strength, tensile strength, total elongation, chemical requirements, and metallic-coating thickness.

C. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Steel Stud Manufacturers Association.

D. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Consolidated Fabricators, Corp.

B. Approved equal.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, registered in California, to design cold-formed steel framing.

B. Structural Performance: Provide cold-formed steel framing capable of withstanding design loads within limits and under conditions indicated.

1. Design Loads: As required for the imposed loads and in no case less than Code minimums.
2. Deflection Limits: Design framing systems to withstand design loads without deflections greater than the following:

a.
b. Interior Load-Bearing Wall Framing: Horizontal deflection of 1/240 of the wall height under a horizontal load of 5 lbf/sq. ft..
c.
d. Interior Non-Load-Bearing Framing: Horizontal deflection of 1/240 of the wall height under a horizontal load of 5 lbf/sq. ft..
e.
f. Ceiling Joist Framing: Vertical deflection of 1/240 of the span for live loads and 1/240 for total loads of the span.

3. Design framing systems to provide for movement of framing members located outside the insulated building envelope without damage or overstressing, sheathing failure, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change of 120 deg F.
4. Design framing system to maintain clearances at openings, to allow for construction tolerances, and to accommodate live load deflection of primary building structure as follows:

a. Upward and downward movement of 1 inch.

5. Design exterior non-load-bearing wall framing to accommodate horizontal deflection without regard for contribution of sheathing materials.

C. Cold-Formed Steel Framing Standards: Unless more stringent requirements are indicated, framing shall comply with AISI S100, AISI S200, and the following:

1. Floor and Roof Systems: AISI S210.
2. Wall Studs: AISI S211.
3. Headers: AISI S212.
4. Lateral Design: AISI S213.

D. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency acceptable to authorities having jurisdiction.

2.3 COLD-FORMED STEEL FRAMING MATERIALS

A. Steel Sheet: ASTM A1003, Structural Grade, Type H, metallic coated, of grade and coating designation as follows:

1. Grade: As required by structural performance.
2. Coating: G90 or equivalent.

B. Steel Sheet for Vertical Deflection or Drift Clips: ASTM A653, structural steel, zinc coated, of grade and coating as follows:

1. Grade: As required by structural performance.
2. Coating: G90.

2.4 LOAD-BEARING WALL FRAMING

A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:

1. Minimum Base-Metal Thickness: 0.0329 inch.
2. Flange Width: 1-5/8 inches.

B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with straight flanges, and as follows:

1. Minimum Base-Metal Thickness: Matching steel studs.

2. Flange Width: 1-1/4 inches.

C. Steel Box or Back-to-Back Headers: Manufacturer's standard C-shapes used to form header beams, of web depths indicated, unpunched, with stiffened flanges, and as follows:

1. Minimum Base-Metal Thickness: 0.0329 inch.
2. Flange Width: 1-5/8 inches.
3.
4.

2.5 INTERIOR NON-LOAD-BEARING WALL FRAMING

A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:

1. Minimum Base-Metal Thickness: 0.0329 inch.
2. Flange Width: 1-5/8 inches.
3.

B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with unstiffened flanges, and as follows:

1. Minimum Base-Metal Thickness: Matching steel studs.
2. Flange Width: 1-1/4 inches.

C. Vertical Deflection Clips: Manufacturer's standard bypass or head clips, capable of accommodating upward and downward vertical displacement of primary structure through positive mechanical attachment to stud web.

1. Simpson Strong-Tie Co., Inc.

2. Approved equal.

D. Single Deflection Track: Manufacturer's single, deep-leg, U-shaped steel track; unpunched, with unstiffened flanges, of web depth to contain studs while allowing free vertical movement, with flanges designed to support horizontal loads and transfer them to the primary structure, and as follows:

1. Minimum Base-Metal Thickness: 0.0428 inch.
2. Flange Width: 1 inch plus the design gap for one-story structures and 1 inch plus twice the design gap for other applications.

E. Double Deflection Tracks: Manufacturer's double, deep-leg, U-shaped steel tracks, consisting of nested inner and outer tracks; unpunched, with unstiffened flanges.

1. Outer Track: Of web depth to allow free vertical movement of inner track, with flanges designed to support horizontal loads and transfer them to the primary structure, and as follows:

    a. Minimum Base-Metal Thickness: 0.0428 inch.
    b. Flange Width: 1 inch plus the design gap for one-story structures and 1 inch plus twice the design gap for other applications.

2. Inner Track: Of web depth indicated, and as follows:

    a. Minimum Base-Metal Thickness: 0.0428 inch.
    b. Flange Width: Sum of outer deflection track flange width plus 1 inch.

F. Drift Clips: Manufacturer's standard bypass or head clips, capable of isolating wall stud from upward and downward vertical displacement and lateral drift of primary structure through positive mechanical attachment to stud web and structure.

2.6 CEILING JOIST FRAMING

A. Steel Ceiling Joists: Manufacturer's standard C-shaped steel sections, of web depths indicated, unpunched, with stiffened flanges, and as follows:

1. Minimum Base-Metal Thickness: 0.0329 inch.
2. Flange Width: 1-5/8 inches, minimum.
3.

2.7 FRAMING ACCESSORIES

A. Fabricate steel-framing accessories from ASTM A1003, Structural Grade, Type H, metallic coated steel sheet, of same grade and coating designation used for framing members.

B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:

1. Supplementary framing.
2. Bracing, bridging, and solid blocking.
3. Web stiffeners.
4. Anchor clips.
5. End clips.
6. Foundation clips.
7. Gusset plates.
8. Stud kickers and knee braces.
9. Joist hangers and end closures.
10. Hole-reinforcing plates.

11. Backer plates.

2.8 ANCHORS, CLIPS, AND FASTENERS

A. Steel Shapes and Clips: ASTM A36, zinc coated by hot-dip process according to ASTM A123.

B. Anchor Bolts: As indicated in the Anchorage in Concrete and Masonry section.

C. Post-Installed Anchors: As indicated in the Anchorage in Concrete and Masonry section.

1. Uses: Securing cold-formed steel framing to structure.
2. Type: Expansion or adhesive anchors.
3. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941, Class Fe/Zn 5, unless otherwise indicated.
4. Material for Exterior or Interior Locations and Where Stainless Steel Is Indicated: Alloy Group 2 stainless-steel bolts, ASTM F593, and nuts, ASTM F594.

D. Power-Actuated Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

E. Mechanical Fasteners: ASTM C1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.

1. Head Type: Low-profile head beneath sheathing; manufacturer's standard elsewhere.

F. Welding Electrodes: Comply with AWS standards.

2.9 MISCELLANEOUS MATERIALS

A. Galvanizing Repair Paint: ASTM A780.

B. Cement Grout: Portland cement, ASTM C150, Type I; and clean, natural sand, ASTM C404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.

C. Nonmetallic, Nonshrink Grout: As indicated in the Grouting section, and with a fluid consistency and 30-minute working time.

D. Shims: Load-bearing, high-density, multimonomer, nonleaching plastic; or cold-formed steel of same grade and metallic coating as framing members supported by shims.

E. Sealer Gaskets: Closed-cell neoprene foam, 1/4 inch thick, selected from manufacturer's standard widths to match width of bottom track or rim track members as required.

2.10 FABRICATION

A. Fabricate cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened, according to referenced AISI's specifications and standards, manufacturer's written instructions, and requirements in this Section.

1. Fabricate framing assemblies using jigs or templates.
2. Cut framing members by sawing or shearing; do not torch cut.
3. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, pneumatic pin fastening, or riveting as standard with fabricator. Wire tying of framing members is not permitted.

    a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
    b. Locate mechanical fasteners and install according to Shop Drawings, with screws penetrating joined members by no fewer than three exposed screw threads.

4. Fasten other materials to cold-formed steel framing by welding, bolting, pneumatic pin fastening, or screw fastening, according to Shop Drawings.

B. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies by means that prevent damage or permanent distortion.

C. Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable variation of 1/8 inch in 10 feet and as follows:

1. Spacing: Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
2. Squareness: Fabricate each cold-formed steel framing assembly to a maximum out-of-square tolerance of 1/8 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, conditions, and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Before sprayed fire-resistive materials are applied, attach continuous angles, supplementary framing, or tracks to structural members indicated to receive sprayed fire-resistive materials.

B. After applying sprayed fire-resistive materials, remove only as much of these materials as needed to complete installation of cold-formed framing without reducing thickness of fire-resistive materials below that required to obtain fire-resistance ratings indicated. Protect remaining fire-resistive materials from damage.

C. Install load-bearing shims or grout between the underside of load-bearing wall bottom track and the top of foundation wall or slab at locations with a gap larger than 1/4 inch to ensure a uniform bearing surface on supporting concrete or masonry construction.

D. Install sealer gaskets at the underside of wall bottom track or rim track and at the top of foundation wall or slab at stud or joist locations.

3.3 INSTALLATION, GENERAL

A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.

B. Install cold-formed steel framing according to AISI S200, AISI S202, and manufacturer's written instructions unless more stringent requirements are indicated.

C. Install shop- or field-fabricated, cold-formed framing and securely anchor to supporting structure.

1. Screw, bolt, or weld wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch.

D. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.

1. Cut framing members by sawing or shearing; do not torch cut.
2. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.

    a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
    b. Locate mechanical fasteners, install according to Shop Drawings, and comply with requirements for spacing, edge distances, and screw penetration.

E. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.

F. Install temporary bracing and supports to secure framing and support loads equal to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.

G. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.

H. Install insulation, specified in Section 072100 "Thermal Insulation," in framing-assembly members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.

I. Fasten hole-reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.

3.4 LOAD-BEARING WALL INSTALLATION

A. Install continuous top and bottom tracks sized to match studs. Align tracks accurately and securely anchor at corners and ends, and at spacings as follows:

1. Anchor Spacing: To match stud spacing (24 inches max.).

B. Squarely seat studs against top and bottom tracks, with gap not exceeding 1/8 inch between the end of wall-framing member and the web of track. Fasten both flanges of studs to top and bottom tracks. Space studs as follows:

1. Stud Spacing: 16 inches or **As indicated on Drawings**.

C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar configurations.

D. Align studs vertically where floor framing interrupts wall-framing continuity. Where studs cannot be aligned, continuously reinforce track to transfer loads.

E. Align floor and roof framing over studs according to AISI S200, Section C1. Where framing cannot be aligned, continuously reinforce track to transfer loads.

F. Anchor studs abutting structural columns or walls, including masonry walls, to supporting structure.

G. Install headers over wall openings wider than stud spacing. Locate headers above openings. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.

1. Frame wall openings with not less than a double stud at each jamb of frame. Fasten jamb members together to uniformly distribute loads.
2. Install tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with clip angles or by welding, and space jack studs same as full-height wall studs.

H. Install supplementary framing, blocking, and bracing in stud framing indicated to support fixtures, equipment, services, casework, heavy trim, furnishings, and similar work requiring attachment to framing.

1. If type of supplementary support is not indicated, comply with stud manufacturer's written recommendations and industry standards in each case, considering weight or load resulting from item supported.

I. Install horizontal bridging in stud system, spaced vertically as indicated on Shop Drawings but not more than 48 inches apart. Fasten at each stud intersection.

1. Channel Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs with a minimum of two screws into each flange of the clip angle for framing members up to 6 inches deep.
2. Strap Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges, and secure solid blocking to stud webs or flanges.
3. Bar Bridging: Proprietary bridging bars installed according to manufacturer's written instructions.

J. Install steel sheet diagonal bracing straps to both stud flanges; terminate at and fasten to reinforced top and bottom tracks. Fasten clip-angle connectors to multiple studs at ends of bracing and anchor to structure.

K. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

L.

3.5 INTERIOR NON-LOAD-BEARING WALL INSTALLATION

A. Install continuous tracks sized to match studs. Align tracks accurately and securely anchor to supporting structure.

B. Fasten both flanges of studs to top and bottom track unless otherwise indicated. Space studs as follows:

1. Stud Spacing: As indicated on Drawings (24 inches maximum)..

C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar requirements.

D. Isolate non-load-bearing steel framing from building structure to prevent transfer of vertical loads while providing lateral support.

1. Install single deep-leg deflection tracks and anchor to building structure.
2. Install double deep-leg deflection tracks and anchor outer track to building structure.
3. Connect vertical deflection clips to studs and anchor to building structure.
4. Connect drift clips to cold-formed steel metal framing and anchor to building structure.

E. Install horizontal bridging in wall studs, spaced vertically in rows indicated on Shop Drawings but not more than 48 inches apart. Fasten at each stud intersection.

1. Channel Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs.
2. Strap Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.
3. Bar Bridging: Proprietary bridging bars installed according to manufacturer's written instructions.

F. Top Bridging for Single Deflection Track: Install row of horizontal bridging within 12 inches of single deflection track. Install a combination of bridging and stud or stud-track solid blocking of width and thickness matching studs, secured to stud webs or flanges.

1. Install solid blocking at centers indicated on Shop Drawings but not more than 96 inches.

G. Install miscellaneous framing and connections, including stud kickers, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.6 JOIST INSTALLATION

A. Install perimeter joist track sized to match joists. Align and securely anchor or fasten track to supporting structure at corners, ends, and spacings indicated on Shop Drawings.

B. Install joists bearing on supporting frame, level, straight, and plumb; adjust to final position, brace, and reinforce. Fasten joists to both flanges of joist track.

1. Install joists over supporting frame with a minimum end bearing of 1-1/2 inches.
2. Reinforce ends and bearing points of joists with web stiffeners, end clips, joist hangers, steel clip angles, or steel-stud sections.

C. Space joists not more than 2 inches from abutting walls, and as follows:

1. Joist Spacing: As indicated on Drawings but not more than 24 inch centers.

D. Frame openings with built-up joist headers, consisting of joist and joist track or another combination of connected joists if indicated.

E. Install joist reinforcement at interior supports with single, short length of joist section located directly over interior support, with lapped joists of equal length to joist reinforcement.

1. Install web stiffeners to transfer axial loads of walls above.

F. Install bridging at intervals indicated on Shop Drawings but not more the 48 inch centers. Fasten bridging at each joist intersection as follows:

1. Joist-Track Solid Bridging: Joist-track solid blocking of width and thickness indicated, secured to joist webs.
2. Combination Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and joist-track solid blocking of width and thickness indicated. Fasten flat straps to bottom flange of joists and secure solid blocking to joist webs.

G. Secure joists to load-bearing interior walls to prevent lateral movement of bottom flange.

H. Install miscellaneous joist framing and connections, including web stiffeners, closure pieces, clip angles, continuous angles, hold-down angles, anchors, and fasteners, to provide a complete and stable joist-framing assembly.

3.7 ERECTION TOLERANCES

A. Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet and as follows:

1. Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

3.8 FIELD QUALITY CONTROL

A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Field and shop welds will be subject to testing and inspecting.

C. Testing agency will report test results promptly and in writing to Design-Builder.

D. Cold-formed steel framing will be considered defective if it does not pass tests and inspections.

E. Additional testing and inspecting, at Design-Builder's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.9 REPAIRS AND PROTECTION

A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A780 and manufacturer's written instructions.

B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that cold-formed steel framing is without damage or deterioration at time of Substantial Completion.

END OF SECTION 05 40 00

Section 05 50 00

METAL FABRICATIONS

PART 1 - GENERAL

This section covers the fabrication and installation of miscellaneous metal fabrications, including but not limited to the items listed in 1.2.

1.1 RELATED DOCUMENTS

A. Refer to Drawings and 01100 Section for additional information.

1.2 SUMMARY

A. Section Includes:

1. Steel framing and supports for ceiling-hung toilet compartments.
2. Steel framing and supports for operable partitions.
3. Steel framing and supports for overhead doors.
4. Steel framing and supports for countertops.
5. Steel tube reinforcement for low partitions.
6. Steel framing and supports for mechanic and electrical equipment.
7. Steel framing and supports for applications where framing and supports are not specified in other Sections.
8. Steel shapes for supporting elevator door sills.
9. Metal ladders.
10. Ladder fall protection safety systems.
11. Metal floor plate and supports.
12. Structural-steel door frames.
13. Miscellaneous steel trim including steel angle corner guards, steel edgings and loading-dock edge angles.
14. Pipe and/or Downspout guards.
15. Abrasive metal nosings and thresholds.
16. Cast-iron wheel guards.
17. Metal downspout boots
18. Clevises and Turnbuckles.
19. Eyebolts and Eyenuts
20. Welded headed studs.
21. Deformed bar anchors.
22. Bird screen.
23. Stop plates and grooves.
24. Basin effluent launders.
25. Basin/tank weir plates.

26. Scum baffles.
27. Metering weirs.
28. Bar screens.
29. Lime troughs.
30. Steel tanks and channels
31. Screw conveyors
32. Vortex grit equipment

B. Products furnished, but not installed, under this Section include the following:Steel weld plates and angles for casting into concrete for applications where they are not specified in other Sections.

C. Related Requirements:
   1. Structural Metals section.

1.3 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Metal nosings.

B. Shop Drawings: Show fabrication and installation details. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items. Provide Shop Drawings for the following:

   1. Steel framing and supports for ceiling-hung toilet compartments.
   2. Steel framing and supports for operable partitions.
   3. Steel framing and supports for overhead doors and grilles.
   4. Steel framing and supports for countertops.
   5. Steel tube reinforcement for low partitions.
   6. Steel framing and supports for mechanical and electrical equipment.
   7. Steel framing and supports for applications where framing and supports are not specified in other Sections.
   8. Steel shapes for supporting elevator door sills.

9. Metal ladders.
10. Ladder fall protection safety systems.
11. Metal floor plate and supports.
12. Structural-steel door frames.
13. Miscellaneous steel trim including steel angle corner guards, steel edgings and loading-dock edge angles.
14. Pipe and/or Downspout guards.
15. Abrasive metal nosings and/or thresholds.
16. Cast-iron wheel guards.
17. Metal downspout boots.
18. Clevises and Turnbuckles.
19. Eyebolts and Eyenuts
20. Welded headed studs.
21. Deformed bar anchors.
22. Bird screen.
23. Stop plates and grooves.
24. Basin effluent launders.
25. Basin/tank weir plates.
26. Scum baffles.
27. Metering weirs.
28. Bar screens.
29. Lime troughs.
30. Steel tanks and channels
31. Screw conveyors
32. Vortex grit equipment

C. Samples for Verification: For each type and finish of extruded nosing.

D. Delegated-Design Submittal: For ladders, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer.

B. Mill Certificates: Signed by stainless-steel manufacturers, certifying that products furnished comply with requirements.

C. Welding certificates.

D. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

E. Research/Evaluation Reports: For post-installed anchors, from ICC-ES.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.7 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, registered in the State of California, to design ladders.

B. Structural Performance of Aluminum Ladders: Aluminum ladders shall withstand the effects of loads and stresses within limits and under conditions specified in ANSI A14.3.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Steel Plates, Shapes, and Bars: ASTM A36.

C. Stainless-Steel Sheet, Strip, and Plate: ASTM A240 or ASTM A666, Type 304L or 316L as required.

D. Stainless-Steel Bars and Shapes: ASTM A276, Type 316L.

E. Rolled-Steel Floor Plate: ASTM A786, rolled from plate complying with ASTM A36 or ASTM A283, Grade C or D.

F. Rolled-Stainless-Steel Floor Plate: ASTM A793.

G. Abrasive-Surface Floor Plate: Steel plate with abrasive granules rolled into surface or with abrasive material metallically bonded to steel.

1. Harsco Industrial IKG.

2. Ross Technology Corporation.

3. W.S. Molnar Company.

4. Alro Steel.

5. Approved equal.

H. Steel Tubing: ASTM A500, cold-formed steel tubing.

I. Steel Pipe: ASTM A53, Standard Weight (Schedule 40) unless otherwise indicated.

J. Slotted Channel Framing: Cold-formed metal box channels (struts) complying with MFMA-4.

1. Size of Channels: As indicated (1-5/8 by 1-5/8 inches minimum).
2. Material: Galvanized steel, ASTM A653, structural steel, Grade 33, with G90 coating; **0.108-inch** nominal thickness.
3. Material: Cold-rolled steel, ASTM A1008, structural steel, Grade 33; 0.0966-inch minimum thickness; hot-dip galvanized after fabrication.

K. Cast Iron: Either gray iron, ASTM A48, or malleable iron, ASTM A47, unless otherwise indicated.

L. Aluminum Plate and Sheet: ASTM B209, Alloy 6061-T6.

M. Aluminum Extrusions: ASTM B221, Alloy 6063-T6.

N. Aluminum-Alloy Rolled Tread Plate: ASTM B632, Alloy 6061-T6.

O. Aluminum Castings: ASTM B26, Alloy 443.0-F.

P. Bronze Extrusions: ASTM B455, Alloy UNS No. C38500 (extruded architectural bronze).

Q. Bronze Castings: ASTM B584, Alloy UNS No. C83600 (leaded red brass) or No. C84400 (leaded semired brass).

R. Nickel Silver Extrusions: ASTM B151, Alloy UNS No. C74500.

S. Nickel Silver Castings: ASTM B584, Alloy UNS No. C97600 (20 percent leaded nickel bronze).

T. Forged Steel Clevises and Turnbuckles: AISI C-1035.

U. Forged Steel Eyebolts and Eyenuts: AISI C-1030, ANSI B 18.15 Type 2 shoulder pattern unless otherwise required.

V. Headed Concrete Anchors: ASTM A108 with a minimum 50,000 psi yield strength and minimum 60,000 psi tensile strength. TRW/Nelson or equal.

W. Deformed Bar Anchors: ASTM A496 with a minimum 70,000 psi yield strength and minimum 80,000 psi tensile strength. TRW/Nelson or equal.

X. Bird Screen: 2 mesh brass or copper wire cloth, minimum wire diameter 0.063 inch.

2.3 FASTENERS

A. General: Unless otherwise indicated, provide Type 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B633 or ASTM F1941, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.

1. Provide stainless-steel fasteners for fastening aluminum.
2. Provide stainless-steel fasteners for fastening stainless steel.
3. Provide stainless-steel fasteners for fastening nickel silver.
4. Provide bronze fasteners for fastening bronze.

B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563; and, where indicated, flat washers.

C. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A325, Type 3; with hex nuts, ASTM A563, Grade C3; and, where indicated, flat washers.

D. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F593; with hex nuts, ASTM F594; and, where indicated, flat washers; Alloy Group 2.

E. Anchor Bolts: ASTM F1554, Grade 36, of dimensions indicated; with nuts, ASTM A563; and, where indicated, flat washers.

1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.

F. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E488, conducted by a qualified independent testing agency.

G. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A47 malleable iron or ASTM A27 cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F2329.

H. Post-Installed Anchors: Torque-controlled expansion anchors or adhesive anchors, as specified in the Anchorage in Concrete and Masonry section.

1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941, Class Fe/Zn 5, unless otherwise indicated.
2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 2 stainless-steel bolts, ASTM F593, and nuts, ASTM F594.

I. Slotted-Channel Inserts: Cold-formed, hot-dip galvanized-steel box channels (struts) complying with MFMA-4, 1-5/8 by 7/8 inches by length indicated with anchor straps or studs not less than 3 inches long at not more than 8 inches o.c. Provide with temporary filler and tee-head bolts, complete with washers and nuts, all zinc-plated to comply with ASTM B633, Class Fe/Zn 5, as needed for fastening to inserts.

2.4 MISCELLANEOUS MATERIALS

A. Shop Primers: Provide primers that comply with the General Equipment Stipulations section.

B. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.

1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.

C. Water-Based Primer: Emulsion type, anticorrosive primer for mildly corrosive environments that is resistant to flash rusting when applied to cleaned steel, complying with MPI#107 and compatible with topcoat.

D. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.

E. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.

F. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187.

H. Nonshrink, Nonmetallic Grout: As indicated in the Grouting section.

I. Concrete: Comply with requirements in the Cast-in-Place Concrete section.

2.5 FABRICATION, GENERAL

A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Form exposed work with accurate angles and surfaces and straight edges.

E. Weld corners and seams continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.

G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

J. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8 by 1-1/2 inches, with a minimum 6-inch embedment and 2-inch hook, not less than 8 inches from ends and corners of units and 24 inches o.c., unless otherwise indicated.

2.6 MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.

B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.

1. Fabricate units from slotted channel framing where indicated.
2. Furnish inserts for units installed after concrete is placed.

C. Fabricate supports for operable partitions from continuous steel beams of sizes indicated with attached bearing plates, anchors, and braces as indicated. Drill or punch bottom flanges of beams to receive partition track hanger rods; locate holes where indicated on operable partition Shop Drawings.

D. Galvanize miscellaneous framing and supports where indicated.

E. Prime miscellaneous framing and supports with primer specified in the General Equipment Stipulations section where indicated.

2.7 METAL LADDERS

A. General:

1. Comply with ANSI A14.3, except for elevator pit ladders.
2. For elevator pit ladders, comply with ASME A17.1/CSA B44.

B. Steel Ladders:

1. Space siderails as indicated on the Drawings.
2. Siderails: Continuous, size and type as indicated on the Drawings.
3. Rungs: Steel bars; size and shape as indicated on the Drawings.

4. Fit rungs in centerline of siderails; plug-weld and grind smooth on outer rail faces.
5. Provide nonslip surfaces on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.
6. Provide nonslip surfaces on top of each rung by coating with abrasive material metallically bonded to rung.

    a. Manufacturers: Subject to compliance with requirements, provide products by the following:

        1) Harsco Industrial IKG, a division of Harsco Corporation.

        2) Approved Equal.
7. Support each ladder as indicated on the drawings with welded or bolted steel brackets.
8. Galvanize exterior ladders, including brackets.
9. Prime exterior ladders, including brackets and fasteners, with primer specified in the General Equipment Stipulations section.

C. Aluminum Ladders:

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

    a. Halliday Products.
    b. O'Keeffe's Inc.
    c. Approved equal.

2. Space siderails as indicated on the Drawings.
3. Siderails: Continuous, size and type as indicated on the Drawings.
4. Rungs: Extruded-aluminum tubes, size and shape as indicated on the Drawings.
5. Fit rungs in centerline of siderails; fasten by welding or with stainless-steel fasteners or brackets and aluminum rivets.
6. Support each ladder as indicated on the Drawings with welded or bolted aluminum brackets.
7. Provide minimum 72-inch-high, hinged security door with padlock hasp at foot of ladder to prevent unauthorized ladder use.

2.8 LADDER FALL PROTECTION SAFETY SYSTEM

A. General:

1. Fall protection safety systems shall be OSHA approved.

2. Fall protection safety system shall consist of a carrier, safety sleeve, lanyard, and connectors, and be suitable for operation with a body harness. Body harness provided by Owner.
3. Fall protection safety system shall be 3M Lad-Saf system, or equal.

2.9 METAL FLOOR PLATE

A. Fabricate from rolled-steel floor plate, rolled-stainless-steel floor plate, rolled-aluminum-alloy tread, or abrasive-surface floor plate as indicated on the Drawings:

1. Thickness: As indicated on the Drawings.

B. Provide angle supports as indicated on the Drawings.

C. Include angle stiffeners, and fixed and removable sections as indicated on the Drawings.

D. Provide flush bar drop handles for lifting removable sections, one at each end of each section.

2.10 STRUCTURAL-STEEL DOOR FRAMES

A. Fabricate structural-steel door frames from steel shapes, plates, and bars of size and to dimensions indicated, fully welded together, with 5/8-by-1-1/2-inch steel channel stops, unless otherwise indicated. Plug-weld built-up members and continuously weld exposed joints. Secure removable stops to frame with countersunk machine screws, uniformly spaced at not more than 10 inches o.c. Reinforce frames and drill and tap as necessary to accept finish hardware.

1. Provide with integrally welded steel strap anchors for securing door frames into adjoining concrete or masonry.

B. Extend bottom of frames to floor elevation indicated with steel angle clips welded to frames for anchoring frame to floor with expansion shields and bolts.

C. Galvanize and prime steel frames.

D. Prime steel frames with primer specified in the Protective Coatings section.

2.11 MISCELLANEOUS STEEL TRIM

A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.

1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

C. Galvanize and prime miscellaneous steel trim.

D. Prime miscellaneous steel trim with primer specified in the Protective Coatings section.

2.12 PIPE AND/OR DOWNSPOUT GUARDS

A. Fabricate pipe and/or downspout guards from 3/8-inch-thick by 12-inch-wide steel plate, bent to fit flat against the wall or column at both ends and to fit around pipe with 2-inch clearance between pipe and pipe guard. Drill each end for two 3/4-inch anchor bolts.

B. Galvanize and prime pipe and/or downspout guards.

C. Prime pipe and/or downspout guards with zinc-rich primer.

2.13 ABRASIVE METAL [**NOSINGS**] [**AND**] [**THRESHOLDS**]

A. Cast-Metal Units: Cast [**iron**] [**aluminum**] [**bronze (leaded red or semired brass)**] [**nickel silver (leaded nickel bronze)**], with an integral-abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both. Fabricate units in lengths necessary to accurately fit openings or conditions.
   1. Nosings: Cross-hatched units, 4 inches wide with [**1/4-inch**] [**1-inch**] lip, for casting into concrete.
   2. Nosings: Cross-hatched units, 1-1/2 by 1-1/2 inches, for casting into concrete.
   3. Thresholds: Fluted-saddle-type units, 5 inches wide by 1/2 inch high, with tapered edges.
   4. Thresholds: Fluted-interlocking- (hook-strip-) type units, 5 inches wide by 5/8 inch high, with tapered edge.
   5. Thresholds: Plain-stepped- (stop-) type units, 5 inches wide by 1/2 inch high, with 1/2-inch step.

B. Extruded Units: [**Aluminum**] [**Bronze**], with abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder. Fabricate units in lengths necessary to accurately fit openings or conditions.
   1. Provide ribbed units, with abrasive filler strips projecting 1/16 inch above aluminum extrusion.

2. Provide solid-abrasive-type units without ribs.
3. Nosings: Square-back units, [**1-7/8 inches**] [**3 inches**] [**4 inches**] wide, for casting into concrete steps.
4. Nosings: Beveled-back units, [**3 inches**] [**4 inches**] wide with 1-3/8-inch lip, for surface mounting on existing stairs.
5. Nosings: Two-piece units, 3 inches wide, with subchannel for casting into concrete steps.

C. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.

D. Drill for mechanical anchors and countersink. Locate holes not more than 4 inches from ends and not more than 12 inches o.c., evenly spaced between ends, unless otherwise indicated. Provide closer spacing if recommended by manufacturer.

1. Provide two rows of holes for units more than 5 inches wide, with two holes aligned at ends and intermediate holes staggered.

E. Apply bituminous paint to concealed surfaces of cast-metal units.

F. Apply clear lacquer to concealed surfaces of extruded units.

2.14 CAST-IRON WHEEL GUARDS

A. Provide wheel guards made from cast-iron, 3/4-inch-thick, hollow-core construction, of size and shape indicated. Provide holes for countersunk anchor bolts and grouting.

B. Prime cast-iron wheel guards with primer specified in the Protective Coatings section.

2.15 METAL DOWNSPOUT BOOTS

A. Provide downspout boots made from cast iron or aluminum, as indicated on the drawings, in heights indicated with inlets of size and shape to suit downspouts. Provide units with flanges and holes for countersunk anchor bolts.

1. Outlet: [Vertical, to discharge into pipe] [Horizontal, to discharge into pipe] [At 35 degrees from horizontal, to discharge onto splash block or pavement].

B. Prime cast-iron downspout boots with [zinc-rich primer.] [primer specified in the Protective Coatings section.]

2.16 LOOSE BEARING AND LEVELING PLATES

A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

B. Galvanize plates.

C. Prime plates with primer specified in the Protective Coatings section.

2.17 STEEL WELD PLATES AND ANGLES

A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.18 STOP PLATES AND GROOVES

A. Stop plates shall be fabricated with the edges accurately finished. Plates shall be provided with suitable lifting handles and angle stiffeners as indicated on the Drawings. Each stop plate shall be permanently marked to identify its intended location.

B. Stop plate grooves shall be cast iron Neenah “Series R-7501” with all interior surfaces machined.

2.19 BAR SCREENS

A. Bar screens shall be fabricated from bars and shapes in accordance with the details indicated on the Drawings.

2.20 FINISHES, GENERAL

A. Finish metal fabrications after assembly.

B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.21 STEEL AND IRON FINISHES

A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153 for steel and iron hardware and with ASTM A123 for other steel and iron products.

1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.

B. Preparation for Shop Priming Galvanized Items: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic phosphate process.

C. Shop prime iron and steel items not indicated to be galvanized unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.

1. Shop prime with universal shop primer.

D. Preparation for Shop Priming: Prepare surfaces to comply with requirements indicated below:

1. Exterior Items: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
2. Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
3. Items Indicated to Receive Primers Specified in the Protective Coatings section: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
4. Other Items: SSPC-SP 3, "Power Tool Cleaning."

E. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

2.22 ALUMINUM FINISHES

A. As-Fabricated Finish: AA-M12.

B. Clear Anodic Finish: AAMA 611, Class I, AA-M12C22A41.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded

because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

C. Field Welding: Comply with the following requirements:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

F. Corrosion Protection: Coat concealed surfaces of aluminum that come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:

1. Cast Aluminum: Heavy coat of bituminous paint.
2. Extruded Aluminum: Two coats of clear lacquer.

3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.

B. Anchor supports for [**ceiling hung toilet partitions**] [**operable partitions**] [**overhead doors**] [**and**] [**overhead grilles**] securely to, and rigidly brace from, building structure.

3.3 INSTALLING NOSINGS AND THRESHOLDS

A. Center nosings on tread widths unless otherwise indicated.

B. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.

C. Seal thresholds exposed to exterior with elastomeric sealant complying with Section 079200 "Joint Sealants" to provide a watertight installation.

3.4 INSTALLING CAST-IRON WHEEL GUARDS

A. Anchor wheel guards to concrete or masonry construction to comply with manufacturer's written instructions. Fill cores solidly with concrete.

3.5 INSTALLING BEARING AND LEVELING PLATES

A. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of plates.

B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with nonshrink grout. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.6 INSTALLING STOP PLATES AND GROOVES

A. Stop plate grooves shall be installed plumb and straight within a tolerance of 3/32 inch and with the opposite sides and bottom aligned in a single plane to prevent binding of the stop plate. If necessary to meet this requirement, a space shall be boxed out for guides, and the guides grouted in place later. Stop plates shall be set in place as needed for testing and startup procedures.

3.7 INSTALLING BASIN EFFLUENT LAUNDERS

A. Weir plates shall not be installed until after field painting of the effluent launders has been completed. Before installation of the weir plates, contact surfaces between weir plates and launders shall be given a heavy coat of sealant as specified in the caulking section.

3.8 INSTALLING BASIN WEIR PLATES

A. Before installation, surfaces in contact with concrete shall be given a heavy coating of sealant as specified in the caulking section. Weir plates shall be adjusted after installation to provide uniform overflow rate at all points.

3.9 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

   1. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.

B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in the Protective Coatings section.

C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.

END OF SECTION 055000

Section 05 50 13

STRUCTURAL METALS

PART 1 - GENERAL

1-1. SCOPE. This section covers the fabrication and erection of structural metal items.

Except as otherwise specified or indicated on the Drawings, all work shall conform to the applicable provisions of the AISC "Steel Construction Manual" (14th edition) with the exception of the "Code of Standard Practice for Steel Buildings and Bridges"; and the Aluminum Association "Specification for Aluminum Structures".

Special inspection during the fabrication and erection of structural steel, if required by the local building code, is addressed in the Code-Required Special Inspections and Procedures section.

Both inch-pound (English) and SI (metric) units of measurement are specified herein; the values expressed in inch-pound units shall govern.

1-2. SUBMITTALS. Complete data, fabrication drawings, and setting or erection drawings covering all structural and miscellaneous metal items shall be submitted in accordance with the Submittals Procedures section.

All bolted connections and welds shall be properly identified on the shop drawings. Welding procedures, welding procedure qualification records and welder qualifications shall be submitted.

Submittals for high strength bolts, tension control bolts and load indicator washers shall include statements from the bolt and washer manufacturers certifying satisfactory compliance with the governing standards and the specified tests.

Submittals for items that are designed by the fabricator shall include drawings sealed by a professional engineer registered in the state of the project. Data shall include confirmation that the design meets all applicable code requirements. Calculations shall be submitted when requested by the Structural Engineer of Record.

1-3. DELIVERY, STORAGE, AND HANDLING. Materials shall be handled, transported, and delivered in a manner which will prevent bends, dents, significant coating damage, or corrosion. Damaged materials shall be promptly

replaced. Structural and miscellaneous metal work shall be stored on blocking so that no metal touches the ground and water cannot collect thereon. The material shall be protected against bending under its own weight or superimposed loads.

Bolting materials shall be stored indoors. Weld rod shall be stored in accordance with the supplier's instructions and AWS D1.1.

1-4. FABRICATOR QUALIFICATION. All fabricating plants providing structural steel shall be qualified fabricators who participate in the AISC Certification program and are designated an AISC Certified Plant, Category BU.

PART 2 - PRODUCTS

2-1. GENERAL. All materials needed for both shop and field assembly shall be furnished.

2-2. MATERIALS.

Steel

Shapes (W, WT)	ASTM A992.
Shapes (S, M, HP, C)	ASTM A36 or ASTM A572 Grade 50.
Other Shapes (angles)	ASTM A36.
Plates and Bars	ASTM A36.
Sheets	ASTM A1008 CS Type B or A1011 CS Type B.
Pipe	ASTM A53, Type E or S, Grade B (F_y = 35 ksi).
Round Structural Tubing	ASTM A500, Grade C (F_y = 46 ksi).
Square and Rectangular Structural Tubing	ASTM A500, Grade C (F_y = 50 ksi).

Bolts and Nuts

Bolts, High Strength	ASTM F3125, Grade A325.

Bolts, Tension Control Type (Twist off)	ASTM F3125, Grade 1852.
Bolts, unfinished	ASTM A307.
Nuts, Heavy-Hex	ASTM A563, grade and finish compatible with bolts.
Nuts, Self-Locking	Prevailing torque type; IFI-100, Grade A.
Washers	
Flat, Hardened	ASTM F436, Type 1.
Lock	ANSI/ASME B18.21.1, helical spring type.
Beveled	ASTM F436.
Load Indicator	ASTM F959, compressible-washer-type direct tension indicator; type compatible with bolts tested in accordance with Article 10.2 of ASTM F959.
Threaded Rods (Including Hanger Rods for Pipe Supports)	ASTM A36. Threaded rods shall have sufficient threading to permit the maximum adjustment available. Continuously threaded rod is not acceptable for rods over 12 inches in length.
Forged Steel Sleeve Nuts	AISI C-1018, Grade 2.
Stainless Steel	
Shapes	ASTM A1069 or A276, Type 316L.
Plates	ASTM A240, Type 316L.
Pipe	ASTM A312, Grade TP316L.
Tube	ASTM A269, Grade TP316L.
Checkered Plate	ASTM A793, Type 316L, raised pattern A.

Bolts	ASTM F593, Alloy Group 1 or 2, minimum yield strength of 45 ksi.
Nuts	ASTM F594, Alloy Group shall match that of the bolts. Nuts shall have a minimum proof stress equal to or greater than the minimum full-size tensile strength of the bolts.
Washers	
Flat	ANSI/ASME B18.22.1, Type 316.
Lock	ANSI/ASME B18.21.1, helical spring type, Type 316.
Threaded Rods (Including Hanger Rods for Pipe Supports)	ASTM A593, Alloy Group 1 or 2, minimum yield strength of 45 ksi.
Aluminum	
Sheet and Plate	ASTM B209, Alloy 6061-T6.
Rolled Sections	ASTM B308, Alloy 6061-T6. All members shall be Aluminum Association standard shapes. Special shapes with sloping flange surfaces, or Army-Navy type members, shall not be used unless specifically indicated on the Drawings.
Rod and Bar (Rolled or Drawn)	ASTM B211, Alloy 6061-T6 or 2017-T4.
Extrusions	ASTM B221, Alloy 6063-T5 or T6.
Pipe	ASTM B429, Alloy 6061-T6.
Rivets	ASTM B316, Alloy 6061-T6.
Bolts, Aluminum	ASTM F468, Alloy 2024-T4.
Nuts, Aluminum	ASTM F467, Alloy 6061-T6.
Washers, Aluminum	

Flat	ANSI/ASME B18.22.1, Type 6061 T-6.
Lock	ANSI/ASME B18.21.1, helical spring type, Type 6061-T6.
Weld Metal (Steel Connections)	ANSI/AWS D1.1, Table 3.1, filler metal with minimum 70 ksi tensile strength unless otherwise required.
Rails	
Crane	ASTM A1.
Railroad	ASTM A1.
Shop Coatings	
Universal Primer	As indicated in the Protective Coatings section.
Bituminous Paint	Metal fabricator's standard product.
Galvanizing	ASTM A123, A153, A385, and F2329 as applicable.

2-3. STAIRS. Stairs shall be fabricated to the dimensions, arrangements and sizes indicated on the Drawings. Stairs shall be true to line and slope, shall be rigidly supported, and shall be braced and tightened to prevent movement. All treads shall be level and in perfect alignment and spacing.

After installation, stairs shall be rigid and shall not sway noticeably or deflect under foot traffic. If necessary to prevent noticeable movement, additional supports or bracing shall be provided.

2-3.01. Stair Design. Stairs shall be designed by the stair supplier in general accordance with details indicated on the Drawings. The design shall comply with all applicable provisions of the local building code, ANSI A117.1, and OSHA as applicable. The drawings shall be sealed by a professional engineer registered in the state of the project. If requested, calculations shall be submitted to the Structural Engineer of Record.

The completed fabrications shall support a uniform live load of 100 lbs per square foot and a concentrated load of 300 lbs applied at the center of the span.

Individual treads and platforms shall be designed to support a uniform live load of 100 lbs per square foot or a 300 lb concentrated live load applied on an area of 4 square inches. Vertical deflections under full live load shall be limited to span/240. Stairs and landings shall be braced or otherwise designed to avoid noticeable sidesway.

The stair design and details shall be coordinated with the handrailing and guardrailing supplied. Stair members shall be adequate to accept loads from the rail posts based upon the criteria in the Metal Railings section.

Connections between the stair members and the supporting structure shall be adequate to transfer all loadings, and shall be designed in accordance with all applicable provisions of the AISC manual and ACI 318 Chapter 17. The number and type of connections shall comply, at a minimum, with the Drawings. All necessary brackets, bolts, and anchors shall be provided.

2-3.02. Nosings. All stair treads shall have non-skid nosings, either fabricated integrally with the tread or attached with stainless steel bolts and self-locking nuts.

2-3.03. Grating Stairs. Treads shall be fabricated from grating material in accordance with the Metal Gratings section.

2-3.04. Pan Type Stairs. Risers and subtreads shall be fabricated from 12 USS gage steel and subplatforms from 10 USS gage steel. Fill depth shall be 2 inches for treads and 3 inches for platforms. Each riser shall have an integral non-slip nosing and a formed sanitary cove, located so that the toe of the cove will be at the surface of the concrete fill or applied finish.

2-3.05. Cast Aluminum Stairs. Risers and subtreads shall be fabricated from cast aluminum as indicated on the details on the Drawings.

2-4. CRANE SYSTEMS. Steel beams used as underhung crane or hoist runways shall be straight and level. The upper surface of the lower flange of each beam shall be smooth, with all projections ground off. Joints shall be close-fitting and free from unevenness. The beams shall be rigidly supported in exact alignment. A section of each runway beam shall not be installed until after the crane or hoist has been installed.

Stops as recommended by the crane or hoist manufacturer shall be bolted in place on each end of each runway beam to limit the travel of the crane or hoist. Stops shall be so located that the crane or hoist does not come into contact with any part of the structure or piping. If the crane or hoist is required to be powered, at the power feed end of the runway the stops shall be designed so that the cable trolleys will pass beneath the stops. The stops shall be so located that there is

sufficient room on the runway for storage of the cable trolleys beyond the stops. Secondary stops shall be provided for the cable trolleys.

2-4.01. Crane Rails. Rails on which a traveling, top running crane is to travel shall be furnished complete with clamps or hook bolts, splice plates, stops, anchor bolts and nuts, and other accessories necessary to complete the installation indicated on the Drawings.

2-5. STRUCTURAL STEEL BOLTED CONNECTIONS. Bolt holes shall have a diameter nominally 1/16 inch larger than the nominal bolt diameter. Bolt holes for one ply of vertical diagonal bracing connections may be oversized to a diameter nominally 3/16 inch larger than the nominal bolt diameter.

2-6. SHOP COATING. All items shall be shop coated as specified herein. The requirements for field painting are covered in the Protective Coatings section.

Contact surfaces of structural steel slip critical bolted connections shall not be shop coated. Contact surfaces of structural steel bearing type bolted connections may be shop coated.

2-6.01. Cleaning. Surfaces shall be dry and of proper temperature when coated, and shall be free of grease, oil, dirt, dust, grit, rust, loose mill scale, weld flux, slag, weld spatter, and other objectionable substances. Articles to be galvanized shall be pickled before galvanizing. All other ferrous metal surfaces shall be cleaned by solvent, high-speed power wire brushing or by blasting to the extent recommended by the paint manufacturer and as required in the Protective Coatings section.

2-6.02. Edge Grinding. Sharp projections of cut or sheared edges of ferrous metals which will be submerged in operation, except for items specified to be hot-dip galvanized, shall be ground to a radius as needed to ensure satisfactory paint adherence and as required in the Protective Coatings section.

2-6.03. Prime Painted Steel. Unless otherwise specified or indicated on the Drawings, all ungalvanized structural and miscellaneous steel shall be given a universal prime coat in the shop after fabrication. The dry film thickness of the universal primer shall be at least 5 mils. Steel surfaces shall be prime-coated as soon as practicable after cleaning. Steel shall not be moved or handled until the shop coat is dry and hard.

2-6.04. Galvanizing. Steel materials required to be galvanized are indicated on the Drawings. All galvanizing shall be done by the hot-dip process after fabrication. An approved zinc-rich paint shall be used to touch up minor coating damage, in accordance with ASTM A780. Materials with significant coating damage shall be regalvanized or replaced.

Bolts, nuts, and washers shall be galvanized when connected materials are galvanized or where indicated on the Drawings. The use of zinc-plated bolts will not be acceptable.

2-6.05. Stainless Steel. Unless otherwise specified, all items fabricated from stainless steel shall be thoroughly cleaned and degreased after fabrication. Pickling or a light blast cleaning shall produce a modest etch and remove all embedded iron and heat tint. Surfaces shall be subjected to a 24 hour water test or a ferroxyl test to detect the presence of residual embedded iron and shall be retreated as needed to remove all traces of iron contamination. Surfaces shall be adequately protected during shipping and handling to prevent contact with iron or steel objects or surfaces.

2-6.06. Aluminum. All surfaces of aluminum which will be in contact with concrete, mortar, or dissimilar metals shall be given a coat of bituminous paint.

PART 3 - EXECUTION

3-1. STRUCTURAL STEEL ERECTION. Structural steel shall be erected so that individual pieces are plumb, level, and aligned within a tolerance of 1:500. The elevations of the top of floor and roof members shall be within 1/16 inch of the elevations indicated on the Drawings. The faces of girts and other supporting members for rigid wall panels shall be in vertical planes within a maximum variation of 1/8 inch.

All members and parts, as erected, shall be free of warps, local deformations, and unauthorized bends. All parts shall be assembled accurately as indicated on the Drawings. Light drifting will be permitted to draw parts together, but drifting to match unfair holes will not be permitted. Any enlargement of holes necessary to make connections in the field shall be done by reaming with twist drills and only with the approval of the Structural Engineer of Record. Enlarging holes by burning will not be permitted.

Baseplates shall be set level in exact position and grouted in place.

3-1.01. Inspection and Testing. Special inspection will be performed as indicated in the Code Required Special Inspections and Procedures section. The erector shall provide access as needed to facilitate all inspections and shall provide timely notification during erection when inspection milestones are approaching.

3-1.02. Crane Rails. Crane rails shall be installed level and in accurate alignment and shall form a continuous, smooth track. Rail installation tolerances shall be in accordance with CMAA Specification 70.

3-2. STRUCTURAL STEEL BOLTED CONNECTIONS. Unless otherwise indicated on the Drawings, bolted connections for structural steel, as defined in the AISC manual, shall be made with ASTM F3125 high strength bolts conforming to the "Specification for Structural Joints Using High-Strength Bolts" as approved by the Research Council on Structural Connections. The method of installation, pretensioning procedures, bolting equipment and tools shall likewise conform to the above referenced standard.

When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts, or washers, shall be free of loose mill scale, dirt, burrs, oil, and other foreign material that would prevent solid seating of the parts.

Beveled washers shall be used when the bearing faces of bolted parts have a slope of 1:20 or greater with respect to a plane perpendicular to the bolt axis. Bolt length shall be increased as needed to accommodate the beveled washers.

If oversized holes are provided in an outer ply, a hardened flat washer shall be installed over each hole during bolting. Load indicator washers shall not be substituted for hardened flat washers required for oversized holes.

Tightening of each connection assembly shall progress systematically from the most rigid part of the joint toward the free edges until all have been sufficiently rotated or the load indicator washers on all bolts have been closed to the average gap stipulated by the load indicator washer manufacturer.

Except as otherwise indicated on the Drawings or specified herein, bolted connections shall be bearing type with threads excluded from the shear plane. Slip critical connections shall be used in diagonal bracing connections, where oversize holes or slotted holes parallel to the direction of the load are used, and where indicated on the Drawings.

Bolts in all structural steel connections, both bearing and slip critical, shall be fully pretensioned in accordance with the AISC standards unless specifically noted otherwise on the Drawings. The calibrated wrench method of pretensioning bolts will not be acceptable. Acceptable pretensioning methods are as follows:

Connection Type	Acceptable Pretensioning Method
Bearing	Turn of the nut method and load-indicator washers are acceptable. Tension control (twist-off) type bolts may be used only if approved by the Structural Engineer of Record.

Slip-Critical	Load indicator washers.

3-2.01. Turn of the Nut Method. The bolt, nut, and material shall be match marked. A wax lumber marker or paint shall be used to clearly mark the assembly.

3-2.02. Load-Indicator Washers. Load indicator washers shall be installed in accordance with the manufacturer's recommendations, as supplemented herein. To facilitate proper tightening of fastener assemblies with load indicator washers, a hardened flat washer shall be installed under the turned element (bolt head or nut) and between the turned element and the load indicator washer protrusions, in all cases. Whenever possible, the load indicator washer shall be installed on the head end of the bolt. If the bolt head will not be visible for inspection of the indicator washer after installation, or if the bolt head must be turned to tighten the assembly, the load indicator washer may be installed on the nut end of the bolt.

3-2.03. Tension Control (Twist-off) Bolts. Patented tension control bolts shall be of equivalent size and strength to the indicated high strength bolts, and shall be installed in strict accordance with the manufacturer's instructions. Load-indicator washers are not required on tension control bolts.

3-3. STRUCTURAL, STAINLESS, AND MISCELLANEOUS STEEL WELDING. Welding and related operations shall conform to applicable provisions of AWS D1.1 for steel and AWS D1.6 for stainless steel. All welding shall be performed in accordance with written procedures, using only those joint details which have prequalified status. All welding shall be performed by welders qualified in accordance with the American Welding Society.

Welds not dimensioned on the Drawings shall be sized to develop the full strength of the least strength component of the connection.

Where structural or miscellaneous steel connections are welded, all butt and miter welds shall be continuous and, where exposed to view, shall be ground smooth. Intermittent welds shall have an effective length of at least 2 inches and shall be spaced not more than 6 inches apart.

Surfaces to be welded and surfaces within 2 inches of a weld shall be free from loose or thick scale, slag, rust, moisture, grease, paint and other foreign materials that would prevent proper welding or release objectionable fumes.

Only shielded metal arc, gas metal arc, flux cored arc, submerged arc, and gas tungsten arc welding are permitted. For flux cored arc welding, only E70xx one (1) or five (5) wire electrodes with supplemental gas shielding shall be permitted.

Use of electroslag or electrogas welding processes or the short-circuiting transfer mode of the gas metal arc process will not be acceptable.

Field welded connections shall not be substituted for field bolted connections indicated on the Drawings.

3-4. STRUCTURAL AND MISCELLANEOUS ALUMINUM. Unless otherwise noted, all work shall conform to applicable provisions of the Aluminum Association "Specification for Aluminum Structures".

3-4.01. Connections. Connections not specifically detailed on the Drawings shall develop the full strength of the least strength member of the connections. Bolted connections shall be all-bolted bearing type, equipped with a helical spring lock washer under the stationary element (bolt head or nut) and a flat washer under the turned element. All bolts shall be fully tightened. Bolts and nuts for structural aluminum connections shall be stainless steel. A sufficient number of bolts shall be provided in each connection to develop the shear strength of the member.

Welded connections shall be made in accordance with the American Welding Society D1.2, Structural Welding Code - Aluminum. All welding shall be performed by welders qualified in accordance with American Welding Society. Welds shall be free of porosity, cracks, holes, and flux. Welded connections shall not be substituted for bolted connections without prior approval of the Structural Engineer of Record.

3-4.02. Erection. Structural aluminum shall be erected so that individual pieces are plumb, level, and aligned within a tolerance of 1:500. The elevation of horizontal members shall be within 1/16 inch of the elevation indicated on the Drawings.

End of Section

SECTION 05 52 13

METAL RAILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel railings.
2. Aluminum railings.
3. Stainless-steel railings.

B. Related Requirements:

1. Structural Metals section for railings associated with stairs.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Manufacturer's product lines of mechanically connected railings.
2. Railing brackets.
3. Grout, anchoring cement, and paint products.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Samples: For each type of exposed finish required.

D. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For pipe and tube railings, for tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Steel Pipe and Tube Railings:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. VIVA Railings, LLC.

b. Approved equal.

B. Aluminum Pipe and Tube Railings:

1. Superior Aluminum Products, Inc.

2. Approved equal.

C. Stainless-Steel Pipe and Tube Railings:

1. VIVA Railings, LLC.

2. Approved equal.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, registered in the State of the project, to design railings, including attachment to building construction.

B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated. An allowable stress increase of 1/3 shall not be incorporated into the design of any part of the railing system.

1. Handrails and Top Rails of Guards:

a. Uniform load of 50 lbf/ ft applied in any direction.
b. Concentrated load of 200 lbf applied in any direction.
c. Uniform and concentrated loads need not be assumed to act concurrently.

2. Infill of Guards:

a. Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft..
b. Infill load and other loads need not be assumed to act concurrently.

2.3 METALS, GENERAL

A. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.

1. Provide type of bracket with predrilled hole for exposed bolt anchorage and that provides 1-1/2-inch clearance from inside face of handrail to finished wall surface.

2.4 STEEL AND IRON

A. Tubing: ASTM A500 (cold formed).

B. Pipe: ASTM A53, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.

1. Provide galvanized finish for exterior installations and where indicated.

C. Plates, Shapes, and Bars: ASTM A36.

D. Cast Iron: Either gray iron, ASTM A48, or malleable iron, ASTM A47, unless otherwise indicated.

2.5 ALUMINUM

A. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.

B. Extruded Bars and Tubing: ASTM B221, Alloy 6063-T5/T52.

C. Extruded Structural Pipe and Round Tubing: ASTM B429, Alloy 6063-T6.

D. Drawn Seamless Tubing: ASTM B210, Alloy 6063-T832.

E. Plate and Sheet: ASTM B209, Alloy 6061-T6.

F. Die and Hand Forgings: ASTM B247, Alloy 6061-T6.

G. Castings: ASTM B26, Alloy A356.0-T6.

2.6 STAINLESS STEEL

A. Tubing: ASTM A554, Grade MT 316L.

B. Pipe: ASTM A312, Grade TP 316L

C. Castings: ASTM A743, Grade CF 8M or CF 3M.

D. Plate and Sheet: ASTM A240 or ASTM A666, Type 316L.

2.7 FASTENERS

A. General: Provide the following:

1. Ungalvanized-Steel Railings: Plated steel fasteners complying with ASTM B633 or ASTM F1941, Class Fe/Zn 5 for zinc coating.
2. Hot-Dip Galvanized Railings: Type 304 stainless-steel or hot-dip zinc-coated steel fasteners complying with ASTM A153 or ASTM F2329 for zinc coating.
3. Aluminum Railings: Type 316 stainless-steel fasteners.
4. Stainless-Steel Railings: Type 316 stainless-steel fasteners.

B. Post-Installed Anchors: Expansion anchors or adhesive anchors, as specified in the Anchorage in Concrete and Masonry section.

1. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941, Class Fe/Zn 5, unless otherwise indicated.
2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 or 2 stainless-steel bolts, ASTM F 93, and nuts, ASTM F594.

2.8 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.

C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

D. Shop Primers: Provide primers that comply with the Protective Coatings section.

E. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.

F. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.

G. Epoxy Intermediate Coat: Complying with MPI #77 and compatible with primer and topcoat.

H. Polyurethane Topcoat: Complying with MPI #72 and compatible with undercoat.

I. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 187.

J. Non-shrink, Nonmetallic Grout: As specified in the Grouting section.

2.9 FABRICATION

A. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

B. Form work true to line and level with accurate angles and surfaces.

C. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove flux immediately.
4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.

D. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.

E. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.

F. Form changes in direction by inserting prefabricated elbow fittings.

G. Close exposed ends of railing members with prefabricated end fittings.

H. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated.

I. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.

1. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.

2.10 STEEL AND IRON FINISHES

A. Galvanized Railings:

1. Hot-dip galvanize steel railings, including hardware, after fabrication.
2. Comply with ASTM A123 for hot-dip galvanized railings.
3. Comply with ASTM A153 for hot-dip galvanized hardware.

B. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 3, "Power Tool Cleaning."

C. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.

1. Do not apply primer to galvanized surfaces.

D. High-Performance Coating: Apply epoxy intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.

1. Color: As selected by Architect from manufacturer's full range.

2.11 ALUMINUM FINISHES

A. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Mill Finish: AA-M12, nonspecular as fabricated.

C. Clear Anodic Finish: AAMA 611, AA-M12C22A41.

2.12 STAINLESS-STEEL FINISHES

A. Stainless Steel Tubing Finishes:

1. 180-Grit Polished Finish: Uniform, directionally textured finish.
2. 320-Grit Polished Finish: Oil-ground, uniform, fine, directionally textured finish.
3. Polished and Buffed Finish: 320-grit finish followed by buffing to a high luster finish.

B. Stainless Steel Sheet and Plate Finishes:

1. Directional Satin Finish: ASTM A489, No. 4.
2. High Luster Finish: ASTM A480, No. 7.
3. Mirror Finish: ASTM A480, No. 8.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.

B. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1. Coat, with a heavy coat of bituminous paint, concealed surfaces of aluminum that are in contact with grout, concrete, masonry, wood, or dissimilar metals.

3.2 ANCHORING POSTS

A. Sleeve type: Use metal sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with non-shrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.

B. Post-Installed anchors: Fasten post base flanges to concrete in accordance with the Drawings and the Anchorage in Concrete and Masonry section.

C. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members.

3.3 ATTACHING RAILINGS

A. Attach railings to wall with wall brackets. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.

B. Secure wall brackets and railing end flanges to building construction as follows:

1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
2. For hollow masonry anchorage, use toggle bolts.
3. For wood stud partitions, use hanger or lag bolts set into studs or wood backing between studs. Coordinate with carpentry work to locate backing members.
4. For steel-framed partitions, use hanger or lag bolts set into wood backing between studs. Coordinate with stud installation to locate backing members.
5. For steel-framed partitions, use self-tapping screws fastened to steel framing or to concealed steel reinforcements.
6. For steel-framed partitions, use toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

3.4 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 requirements for touching up shop-painted surfaces.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas, and repair galvanizing to comply with ASTM A780.

END OF SECTION

SECTION 05 53 13

METAL GRATINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, apply to this Section.

1.2 SUMMARY

A. Section includes metal bar gratings.

B. Related Requirements:

1. Structural Metals section for structural metal framing system components and metal framed stairs.
2. Metal Railings section for metal pipe and tube handrails and railings.

1.3 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written instructions to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorages for gratings, grating frames, and supports. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Clips and anchorage devices for gratings.
2. Paint products.

B. Shop Drawings: Include plans, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS

A. Mill Certificates: Signed by manufacturers of stainless steel certifying that products furnished comply with requirements.

B. Welding certificates.

C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
4. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.7 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with gratings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Fisher & Ludlow; a NUCOR Company.
2. Harsco Industrial IKG, a division of Harsco Corporation.
3. Ohio Gratings, Inc.
4. Approved equal.

2.2 METAL BAR GRATINGS

A. Metal Bar Grating Standards: Comply with NAAMM MBG 531, "Metal Bar Grating Manual" and NAAMM MBG 532, or "Heavy-Duty Metal Bar Grating Manual " where heavy-duty metal bar grating is required on the Drawings.

B. Welded Steel Grating:

1. Bearing Bar Spacing: 1-3/16 inches o.c.
2. Bearing Bar Depth: As indicated on Drawings.
3. Bearing Bar Thickness: 3/16 inch minimum.
4. Crossbar Spacing: 4 inches o.c.
5. Traffic Surface: Plain, unless indicated otherwise on the Drawings.
6. Steel Finish: Hot-dip galvanized with a coating weight of not less than 1.8 oz./sq. ft. of coated surface.

C. Pressure-Locked, Stainless-Steel Grating: Fabricated by pressing rectangular flush-top crossbars into slotted bearing bars or swaging crossbars between bearing bars.

1. Bearing Bar Spacing: 1-3/16 inches o.c.
2. Bearing Bar Depth: As indicated on Drawings.
3. Bearing Bar Thickness: 3/16 inch minimum.
4. Crossbar Spacing: 4 inches o.c.
5. Traffic Surface: Plain, unless indicated otherwise on Drawings.
6. Finish: Mill finish.

D. Pressure-Locked, Rectangular-Bar Aluminum Grating: Fabricated by pressing rectangular flush-top crossbars into slotted bearing bars or swaging crossbars between bearing bars.

1. Bearing Bar Spacing: 1-3/16 inches o.c.
2. Bearing Bar Depth: As indicated on Drawings.
3. Bearing Bar Thickness: 3/16 inch minimum.
4. Crossbar Spacing: 4 inches o.c.
5. Traffic Surface: Plain, unless indicated otherwise on Drawings.
6. Aluminum Finish: Mill finish.

2.3 FERROUS METALS

A. Steel Plates, Shapes, and Bars: ASTM A36.

B. Steel Bars for Bar Gratings: ASTM A36 or steel strip, ASTM A1011 or ASTM A1018.

C. Wire Rod for Bar Grating Crossbars: ASTM A510.

D. Uncoated Steel Sheet: ASTM A1011, structural steel, Grade 30.

E. Galvanized-Steel Sheet: ASTM A653, structural quality, Grade 33, with G90 coating.

F. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A240, Type 316L.

G. Stainless-Steel Bars and Shapes: ASTM A276, Type 316L.

2.4 ALUMINUM

A. General: Provide alloy and temper recommended by aluminum producer for type of use indicated, with not less than the strength and durability properties of alloy, and temper designated below for each aluminum form required.

B. Extruded Bars and Shapes: ASTM B221, alloys as follows:

1. 6061-T6 or 6063-T6, for bearing bars of gratings and shapes.
2. 6061-T1, for grating crossbars.

C. Aluminum Sheet: ASTM B209, Alloy 5052-H32.

2.5 FASTENERS

A. General: Unless otherwise indicated, provide Type 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B633 or ASTM F1941, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.

1. Provide stainless-steel fasteners for fastening aluminum.
2. Provide stainless-steel fasteners for fastening stainless steel.

B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563 and, where indicated, flat washers.

C. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, nuts, and, where indicated, flat washers; ASTM F593 for bolts and ASTM F594 for nuts, Alloy Group 2.

2.6 MISCELLANEOUS MATERIALS

A. Shop Primers: Provide primers that comply with the Protective Coatings section.

B. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.

1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.

C. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.

D. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187.

2.7 FABRICATION

A. Shop Assembly: Fabricate grating sections in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch material cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form from materials of size, thickness, and shapes indicated, but not less than that needed to support indicated loads.

D. Fit exposed connections accurately together to form hairline joints.

E. Welding: Comply with AWS recommendations and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.

F. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space the anchoring devices to secure gratings, frames, and supports rigidly in place and to support indicated loads.

1. Fabricate toeplates to fit grating units and weld to units in shop unless otherwise indicated.
2. Fabricate toeplates for attaching in the field.
3. Toeplate Height: 4 inches unless otherwise indicated.

G. Removable Grating Sections: Fabricate with banding bars attached by welding to entire perimeter of each section. Include anchors and fasteners of type indicated or, if not indicated, as recommended by manufacturer for attaching to supports.

1. Provide no fewer than four weld lugs for each heavy-duty grating section, with each lug shop welded to two bearing bars.

2. Provide no fewer than four saddle clips for each grating section containing rectangular bearing bars 3/16 inch or less in thickness and spaced 15/16 inch or more o.c., with each clip designed and fabricated to fit over two bearing bars.
3. Provide no fewer than four weld lugs for each grating section containing rectangular bearing bars 3/16 inch or less in thickness and spaced less than 15/16 inch o.c., with each lug shop welded to three or more bearing bars. Interrupt intermediate bearing bars as necessary for fasteners securing grating to supports.
4. Provide no fewer than four flange blocks for each section of aluminum I-bar grating, with block designed to fit over lower flange of I-shaped bearing bars.
5. Furnish threaded bolts with nuts and washers for securing grating to supports.
6. Furnish self-drilling fasteners with washers for securing grating to supports.
7. Furnish galvanized malleable-iron flange clamp with galvanized bolt for securing grating to supports. Furnish as a system designed to be installed from above grating by one person.

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

        1) Kee Safety, Ltd.
        2) Lindapter International.
        3) Approved equal.

H. Fabricate cutouts in grating sections for penetrations indicated. Arrange cutouts to permit grating removal without disturbing items penetrating gratings.

1. Edge-band openings in grating that interrupt four or more bearing bars with bars of same size and material as bearing bars.

I. Do not notch bearing bars at supports to maintain elevation.

2.8 STEEL FINISHES

A. Finish gratings, frames, and supports after assembly.

B. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153 for steel and iron hardware and with ASTM A123 for other steel and iron products.

1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.

C. Shop prime gratings not indicated to be galvanized unless otherwise indicated.

1. Shop prime with universal shop primer.

D. Preparation for Shop Priming: Prepare surfaces to comply with requirements indicated below:

1. Exterior Items: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
2. Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
3. Other Items: SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."

E. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing gratings to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing gratings. Set units accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry.

D. Fit exposed connections accurately together to form hairline joints.

1. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade the surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

E. Attach toeplates to gratings by welding at locations indicated.

F. Field Welding: Comply with AWS recommendations and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

G. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.

3.2 INSTALLING METAL BAR GRATINGS

A. General: Install gratings to comply with recommendations of referenced metal bar grating standards that apply to grating types and bar sizes indicated, including installation clearances and standard anchoring details.

B. Attach removable units to supporting members with type and size of clips and fasteners indicated or, if not indicated, as recommended by grating manufacturer for type of installation conditions shown.

C. Attach nonremovable units to supporting members by welding where both materials are same; otherwise, fasten by bolting as indicated above.

3.3 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 requirements for touching up shop-painted surfaces.

1. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.

B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in the Protective Coatings section.

C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.

END OF SECTION

Section 05 81 00

ANCHORAGE IN CONCRETE AND MASONRY

PART 1 - GENERAL

1-1. SCOPE. This section covers the design and installation of anchors in concrete and masonry. It includes cast-in-place anchor bolts and anchor rods, adhesive anchors for both threaded rods and reinforcing bars, expansion anchors, and undercut anchors.

1-2. GENERAL.

1-2.01. Anchors Designed by Design Builder. Cast-in-place and post-installed anchors that are fully detailed on the Drawings have been designed by Design Builder.

1-2.02. Anchors Designed by Design Builder's Suppliers. Design Builder's material suppliers shall be responsible for design of anchors for railings, ladders, equipment, pre-engineered structures, and other manufactured items, as indicated in the Drawings and Specifications. Anchors shall be designed for all operating conditions, including wind and seismic loadings when indicated in the Meteorological and Seismic Design Criteria section. Cast-in-place anchors shall be used unless post-installed types are indicated on the Drawings or accepted by Design Builder. Adhesive anchors used in vibrating applications, such as for pumps, shall only be used if the manufacturer submits documentation indicating that the product is suitable for the service conditions.

1-2.03. Materials. Unless otherwise indicated, anchors of structural steel members connected to concrete shall have a diameter of at least 3/4 inch, and structural members connected to masonry shall have a diameter of at least 5/8 inch. Anchors for ladders and equipment shall have a diameter of at least 1/2 inch. Anchors for pedestrian railing systems shall have a diameter of at least 3/8 inch.

Unless otherwise indicated on the Drawings, anchors used in the following locations and applications shall be of the indicated materials.

Cast-In-Place Anchor Bolts and Anchor Rods

Submerged locations	Stainless steel.
Locations subject to splashing	Stainless steel.
Buried locations	Stainless steel.
Anchorage of structural steel columns	Galvanized steel.

Other exterior locations	Galvanized steel.
Other interior locations	Carbon steel.

Adhesive, Expansion, and Undercut Anchors

Submerged locations	Stainless steel.
Locations subject to splashing	Stainless steel.
Buried locations	Stainless steel.
Anchorage of structural steel columns	Stainless steel.
Other exterior locations	Stainless steel.
Other interior locations	Carbon steel.

Adhesive, expansion, and undercut anchors may be used instead of cast-in-place anchors only where specifically indicated or permitted on the Drawings or with the specific acceptance by Design Builder.

1-3. SUBMITTALS. Data, catalog cuts, and manufacturer's research reports (from independent organizations such as ICC-ES or IAPMO UES) indicating the manufacturer and types of adhesive anchors, expansion anchors, and undercut anchors to be supplied shall be submitted in accordance with the Submittals Procedures section.

Calculations shall be prepared by a professional engineer licensed in the state of California, using methods and procedures required by the building code.

1-4. DELIVERY, STORAGE, AND HANDLING. Materials shall be handled, transported, and delivered in a manner which will prevent damage or corrosion. Damaged materials shall be promptly replaced. Materials shall be shipped and stored in original manufacturer's packaging.

PART 2 - PRODUCTS

2-1. MATERIALS. Unless otherwise indicated on the drawings, materials shall be as indicated below.

Cast-In-Place Anchor Bolts and Anchor Rods

Carbon steel	ASTM F1554, Grade 36 with compatible nuts.

Galvanized steel	ASTM F1554, Grade 36 with compatible nuts; hot-dip galvanized, ASTM F2329.
Stainless steel	Bolts, ASTM F593, Alloy Group 1 or 2 (minimum yield strength of 45 ksi); nuts, ASTM F594, Alloy Group 1 or 2.
Flat Washers	ANSI B18.22.1; of the same material as anchor bolts and nuts.
Expansion Anchors in Concrete	Products shall be single component anchors tested in accordance with ICC AC193, and shall have a manufacturer's research report in compliance with the applicable building code. The anchors shall be approved for use in cracked concrete, and for resisting seismic forces. Hilti "Kwik-Bolt TZ" or Powers Fasteners "Power-Stud+SD2" (carbon steel), "Power-Stud+SD4" (304 stainless steel), and "Power-Stud+SD6" (316 stainless steel).
Expansion Anchors in Grouted Concrete Masonry Units	Products shall be single component anchors tested in accordance with ICC AC01, and shall have a manufacturer's research report in compliance with the applicable building code. Hilti "Kwik-Bolt TZ Masonry Anchors", Simpson "Wedge-All", or Powers Fasteners "Power-Stud+ SD1".
Undercut Anchors in Concrete	Products shall be tested in accordance with ICC AC193, and shall have a manufacturer's research report in compliance with the applicable building code. Hilti "HDA Undercut Anchor" (carbon steel) and "HDA-R Undercut Anchor" (stainless steel), or Powers Fasteners "Atomic+ Undercut Anchor" (A36 carbon steel).

Adhesive Anchors in Concrete	Products shall be tested in accordance with ICC AC308, and shall have a manufacturer's research report in compliance with the applicable building code. The anchors shall be approved for use in cracked concrete, and for resisting seismic forces.
Threaded Rods and Nuts (Carbon Steel)	ASTM A307 or ASTM F1554 Grade 36.
Threaded Rods and Nuts (Stainless Steel)	ASTM F593, CW.
Reinforcing Bars	ASTM A615, Grade 60, deformed.
Reinforcing Bars, weldable	ASTM A706, Grade 60, deformed.
Adhesive	Hilti "HIT-HY 200", or Powers Fasteners "Pure 110+".
Adhesive Anchors in Grouted Concrete Masonry Units	Products shall be tested in accordance with ICC AC58, and shall have a manufacturer's research report in compliance with the applicable building code.
Threaded Rods and Nuts (Carbon Steel)	ASTM A307 or ASTM F1554 Grade 36.
Threaded Rods and Nuts (Stainless Steel)	ASTM F593 CW (Hilti or Powers systems), or ASTM A193 Grades B6, B8, or B8M (for Simpson system).
Adhesive	Hilti "HIT HY 270", Powers "AC100+ Gold", or Simpson "SET XP".
Adhesive Anchors in Hollow Concrete Masonry Units	Products shall be tested in accordance with ICC AC58, and shall have a manufacturer's research report in compliance with the applicable building code.
Threaded Rods and Nuts (Carbon Steel)	ASTM A307 or ASTM F1554 Grade 36.
Threaded Rods and Nuts (Stainless Steel)	ASTM F593 CW (Hilti or Powers systems), or ASTM A193 Grades B6, B8, or B8M (for Simpson system).

Adhesive	Hilti “HIT HY 270”, Powers “AC100+ Gold”, or Simpson “SET XP”.
Screen Tubes	As recommended by the manufacturer.
Adhesive Anchors in Unreinforced Brick Masonry	Products shall be tested in accordance with ICC AC60, and shall have a manufacturer’s research report in compliance with the applicable building code.
Threaded Rods and Nuts	ASTM A307.
Adhesive	Hilti “HIT HY 270”, Simpson “SET”.
Screen Tubes	As recommended by the manufacturer.

2-2. ANCHORS.

2-2.01. Cast-in-Place Anchor Bolts and Anchor Rods. Cast-in-place anchor bolts and anchor rods shall have forged heads or embedded nuts and washers. Anchors shall be delivered in time to permit setting prior to the placing of structural concrete or masonry grout. Anchor sleeves shall not be used unless acceptable to Design Builder. Unless installed in sleeves, anchor bolts and anchor rods shall be provided with sufficient threads to permit a nut to be installed on the concrete side of the concrete form or the supporting template. Two nuts, a jam nut, and a washer shall be furnished for cast-in-place anchor bolts and anchor rods indicated on the Drawings to have locknuts; two nuts and a washer shall be furnished for cast-in-place anchor bolts and anchor rods without locknuts.

2-2.02. Adhesive, Expansion, and Undercut Anchors. When adhesive, expansion, or undercut anchors are indicated on the Drawings, only acceptable systems shall be used. Acceptable systems shall include only those systems and products specified or specifically indicated by product name on the Drawings. Alternative anchoring systems may be used only when specifically accepted by Design Builder.

Unless otherwise noted, single nuts and washers shall be provided with adhesive anchors, expansion anchors, and undercut anchors. Adhesive anchors shall be free of coatings that would weaken the bond with the adhesive.

Adhesive anchors in hollow CMU masonry and unreinforced brick masonry shall utilize screen tubes as recommended by the manufacturer.

PART 3 - EXECUTION

3-1. GENERAL. Anti-seize thread lubricant shall be liberally applied to projecting, threaded portions of stainless steel anchors immediately before tightening of the nuts.

3-1.01. Compliance With Manufacturer's Instructions. Post-installed anchors shall be installed in accordance with the manufacturer's printed installation instructions and all applicable requirements of the manufacturer's research report for the specific anchor system. If conflicts are found between the Drawings, the manufacturer's printed installation instructions, and the manufacturer's research report installation requirements, Design-Builder shall notify Structural Engineer of Record for resolution

3-1.02. Special Inspection. Special inspection requirements for cast-in-place and post-installed anchors shall be as indicated in the Code-Required Special Inspections and Procedures section or as noted in Drawings. Anchorage work shall be performed in a manner that allows the inspections to take place without adversely impacting the schedule.

3-2. CAST-IN-PLACE ANCHOR BOLTS AND ANCHOR RODS. Cast-in-place anchor bolts and anchor rods shall be carefully positioned with templates and secured in the forms prior to placing concrete, or in masonry bond beams prior to placing grout. Design-Builder shall verify that anchorage devices are positioned in accordance with the Drawings and with applicable equipment or structure submittal drawings.

Threads, bolts, and nuts spattered with concrete or masonry grout during placement shall be cleaned prior to final installation of the bolts and nuts.

Sleeves shall be filled with non-shrink grout.

3-3. ADHESIVE ANCHORS. Adhesive shall be statically mixed in the field during application. All proportioning and mixing of the components shall be in accordance with the manufacturer's recommendations.

Anchors or bars shall be installed in holes hammer drilled into hardened concrete or masonry. Drill shall be set to rotation-only mode when drilling into hollow CMU or into brick. Diameter of holes shall be 1/16 inch larger than the outside diameter of the rod or bar unless recommended otherwise by the anchor system manufacturer. Holes shall be prepared by removing all dust and debris using procedures recommended by the adhesive manufacturer.

Adhesive anchors and holes shall be clean, dry, and free of grease and other foreign matter at the time of installation. The adhesive shall be placed and the rods or bars shall be set in accordance with the recommendations of the manufacturer. Care shall be taken to ensure that all spaces and cavities are filled with adhesive, without voids.

3-3.01. Concrete Installation. Unless indicated otherwise on the Drawings, reinforcing bars shall be embedded to a depth of 15 bar diameters, and threaded rods shall be embedded to a depth that will develop the yield strength of the rod.

Adhesive anchors in concrete shall be installed under the following conditions.

Minimum Age of Concrete Prior to Anchor Installation	21 days.
Concrete Temperature Range	Maximum short-term temperature 162 F, maximum long-term temperature 110 F.
Moisture Condition	Dry concrete.
Type of Lightweight Concrete	N/A
Hole Drilling and Preparation	Hammer drill only.

Installation of adhesive anchors into concrete that are either horizontal or upwardly inclined shall be performed only by personnel certified by the ACI/CRSI Adhesive Anchor Installation Certification Program.

3-3.02. Masonry Installation. Anchors shall be installed to meet all criteria in the manufacturer's installation instructions and ICC-ES reports, including but not limited to minimum compressive strength at time of installation, minimum edge distances, minimum clearances from mortar joints, minimum anchor spacing, and use of screen tubes.

3-4. EXPANSION AND UNDERCUT ANCHORS. Expansion and undercut anchors shall be installed using all procedures and accessory devices recommended by the anchor manufacturer.

End of Section

Section 09 97 24

CORROSION PROTECTION SYSTEMS

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing and installation of corrosion protection systems to be applied to floors and walls at the chemical storage facilities and RO CIP area as specified herein and as indicated on the Drawings. This section covers concrete surface preparation, furnishing and application of a corrosion protection system suitable for each set of specified service conditions, the engineering field services to be provided by the material manufacturer and applicator as well as any appurtenances that are required to provide a completed corrosion protection system.

1-2. QUALITY ASSURANCE.

1-2.01. Manufacturer's Field Services. The field services provided by the material manufacturer shall include review of the project before surface preparation; certification of the manufacturer's product for the application; approval of the applicator, the materials, and the procedure to be used; approval of the surface preparation; and approval of the application.

A representative of the corrosion protection system material manufacturer shall submit, through Contractor, written approvals/certification of the proposed protection system materials, application procedures, applicator, and surface preparation requirements.

1-2.02. Applicator Field Services. The Applicator of the corrosion protection system shall contact the corrosion protection system material manufacturer during the bidding phase of the project and shall include in the cost of this work and the estimated cost of the manufacturers engineering field services as specified.

The corrosion protection system Applicator shall submit a satisfactory experience record including references for previous application of the specified corrosion protection systems to concrete structures of similar design and complexity. After the application is complete, the Applicator of the corrosion protection system shall certify that the corrosion protection system is free of pinholes and holidays.

The Applicator shall also perform and provide the adhesion testing and results to determine compliance with the specified minimum pull-off adhesion strength.

Following the application, the Applicator shall certify that the corrosion protection system is free of pinholes and holidays.

1-3. SUBMITTALS. In accordance with the Submittals Procedures section, complete specifications and data on the protection system, application instructions for the protection system, and material manufacturer's approvals for the protection system furnished under this section shall be submitted for Design-Builder review. The lining manufacturer shall submit acceptable lining termination details and metal accessories encapsulation details

1-4. DELIVERY, STORAGE, AND HANDLING. The material shall be delivered to the jobsite in original unopened containers with labels intact. Protection system components shall be stored indoors in an appropriate location and environment in accordance with the manufacturer's recommendations and shall be protected against freezing.

Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

1-5. WARRANTY. Material manufacturer shall warrant the chemical resistance of each corrosion protection system (products and labor) for a period of three years from the date of Substantial Completion when exposed to the customer's normal operating conditions as stated in the specification.

PART 2 - PRODUCTS

2-1. PERFORMANCE AND DESIGN REQUIREMENTS.

2-1.01. General Service Conditions. The corrosion protection system shall provide splash and spill protection for 72 hours from the chemicals as specified herein.

2-2. MATERIALS. Materials shall be suitable for the specified service conditions. Products composing the corrosion protection system shall be chemically resistant to the chemicals, concentrations, temperatures, exposure times, and other relevant service conditions. In many cases, repair materials, primers, flexible basecoats, and other ancillary products that will be protected by a corrosion resistant and/or wear resistant layer of the protection system and may not be required to meet these criteria provided the overall protection system complies with the performance criteria.

Corrosion protection systems specified herein shall be the type of product/system specified for the services and shall be the products of Dudick Inc., Carboline Company, Tnemec Company, International Paint, LLC/Ceilcote, Stonard, without exception. The products of other manufacturers and/or their corrosion protection systems will not be acceptable.

2-2.01. Epoxy Protection Systems.

2-2.01.01. Service Conditions for Epoxy Protection Systems.

Chemicals to be contained at the maximum chemical temperature of 120°F that are corrosive to concrete:

Sodium bisulfite; 38% conc.

Anti-Scalant

Chemicals to be contained at the maximum chemical temperature of 120°F that are not corrosive to concrete, do not stain concrete, and are not hazardous to the environment:

Polymer.

Epoxy protection systems will be exposed to sunlight, UV, and outdoor atmosphere.

2-2.01.02. System Requirements for Epoxy Protection Systems.

Type of lining system.	Coating, non-reinforced, and Lining , with reinforced with flexible basecoat.
Location(s) where coating corrosion protection system is required:	Polymer area within sludge facility.
Location(s) where mat reinforce with flexible basecoat lining system is required:	RO CIP area (including trench), anti-scalant area within chemical facility, sodium bisulfite area within chemical facility

2-2.01.03. Epoxy Coating Protection System. When an epoxy coating lining system is required, the epoxy corrosion protection system shall be a two-component, 100 percent solids, solvent-free, epoxy resin, silica filled, high-build protective and waterproofing coating. All resins in this system shall be 100 percent solids with at least two components. The concrete surface primer shall be an epoxy resin primer containing 100 percent solids. The finish coats shall be amine cured epoxy resin.

2-2.01.04. Epoxy Flexible Lining Protection System. When an epoxy lining system with a flexible basecoat is required, the corrosion protection system shall be a two-component, 100 percent solids, solvent-free, epoxy resin, silica filled, fiberglass mat reinforced flexible basecoat, high-build protective and waterproofing lining. All resins in this system shall be 100 percent solids with at

least two components. The concrete surface primer shall be an epoxy resin primer containing 100 percent solids. The flexible basecoat shall be certified by the material manufacturer as capable of not less than 50 mils of differential movement without damaging the corrosion protection system. The basecoat shall be a flexible epoxy resin with silica fillers with a chopped strand mat reinforcement and saturant. The finish coats shall be epoxy resin.

2-2.02. Vinyl Ester Protection Systems.

2 -2.02.01. Service Conditions for Vinyl Ester Protection Systems.

Chemicals to be contained at the maximum chemical temperature of 120°F that are corrosive to concrete:

Citric acid; 34% conc.

Vinyl ester protection systems will be exposed to sunlight, UV, and outdoor atmosphere.

2-2.02.02. System requirements for Vinyl Ester Protection Systems.

Type of lining system.	Lining, mat reinforced with flexible basecoat.
Location(s) where a mat reinforced with flexible basecoat lining corrosion protection system is required:	Citric acid area within chemical facility

2-2.02.03. Vinyl Ester Coating Protection System. Not used.

2-2.02.04. Vinyl Ester Rigid Lining Protection System. Not used.

2-2.02.05. Vinyl Ester Flexible Lining Protection System. When a vinyl ester lining system with a flexible basecoat is required, the corrosion protection system shall be a two component, 100 percent solids, solvent-free, high-build protective and waterproofing lining. Concrete surface primer shall be an epoxy resin primer containing 100 percent solids. The flexible basecoat shall be certified by the material manufacturer as capable of not less than 50 mils of differential movement without damaging the corrosion protection system. Flexible basecoat with reinforcement shall be epoxy resin with silica fillers. Reinforcement shall be chopped strand mat. Saturant for reinforcement shall be epoxy resin. Finish coats shall be a two component, 100 percent solids, solvent-free, vinyl ester resin.

2-2.03. Vinyl Ester With Graphite Filler Protection Systems.

2-2.03.01. Service Conditions for Vinyl Ester With Graphite Filler Protection Systems.

Chemicals to be contained at the maximum chemical temperature of 120°F, unless otherwise indicated, that are corrosive to concrete:

Sodium hydroxide; 150°F.

Sodium hypochlorite; up to 15% conc.

Vinyl ester with graphite filler protection systems will be exposed to sunlight, UV, and outdoor atmosphere.

2-2.03.02. System requirements for Vinyl Ester With Graphite Filler Protection Systems.

Type of lining system.	Lining, mat reinforced with flexible basecoat.
Location(s) where a mat reinforced with flexible basecoat lining corrosion protection system is required:	Common sodium hypochlorite / sodium hydroxide storage area within chemical facility (including the truck unloading pit).

2-2.03.03. Vinyl Ester With Graphite Filler Coating System. Not used.

2-2.03.04. Vinyl Ester With Graphite Filler Rigid Lining System. Not used.

2-2.03.05. Vinyl Ester With Graphite Filler Flexible Lining System. The corrosion protection system shall be a two component, 100 percent solids, solvent-free, vinyl ester resin, graphite filled, mat reinforced flexible basecoat, high-build protective and waterproofing lining. Concrete surface primer shall be an epoxy resin primer containing 100 percent solids. The flexible basecoat shall be certified by the material manufacturer as capable of not less than 50 mils of differential movement without damaging the corrosion protection system. Flexible basecoat with reinforcement shall be epoxy resin with silica fillers. Reinforcement shall be chopped strand mat. Saturant for reinforcement shall be epoxy resin. Finish coats shall be a two component, 100 percent solids, solvent-free, graphite filled vinyl ester resin.

2-2.04. Novolac Vinyl Ester Protection Systems. Not used.

2-2.05. Novolac Epoxy Protection Systems.

2-2.05.01. Service Conditions for Novolac Epoxy Protection Systems.

Chemicals to be contained at the maximum chemical temperature as indicate that are corrosive to concrete:

Sulfuric acid; up to 98% conc. at 150°F.

Novolac epoxy protection systems will be exposed to sunlight, UV, and outdoor atmosphere.

2-2.05.02. System requirements for Novolac Epoxy Protection Systems.

Type of lining system.	Lining, mat reinforced with flexible basecoat.
Location(s) where a mat reinforced with flexible basecoat lining corrosion protection system is required:	Sulfuric acid storage and feed area within chemical facility.

2-2.05.03. Novolac Epoxy Coating Protection System. Not used.

2-2.05.04. Novolac Epoxy Rigid Lining Protection System. Not used.

2-2.05.05. Novolac Epoxy Flexible Lining Protection Systems. The novolac epoxy corrosion protection system shall be a two component, 100 percent solids, solvent-free, novolac epoxy resin, silica filled, high-build protective and waterproofing coating. Concrete surface primer shall be an epoxy resin containing 100 percent solids. The flexible basecoat shall be certified by the material manufacturer as capable of not less than 50 mils of differential movement without damaging the corrosion protection system. Flexible basecoat with reinforcement shall be an epoxy resin with silica fillers and chopped strand fiberglass mat. Saturant for reinforcement shall be epoxy resin. Finish coats shall be a two component, 100 percent solids, novolac epoxy resin.

2-2.06. Epoxy Filler Compound. Epoxy filler compound for concrete surfaces shall be a two-component, 100 percent solids epoxy filler or as recommended by the corrosion protection system material manufacturer.

2-2.07. Corrosion Resistant Caulking/Sealant. Chemical resistant caulking/sealant shall be suitable for the specified service conditions and shall be as recommended, in writing, by the protection system material manufacturer.

2-2.08 Reinforced Epoxy Resin Topping Systems. The topping/lining shall provide abrasion resistance and splash and spill resistance for 72 hours at the polymer storage and feed area.

The corrosion protection system shall be a three-component, 100 percent solids, epoxy resin, silica filled, protective and waterproof topping with a heavy-duty reinforcement layer of woven roving. Concrete surface primer shall be an epoxy resin primer containing 100 percent solids. The topping corrosion protection system shall be certified by the material manufacturer as capable of at least 10 mils of differential movement without damaging the corrosion protection system.

2-2.09 Reinforced Vinyl Ester Resin Topping Systems. Not used.

2-2.10 Reinforced Vinyl Ester with Graphite Resin Topping Systems. Not used.

2-2.11 Reinforced Novolac Vinyl Ester Resin Topping Systems. Not used.

2-2.12 Reinforced Novolac Epoxy Resin Topping Systems. Not used.

PART 3 - EXECUTION

3-1. GENERAL. All details, methods, and procedures of mixing, surface preparation, bonding, application, finishing, curing, and protection of the protection system shall be in strict accordance with the recommendations of the material manufacturer. The applicator shall comply with the recommendations of the material manufacturer.

3-2. SURFACE PREPARATION. All surfaces shall comply with the SSPC/NACE guidelines for surface preparation as specified herein and shall meet the manufacturer's recommendations for surface preparation.

All surfaces shall be dry when coated or lined, and shall be free from dirt, dust, sand, mud, oil, grease, rust, mill scale, and other objectionable substances. Oil and grease shall be completely removed as recommended by the material manufacturer before mechanical cleaning is started.

3-2.01. Concrete Surfaces. Concrete surfaces shall be prepared in accordance with SSPC-SP13/NACE 6 and the lining material manufacturer's recommendation. Surfaces shall be free of cracks, pits, projections, or other imperfections that would interfere with the formation of a smooth, unbroken coating film.

New concrete shall be cured for at least 28 days before lining is applied and shall be ready to receive the lining as determined by the Applicator and material manufacturer. Concrete surfaces shall be tested for capillary moisture in the concrete in accordance with ASTM D4263. There shall be no capillary moisture migration after 24 hours as determined by the test method. If moisture is observed, the corrosion protection system shall include a vapor barrier that is recommended by the protection system manufacturer.

All concrete surfaces to be lined shall be cleaned in accordance with ASTM D4258 and abrasive blasted in accordance with ASTM D4259. Before the lining is applied, the surfaces shall be thoroughly washed or cleaned by air blasting to remove all dust and residue. The Contractor shall repair all concrete surfaces that have spalls, voids, and cracks and shall remove all fins and other surface projections to produce a flush surface for application of the protection system.

Surface profile shall be at least 4 mils for a coating protection system and at least 22 mils for a lining protection system, but shall not be less than 25 percent of the dry film thickness specified for the corrosion protection system or 40-60 grit sandpaper unless recommended otherwise by the material manufacturer.

Concrete surfaces shall be pinhole free as using an epoxy concrete filler or as recommended by the material manufacturer and acceptable to Design-Builder.

3-2.01.01. Existing Concrete. Not Used.

3-2.01.02. Adhesion Testing. Adhesion testing shall be conducted, by the Applicator, at each application area, after the concrete surfaces has been prepared and approved by the Applicator and lining material manufacturer. Adhesion strength test results shall exceed 400 psi or a higher value if recommended by material manufacturer. Adhesion test results shall be presented to and approved by Design-Builder.

The test area shall be at least 2 square feet to allow a minimum of three tests to be conducted. Pull-off strength adhesion tests shall be conducted by the Applicator in accordance with ASTM D7234 for concrete surfaces using an Elcometer tensile adhesion tester. At least three adhesion tests shall be conducted and the results averaged. Adhesion strength shall equal or exceed the minimum adhesion strength specified herein and by the material manufacturer.

3-2.02. Metal Surfaces. Metal surfaces shall be prepared in accordance with the following: All sharp edges, and corners are to be ground smooth, welds are to be ground smooth, in accordance with NACE standard RP0 178, Appendix C. Designation C, shall have all weld slag and splatter removed and be free of all defects. The surfaces shall be abrasive blasted in conformance with SSPC SP-10 and shall be at least a 3 mil surface profile.

3-3. MIXING AND THINNING. Materials shall be thoroughly mixed each time any is withdrawn from the container, and the containers shall be kept tightly closed except while the material is being withdrawn.

Corrosion protection system components shall be mixed to proper consistency and viscosity in accordance with the manufacturer's recommendations. Thinning will not be permitted. No adulterant, unauthorized thinner, or other material not

included in the formulation, shall be added to the protection system components for any purpose

3-4. APPLICATION. Corrosion protection systems shall be applied in accordance with the manufacturer's recommendations and in a neat manner, with finished surfaces free of runs, sags, ridges, laps, and brush marks. In no case shall the dry film thickness of applied protection system be less than the thickness recommended by the material manufacturer.

Grit shall be broadcast into first finish lining coat to produce an anti-skid surface.

Each coat shall be applied over the previous coat in accordance with the recommendations of the material manufacturer. Each coat shall be applied in a manner that will produce an even film of uniform and proper thickness. In no case shall coating be applied at a rate of coverage which is greater than the maximum rate recommended by the material manufacturer.

Recoating shall be applied in accordance with manufacturer's recommendations.

Alternate coats shall be of contrasting colors to facilitate in obtaining complete coverage. The first coat shall be a dark color.

Corrosion protection systems showing checks, blisters, excessive sags, teardrops, or fat edges will not be acceptable and shall be entirely removed and the surface recoated. The protection system shall be free of pinholes and holidays.

Corrosion protection systems shall be applied when surface temperature is at least 50°F and at least 5°F above dewpoint, and relative humidity is 85 percent or lower. Protection system shall not be applied in direct sunlight or when the temperature of the concrete is rising. Preferably the protection system shall be applied when the temperature of the concrete is dropping.

When applying high build protection system with a roller or brush and where a dry film thickness of at least 4 mils per coat is required, two or more coats shall be applied to achieve the recommended dry film thickness equal to a spray applied coating.

3-4.01. Epoxy Protection Systems.

3-4.01.01. Epoxy Coating Protection System. Epoxy coating corrosion protection system shall be applied in three or more coats. The system shall consist of one prime coat and two or more finish coats. The prime coat shall be at least 6 mils wet film thickness (WFT). Each finish coat shall be 6-8 mils dry film thickness (DFT). The protection system shall have a total thickness of at least 20 mils DFT.

3-4.01.02. Epoxy Flexible Lining Protection System. The corrosion protection system shall be applied in four or more coats. The system shall consist of one prime coat, one basecoat with reinforcement and saturant, and two or more finish coats. The prime coat shall be at least 6 mils wet film thickness (WFT). The basecoat shall be trowel applied, to a thickness that provides the specified minimum differential movement. The reinforcement shall be pressed firmly into the basecoat, and then saturated with the basecoat resin mixture. Each finish coat shall be 8 mils dry film thickness (DFT). The protection system shall have a total thickness of at least 90 mils DFT.

3-4.02. Vinyl Ester Protection Systems.

3-4.02.01. Vinyl Ester Coating Protection System. Not used.

3-4.02.02. Vinyl Ester Rigid Lining Protection System. Not used.

3-4.02.03. Vinyl Ester Flexible Lining Protection System. The corrosion protection system shall be applied in four or more coats. The protection system shall consist of one prime coat, one basecoat, reinforcement and saturant, and two or more finish coats. The prime coat wet film thickness shall be at least 5 mils. The basecoat shall be trowel applied, to a thickness that provides the specified minimum differential movement. The reinforcement shall be pressed firmly into the basecoat, and then saturated with the basecoat resin mixture. Each finish coat shall be 15-20 mils dry film thickness. The protection system shall have a total dry film thickness of at least 100 mils.

3-4.03. Vinyl Ester With Graphite Filler Protection Systems.

3-4.03.01. Vinyl Ester With Graphite Filler Coating System. Not used.

3-4.03.02. Vinyl Ester With Graphite Filler Rigid Lining System. Not used.

3-4.03.03. Vinyl Ester With Graphite Filler Flexible Lining System. The corrosion protection system shall be applied in four or more coats. The corrosion protection system shall consist of one prime coat, one basecoat, reinforcement and saturant, and two or more finish coats. The prime coat wet film thickness shall be at least 5 mils. The flexible basecoat shall be trowel applied, to a thickness that provides the specified minimum differential movement. The reinforcement shall be pressed firmly into the basecoat, and then saturated with the basecoat resin mixture. Each finish coat shall be 15-20 mils dry film thickness. The protection system shall have a total dry film thickness of at least 100 mils.

3-4.04. Novolac Vinyl Ester Protection Systems. {Not used.}

Specifier: For 100% acetic acid, the corrosion protection lining system thickness shall be changed to at least double the indicated thickness.

3-4.05. Novolac Epoxy Protection Systems.

3-4.05.01. Novolac Epoxy Coating Protection System. Not used.

3-4.05.02. Novolac Epoxy Rigid Lining Protection System. Not used.

3-4.05.03. Novolac Epoxy Flexible Lining Protection Systems. The corrosion protection system shall be applied in four or more coats. The protection system shall consist of one prime coat, one basecoat, reinforcement and saturant, and two or more finish coats. The prime coat wet film thickness shall be at least 4 mils. The basecoat shall be trowel applied, to a thickness that provides the specified minimum differential movement. The reinforcement shall be pressed firmly into the basecoat, and then saturated with the basecoat resin mixture. Each finish coat shall be 15-20 mils dry film thickness. The protection system shall have a total dry film thickness of at least 100 mils.

3-4.06. Epoxy Filler. An epoxy filler shall be used in a 1-inch minimum radius to fill in floor to wall joints for a liquid tight joint.

3-4.07. Corrosion Resistant Caulking/Sealant. Corrosion resistant caulking/sealant shall be used at any penetration in the lining, such as at anchorage of pipe supports and chemical storage tanks.

3-4.08 Topping System. The reinforced resin topping systems shall be applied when surface temperature is 50^{o}F or higher and relative humidity is 90 percent or lower. Toppings shall not be applied in direct sunlight or when the temperature of the concrete is rising. Preferably the topping shall be applied when the temperature of the concrete is dropping.

3-4.08.01. Bonding. Topping shall be bonded to a clean, dry, and properly prepared concrete surface and that has been coated with a concrete primer that is acceptable to the topping manufacturer and Design-Builder.

3-4.08.02. Minimum Thickness. Topping shall have a minimum thickness of 1/8 inch.

3-4.08.03. Finish. Topping shall receive a uniform trowel finish.

3-5. FIELD QUALITY CONTROL. Finished surfaces shall be cleaned and prepared as needed to properly conduct the visual inspection, spark testing, and adhesion testing. All inspection and testing shall be witnessed by Applicator and Material Manufacturer. Repairs shall be acceptable to Design-Builder.

3-5.01. Visual Inspection. The surface of the liner shall be visually inspected for areas defects, air inclusion, pinholes, or other imperfections in the system that may prevent a complete seal of the surfaces.

3-5.02. Spark Testing. Where practical, after liners are installed, the applicator shall spark-test all lined metal surfaces using an acceptable high-voltage electrical spark tester set at the recommended voltage. The material manufacturer shall verify the testing equipment is working properly before beginning the spark testing of the lining. The electrode movement shall be continuous and shall proceed in a systematic manner that will cover 100 percent of the lining surface.

3-5.03. Adhesion Testing. The Design-Builder reserves the right to require adhesion testing of any finished corrosion protection system application specified herein. Adhesion testing shall be conducted as specified in Paragraph 3-2.01.01 above by the Applicator. Adhesion strength test results shall exceed 300 psi or a higher value. Finished system adhesion test results shall be presented to and approved by Design-Builder, Applicator, and lining material manufacturer. Following adhesion testing, the area(s) tested shall be repaired by the Applicator with the specified products and methods specified herein.

If the finished system fails an adhesion test, the cause of the failure shall be determined and corrected before the test is repeated on a new test area. If the adhesion test fails a second time, the Design-Builder reserves the right to require the entire surface to be completely removed and reapplied at no cost.

3-5.04. Film Thickness. Coating film thickness shall be verified by measuring the wet film thickness of each coat as it is applied and the dry film thickness of the entire system. Wet film thickness shall be measured with a gauge that will measure the wet film thickness within an accuracy of ±0.5 mil. Dry film thickness for concrete shall be measured using a Defelsko Positector 200 series or equal, in accordance with SSPC-PA9 (concrete) and PA2 (steel). At the discretion of the Design-Builder, core samples could be obtained for measuring dry film thickness.

3-6. PROTECTION. Care shall be taken to prevent coating from being dropped or spilled on adjacent surfaces, buildings, structures, or facilities. All surfaces so damaged shall be cleaned, repaired, replaced, or painted as acceptable to Design-Builder.

End of Section

Section 13 34 19

METAL BUILDING SYSTEMS

PART 1 - GENERAL

1-1. SCOPE. This section covers the design, fabrication and erection of the following framed pre-engineered metal building(s) and miscellaneous components.

Building Identification	Water Reclamation Facility	multiple structures
Location	Morro Bay, CA	

Earthwork, concrete, masonry, stairs, rolling doors, overhead doors, interior partitions and ceilings, floor finishes, plumbing, heating, ventilating, air conditioning, hoisting equipment, and electrical work are covered in other sections.

1-2. GENERAL. Building components and accessories shall be designed and erected in full conformity with the Drawings, specifications, engineering data, instructions, and recommendations of the building manufacturer unless exceptions are noted by the Engineer.

The building dimensions shall be as indicated on the Drawings. Fascias, parapets, canopies, screens, and other architectural features shall be as indicated on the Drawings.

The building shall be furnished complete with all primary and secondary structural framing, bracing, connections, metal wall and roof coverings, flashings, closures, metal trim, fasteners, sealants, caulking, and all other accessories needed for a complete weathertight building, and other miscellaneous components or accessory items when required, as specified or indicated on the Drawings. Other appurtenant items such as crane runway beams, supports, and bracing; secondary framing for piping, roof ventilator curbs, conduit, and equipment hangers, etc.; shall be provided as indicated on the Drawings and as specified herein. Framing and connections shall be provided to transfer lateral and vertical loadings from any appurtenant items and secondary framing into the primary structural framing systems.

The building shall include framed openings and flashings for all doors, windows, louvers, and other openings as needed. Doors, hardware, windows, glazing, and louvers shall be as specified in other sections.

Miscellaneous components intended for use on other structures (matching roof or wall panels and girts, for example) shall be provided as indicated on the

Drawings. Such components shall match the appearance of the pre-engineered metal buildings.

1-2.01. Coordination. The metal building erector shall coordinate with Engineer and Design-Builder for the erection and field quality control of the metal building and appurtenances, the erection of any hoisting equipment, installation of equipment, and the installation of any interior systems and finishes.

1-2.02. Governing Standards. The building design and erection shall comply with the codes indicated in the Meteorological and Seismic Design Criteria section.

The building design shall also comply wholly or in part, as specified herein, with the Metal Building Manufacturers Association (MBMA) "Metal Building Systems Manual". In case of conflicting requirements, the applicable building code shall govern.

Steel construction with hot-rolled structural shapes and plates shall be in accordance with AISC "Specifications for Structural Steel Buildings". Light gauge structural steel members shall be designed and detailed in accordance with AISI "Specifications for the Design of Cold-Formed Steel Structural Members". Welding shall be in accordance with AWS D1.1, Structural Welding Code - Steel.

Building erection shall comply with the applicable provisions of OSHA Standard 29 CFR 1926, Subpart R.

1-2.03. Manufacturer Certification. The building manufacturer shall be certified in accordance with the International Accreditation Service (IAS) metal building inspection program, IAS AC472.

1-3. DELIVERY, STORAGE, AND HANDLING. All factory finished materials shall be protected for shipment in accordance with accepted packaging standards. Minor damage to finishes shall be touched up before installation using color-matched, air-drying paint furnished by the manufacturer. No other finish will be acceptable. Any significantly damaged components shall be replaced at no cost to Owner. Anchor bolts and their accessories shall be delivered in time to avoid delays in placing concrete.

1-4. SUBMITTALS. The following items shall be submitted to Engineer for review prior to fabrication of the building elements. All drawings and data shall be submitted in accordance with the Submittals Procedures section.

Complete drawings and data showing anchor bolts, construction details, lateral thrust details, cross-sections, insulation, roof and wall panels, fasteners, accessories, locations of all openings, building elevations, panels colors when noted on Drawings, and flashing details. Drawings

shall be sealed by a professional engineer registered in the state where the building is to be erected.

A letter of design certification listing the design criteria, including design codes, standards, loads, and other design information indicated in this section; and the structural calculations. The letter of design certification and the structural calculations shall be sealed by a professional engineer registered in the state where the building is to be erected.

All loads imposed by the metal building to the foundation.

Documentation of IAS AC472 certification.

Manufacturer's erection information indicating standard recommendations, erection details, and piece markings.

Samples of the manufacturers' available colors.

1-5. WARRANTY. After final acceptance, the completed structure shall be warranted by the metal building manufacturer to be completely weathertight under all weather conditions for a period of 20 years. Leaks which occur during the correction period, whether through roofs, walls, doors, or accessory equipment or materials, shall be repaired at no cost to, and to the satisfaction of, Owner's Representative.

The roof finish shall be warranted by the manufacturer for a period of 25 years. The wall finish shall be warranted by the manufacturer for a period of 25 years.

PART 2 - PRODUCTS

2-1. ACCEPTABLE MANUFACTURERS. Pre-engineered metal buildings shall be as manufactured by Varco-Pruden Buildings.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Minimum design loadings and requirements shall be in accordance with the applicable building code and as specified. Design data for determining seismic, wind, snow and ice loads shall be as indicated in the Meteorological and Seismic Design Criteria section. Load combinations shall be in accordance with the applicable building code.

The building shall be designed in accordance with the following requirements.

Building identification.	All indicated on Drawings
Minimum roof live load.	20 psf

Minimum roof uplift load.	Per building code.
Minimum platform live load.	100 psf
Collateral roof dead load.	5 psf
Interior walls lateral load.	5 psf
Hoisting loads.	See Drawings for hoist/trolley locations and lifting capacities.

Maximum permissible deflections.

Roof Panels	L/60 under the maximum full load condition.
Roof Purlins	Maintain positive drainage under dead plus the greater of (0.5)snow or 5 psf.
Roof Purlins (supporting a plaster or stucco ceiling, roof mounted equipment, or process piping)	L/240 under dead plus live, L/360 under the greater of roof live, snow, or wind.
Roof Purlins (supporting a non-plaster ceiling, and no equipment or process piping)	L/180 under dead plus live, L/240 under the greater of roof live, snow, or wind.
Roof Purlins (no ceiling, equipment, or process piping)	L/150 under the greater of roof live or snow.
Main Roof Members (supporting a plaster or stucco ceiling, cranes, equipment, or process piping)	L/240 under dead plus live, L/360 under the greater of roof live, snow, or wind.
Main Roof Members (supporting a non-plaster ceiling, and no cranes, equipment, or process piping)	L/180 under dead plus live, L/240 under the greater of roof live, snow, or wind.
Main Roof Members (no ceiling, cranes, equipment, or process piping)	L/120 under dead plus live, L/180 under the greater of roof live, snow, or wind.
Roof Purlins or Main Roof Members (with a partition wall below)	3/8 inch under the greater of 0.5(roof live) or snow.
Floor Beams or Girders	L/360 under dead plus live, L/240 under dead.

Floor Beams or Girders (supporting a non-plaster ceiling)	1 inch under dead.
Floor Beams or Girders (supporting a partition wall)	3/8 inch under 0.5(live).
Runway Beams for Top-Running (Bridge) Cranes	L/800 under crane vertical static load.
Runway Beams for Top Running (Bridge) Cranes	L/400 (horizontal) under crane lateral.
Runway Beams for Underhung Cranes	L/450 under crane vertical static load.
Runway Beam Supports	1/2 inch inward under live or snow, 1 inch outward under snow.
Machine/Sheave Beams at Elevators	L/1666 under dead plus live.
Machine/Sheave Beams Supports	H/1666 under dead plus live.
Girts and Wind Columns (providing horizontal support to metal wall panels)	L/120 under wind.
Girts and Wind Columns (providing horizontal support to CMU walls)	Lesser of L/240 or 1.5 inches under wind.
Girts and Wind Columns (providing horizontal support to plaster or stucco finishes)	L/360 under wind.
Bare Frame (providing horizontal support to metal wall panels)	H/100 under wind.
Bare Frame (providing horizontal support to precast concrete wall panels)	H/100 under wind.
Bare Frame (providing horizontal support to reinforced CMU walls)	H/200 under wind.
Bare Frame (providing horizontal support to metal panels)	H/100 under wind.
Bare Frame (providing horizontal support to metal panels)	H/100 under wind.
Bare Frame (next to a partition wall)	H/500 under wind.

Bare Frame (supporting top running cab operated crane)	Lesser of H/240 or 2 inches at the runway elevation, under the greater of wind or crane lateral.
Bare Frame (supporting top running pendant operated crane)	H/100 at the runway elevation, under the greater of wind or crane lateral.
Bare Frame (at elevators)	H/500 under wind.

Notes

1. Wind load (for purposes of deflection calculations only) shall be 0.7 times the service level components and cladding pressure.

2. The roof live load or snow load shall not be reduced in consideration of the tributary area.

The building design shall account for all dead, live, and impact loads in accordance with the Metal Building Systems Manual, including conservative estimates for the hoisting equipment weights.

In addition, the building shall be designed to carry loads, including crane rails and runway beams, pipe and equipment, lateral loads of wall systems furnished by others, and other loads as indicated on the Drawings. Secondary framing to carry these loads to the main building frames shall be provided with the building system unless otherwise specifically noted on the Drawings.

Unless specifically authorized by Engineer in writing, for steel building design, columns and posts shall be considered "hinged" at their base. The building foundation shall not be required to accept either full or partial moment fixity from steel building columns or posts.

Masonry wall or wall cladding dead loads shall be considered as supported by the foundation and not the wall girts of the building.

Anchor rods shall be as specified in the Materials paragraph. Anchor rods and related anchorages shall be designed to resist column and brace reactions from loading combinations. The metal building manufacturer shall determine anchor rod diameter, quantity, projection, and arrangement. Each column base plate shall have a minimum of four anchor rods, and the minimum spacing between anchor rods shall be six rod diameters. Anchor rod diameter shall be determined in accordance with ACI 318, Appendix D, assuming that a maximum of two anchor rods transfer shear forces from the columns to the foundation.

If additional shear capacity beyond the shear capacity of the anchor rods is required, a design utilizing shear lugs field welded to an embedded foundation

weld plate shall be utilized. No shear lugs or bars on the underside of the base plate will be permitted unless approved by Engineer.

Bracing shall clear all openings indicated on the Drawings.

Girts shall be uninterrupted past outside column face as indicated on the Drawings.

Columns shall be tapered or straight-sided as indicated on the Drawings.

Metal roof systems shall be Class 90 in accordance with Underwriters' Laboratories "Tests of Wind-Uplift Resistance of Roof Assemblies - UL 580" and shall be listed for Class 90 in Underwriters' Laboratories "Building Materials Directory".

2-3. MATERIALS. Materials for the building shall be new and free from defects, and shall meet the following requirements unless otherwise indicated on the Drawings.

Frames and Structural Components	Steel, ASTM A36 or A572.
Structural Bolts	ASTM A325, black, for main framing. ASTM A307, black, for girts and purlins.
Anchor Rods and Nuts	Headed ASTM F1554, Grade 36 with compatible nuts and washers; hot-dip galvanized, ASTM A153 and A385. Heads may be provided by using a nut on a threaded shaft with mechanically deformed threads to prevent nut rotation.
Flat Washers	ANSI B18.22.1; of a material and with coating compatible with anchor bolts and nuts.
Secondary Framing	ASTM A1011 or A1008, cold-formed, with a minimum yield strength of 50 ksi [345 MPa].
Roof Panels	Varco-Pruden “SLRII”, without exception, 24 gage minimum, 45 ksi [310 MPa] minimum yield steel, with concealed clips.

Wall Panels	Varco-Pruden “ImpressaClad”, 16 inch wide at Operations Building lower walls, 20 gage 42 ksi minimum yield steel with concealed fasteners; and Varco-Pruden "Tech Four" elsehwere, 16 inch wide, 24 gage minimum 42 ksi minimum yield steel, with concealed fasteners.
Insulation (Maintenance Building Shop Roof)	0.6 pcf [9.6 kg/m^3] density glass fiber blankets, faced with a white vinyl polyester scrim with a permeability rating of 0.02; Owens Corning Fiberglass Certified R-MBI; or acceptable equal.
Insulation (Walls)	Furnished by others.
Gutters and Downspouts	Minimum 26 gauge [0.45 mm] galvanized steel conforming to ASTM A653, G-90 coating with factory applied finish.
Flashing and Trim	Steel with factory applied painted finish or galvalume finish for non-painted areas.
Roof Curbs	Manufacturer's standard.
Exposed Fasteners	Self-tapping, carbon steel screws with AISI Type 302 stainless steel cap and metal-back neoprene washers, or as recommended by building manufacturer; screwheads capped or colored to match panel finish.
Sealant	As recommended by building manufacturer and acceptable to Engineer.
Miscellaneous Accessories	Manufacturers' standard.
Personnel Doors and Frames	Furnished by others.
Storefront and Entrance Systems	Furnished by others.
Windows	Wintech S250 Series Aluminum.
Type	Fixed or projecting as indicated in Window Schedules.
Frames	Aluminum extrusions, Alloy 6063, minimum 0.062 inch [1.57 mm] thick, with white finish.

Glazing	Plate or float glass, 1/4 inch [6 mm] thick, ASTM C1036, Type I, Class 1, Q3, clear, safety glass where indicated Window Schedules or required by code.
Glazing	Insulated glass, 3/4 inch [19 mm] thick, ASTM E774, Class A; made from 1/4 inch [6 mm] plate or float glass and 1/4 inch [6 mm] air space, exterior and interior lights clear.
Louvers	Furnished by others.
Baseplate Grout (if required)	See Grouting section.
Touchup Painting	As recommended or as supplied by the building manufacturer.
Finish Painting of Structural Members	See Architectural Painting section.

2-4. FABRICATION. All primary framing shall be shop fabricated for bolted field assembly. Secondary framing shall have bolted or welded connections. All members shall be accurately shop punched. All framing members shall have an easily visible identifying mark.

2-4.01. Wall Panels. Wall panels shall be factory roll formed. Where possible, the panels shall be of one piece from base to eave. All side laps shall have a width of at least one full corrugation.

2-4.02. Roof Panels. Roof panels shall be factory roll formed, with a nominal coverage width of 24 inches [600 mm] and with two major corrugations per panel. Panels shall be of maximum length to minimize end laps.

2-4.03. Insulation. Insulation for walls and roof shall be noncombustible glass fiber blankets with 4 mil [100 µm] vinyl film facing, carrying an Underwriters' Laboratories fire hazard rating for a flame spread of 25 or less.

2-4.04. Trim and Flashings. Trim and flashing members shall be fabricated from the same materials and with the same finishes as the materials to which they are attached. Trim members shall be manufacturer's standard profiles for the use intended.

2-4.05. Gutters and Downspouts. Minimum gutter cross sectional area shall be as indicated on Drawings. Minimum slope of gutters shall be 1/8 inch/foot. The gutter apron shall extend under the roof panels to provide a positive counterflashing. The outside face of the gutter shall be supported with at least 16 gauge [1.52 mm] galvanized steel straps attached to the eave member at a spacing not to exceed 4 feet [1.2 m].

Minimum downspout cross sectional area shall be 12 sq inches. Each downspout shall have an elbow at the base and shall be supported with a minimum of 24 gauge [0.61 mm] galvanized steel clincher bands attached to the wall covering at a spacing not to exceed 10 feet [3.1 m]. The location of downspouts shall be as indicated on the Drawings.

Gutters and downspouts shall be finish coated to match the wall panels.

2-4.06. Anchor Rods. Design-Builder shall furnish anchor rods. Rod embedment shall be in accordance with the Drawings.

The diameter, quantity, projection, and arrangement of the anchor rods shall be based on information provided by the metal building manufacturer.

2-4.07. Hoist and Crane Runways. Hoist monorails and crane runway framing, including crane rails with necessary stops and appurtenances, shall be furnished as indicated on the Drawings and as specified in the Metal Building Systems Manual. Crane and hoist capacities, location and number, span, and travel shall be as indicated on the Drawings.2-4.08. Roof Equipment Curbs. Roof equipment curbs shall be provided where indicated on the Drawings. The curbs shall have a water diverter on the up-slope side. The curb base profile shall match the adjacent roof panel profile. All corners shall be mitered and welded watertight. The curbs shall be reinforced as needed to support the equipment specified or indicated, including the seismic and wind forces thereon. The curbs shall be finished to match the adjacent roof panels.**]**

2-4.09. Windows. Windows shall be provided at the locations and in the sizes indicated on the Drawings. The window types shall be as specified herein. Windows shall be provided complete with thermal broken frames, glazing, weatherstripping, insect screens, and accessories, and shall meet the applicable portions of AAMA Standard 101. Windows shall be glazed as specified herein. All exposed surfaces of frames and accessories shall be finished with manufacturer's standard factory finish.

2-5. COATINGS. Unless otherwise required, finish on exposed surfaces of wall panels, roof panels, flashings, appurtenances, and trim shall be a baked-on 70% PVDF, “Kynar 500” or “Hylar 500”, minimum 0.8 mil thick, over a minimum 0.2 mil primer. Finish on sides concealed by insulation or interior finishes may be manufacturer’s standard.

Multiple colors shall be selected form the manufacturer’s standard color chart. A minimum of 20 colors shall be offered.

All steel parts which are not specified to be factory finished and which are not zinc coated shall be cleaned and shop primed.

Any surfaces abraded or damaged during fabrication shall be touched up or repainted. All welds shall be thoroughly cleaned and touched up with a suitable primer.

A suitable quantity of touchup paint shall be provided with the metal building.

2-6. WARRANTY. The roof and wall panel coating systems shall be warranted against cracking, fading, peeling, crazing, chipping, or other failure.

PART 3 - EXECUTION

3-1. ERECTION. Building parts shall be plumb and level with a tolerance as recommended by the metal building supplier. Fasteners shall be installed and tightened for all connections. High strength structural bolts shall be tensioned by any method set forth in the AISC Steel Construction Manual, except calibrated wrench. Necessary field welding shall be by certified welders in accordance with AWS D1.1, Structural Welding Code - Steel. Welders' qualifications shall be submitted in accordance with the Submittals Procedures section.

A copy of the building manufacturer's erection information shall be kept at the erection site at all times, and shall be available for all building trades.

The metal building erector shall be responsible for verifying prior to starting building erection that the anchor rods are correctly set in the field and the corresponding holes in the baseplates are properly located. If adjustments or corrections are necessary, they shall be submitted to Engineer for review prior to execution, and shall be made at no expense to Owner.

Roof and wall panels, flashings, closures, and other building components shall be installed and sealed to be weathertight. Panels shall be neatly cut and fitted around openings, door and window frames, and other installed accessories. All joints shall be lapped and sealed. Panels shall be securely fastened to structural framing and to each other.

Insulation shall be installed against covering and between supporting members and in a manner to present a neat appearance. Insulation shall have facing at joints lapped and fastened in a manner that will provide continuity of the vapor barrier at joints. The overall wall and roof construction details shall have water vapor transmission rates consistent with the requirements specified for the facing scrim.

Any gutters and downspouts shall be rigidly attached to the building. Gutters shall be installed to provide drainage and shall be designed with adequate provisions for expansion and contraction.

Snow guards shall be attached to the standing seams of the roof panels as per manufacturer's recommendations.

Windows, including frames and accessories, shall be securely anchored to the supporting construction, shall be installed plumb and true, and shall be adjusted as necessary to provide proper operation. All joints at doors and windows shall be sealed to provide weathertight construction and in accordance with the manufacturer's recommendations.

Any factory finished surfaces abraded or damaged during erection shall be repaired and the coating system touched up or repainted with manufacturer's touchup paint. All welds shall be thoroughly cleaned and prime painted.

Field painting of metal surfaces not finish painted at the factory is covered in the painting section.

3-2. FIELD TESTING. The building shall be leak tested with a garden hose stream prior to acceptance. Any leakage discovered shall be corrected and retested.

3-3. PROTECTION. All portions of the building shall be protected from damage during site storage and erection. Damaged parts shall be replaced with undamaged units unless field repairs are authorized by Engineer.

3-4. CLEANING. After completion of construction all soiled surfaces shall be cleaned in accordance with the manufacturer's instructions.

End of Section

Section 211300

FIRE SUPPRESSION SPRINKLER SYSTEMS

PART 1 - GENERAL

This section covers the minimum design, shop fabrication, installation, and acceptance testing requirements for the fixed suppression systems. Fire protection equipment shall be arranged to appropriately protect the plant and equipment in the event of fire.

It is not the intention to specify herein all details of design and construction. The Subcontractor shall ensure that the equipment has been designed, fabricated, and erected in accordance with all engineering codes, standards, and governmental regulations applicable to the specified service.

The Subcontractor shall have full responsibility for compliance with the requirements of these specifications. Review and/or approval of drawings, data, or specifications by the Purchaser with regard to general design and controlling dimensions does not constitute acceptance of any designs, materials, or equipment that will not fulfill the functional or performance requirements established herein or local codes.

The Subcontractor shall provide and coordinate all the terminal points for interfacing the sprinkler system and water supply monitoring switches with building fire alarm control panel provided by Fire Alarm Signaling System (Section 16723) Subcontractor. The combined systems shall be a complete and code compliant systems.

In case of a conflict within the technical requirements, the following hierarchy shall apply:

(1) Mandatory governmental/local regulations and codes.

(2) Purchaser-specified requirements provided herein.

(3) Requirements provided in the technical attachments.

(4) Requirements provided in the technical specifications.

(6) Referenced industry codes and standards and material specifications.

1-1. Scope of Work. The Subcontractor shall furnish complete fire protection systems including, but not limited to, the following: all sprinkler heads, strainers, OS&Y valves, sprinkler system piping, fittings, strainers, fire department connections, backflow preventer assemblies, wall type post indicator valve, pipe hangers and supports, expansion joints, valve tamper switches, pressure switch, sprinkler system electric alarm bell, and instrumentation as required for complete fire protection system. Each system shall be designed to provide the required protection for the specific hazard.

At minimum, the Subcontractor shall supply wet sprinkler system in the Operations Building excluding sprinkler coverage for dedicate electrical rooms such as Operations Electrical Room and Server Room. Subcontractor shall be responsible to confirm that dedicated electrical rooms meet NFPA 13 requirements for exclusion of sprinkler coverage in a fully sprinklered building. At minimum, the Subcontractor shall supply wet sprinkler system in the Maintenance Building excluding sprinkler coverage for dedicate electrical rooms. Subcontractor shall be responsible to confirm that dedicated electrical rooms meet NFPA 13 requirements for exclusion of sprinkler coverage in a fully sprinklered building.

The Subcontractor shall supply and install a backflow preventer assembly upstream of sprinkler system valve station to prevent water back flow into municipal water supply. The backflow preventer assembly shall meet AHJ requirements.

The Subcontractor shall supply and install a wall type post indicator valve at water supply connection into the building upstream of sprinkler system valve station. The wall type post indicator valve shall be provided with tamper switch rated for outdoor condition.

A minimum list of sprinkler systems with basic design parameters is included in the end of this section.

1-2. Items Furnished by Others and Interfaces. Items furnished by others and not in this Scope of Work include the following:

Monitoring and control wiring to connect the specified termination points on the fire protection system equipment and accessories to the building fire alarm system control panel.

Fire alarm control panel, smoke detectors, manual pulls, etc. are provided by fire alarm system supplier scoped under Section 16723.

Piping required to connect building sprinkler system to city water supply.

1-3. Performance and Design Requirements. Minimum performance and design requirements for the fire protection system are indicated herein and in the end of this Section.

1-4. Codes and Standards. Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply:

Work	In Accordance With
Overall design	NFPA, AHJ, Local Building and Fire Codes, and applicable local jurisdiction requirements.
Sprinkler system	NFPA 13 and 820
Pipe thread tolerances	NFPA 13 and ANSI B1.20 Pipe Threads
*Equipment supplied shall be listed by Underwriters Laboratories Inc. (UL) or shall be included in the Approval Guide as published by Factory Mutual (FM) Engineering. Equipment shall be considered as FM-approved only if it conforms to the characteristics and limitations of the individual component approvals and if those components are used in the service intended by the Approval Guide.	

Any conflict between referenced codes or standards, or between the standards and these specifications, shall be referred immediately to the Purchaser who shall determine which standard or specification requirements shall govern.

1-5. Materials. The following materials shall be used:

Component	Material
Piping	
Wet-pipe systems (downstream of isolation gate valve)	Black steel, ASTM A53, Grade B, seamless; or ASTM A106, Grade B, seamless. Minimum Schedule 40
Piping upstream of the sprinkler and spray systems	Black steel, ASTM A53, Grade B, seamless; or ASTM A106, Grade B, seamless. Minimum Schedule 40
Piping downstream of backflow preventer	Standard Weight ASTM A53 schedule 40 with Flanged Fittings. Standard Weight ASTM A53 schedule 40 with Grooved-End Fittings. (optional)
Flanges	
Flanges	Hot-dip galvanized following welding when connected to galvanized pipe
Piping 2 inches (50 mm) and smaller	Screwed or shop welded.
Piping larger than 2 inches (50 mm)	Welded flanges or shop welded connections. (UL or FM Listed grooved style fittings are acceptable.)
Pipe accessories	
Sprinkler fittings (threaded or flanged: tees, couplings, elbows, caps, and reducers)	ANSI B16.3 or B16.1 malleable iron, Class 150 (mitered fittings are not acceptable)
Sprinkler fittings	Galvanized, ASTM A153; no bushing, slip type, or clamp-on rubber gasketed fittings (such as mechanical tee, saddle outlets, etc. not permitted)
Plugs (sprinkler system)	Square head, dissimilar to the fitting to which they are attached
Gaskets	Red rubber sheets, 1/16 inch (1.6 mm) thick, full face, ASTM D2000, No. 2AA705A13L14

Component	Material
Thread sealant	Teflon ribbon, Optional for gas suppression piping: Locktite 592 sealant and primer NF-73656
Thread tolerances	NFPA 13 and ANSI B1.20.1 pipe threads
Bolts and nuts	Steel machine bolts
Piping supports	Per NFPA 13
Supplementary support beams (pipe support)	ASTM A36, fireproof construction
Riser lugs	ASME B31.1
Hanger rods	Per NFPA 13
Water shields	Viking model B-1, or equivalent.
Valves	
Gate valves	OS&Y type, flanged ends
Temper Switch	Approved by AHJ
Backflow Preventer	Approved by AHJ
Wall Type Post Indicator Valve	Approved by AHJ

1-6. Not used.

1-7. Test Requirements. The following testing shall be conducted in accordance with the specified source. This testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Subcontractor unless specifically identified as a Bid Option or Purchaser-conducted. Tests identified as an option are to be priced separately. If identified as Purchaser-conducted, costs for the initial test will be the responsibility of the Purchaser. However, the Subcontractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Tests	In Accordance With	Conducted By
Testing and system acceptance of water based fire protection systems	NFPA 13, 25, and applicable building code	Subcontractor

Tests	In Accordance With	Conducted By
Entire System	Applicable NFPA and Local Building codes and standards	Subcontractor

1-8. Technical Attachments. The following attachments accompany these specifications in either paper or electronic format. Plant areas or equipment to be protected by suppression systems and early warning detection are indicated on the drawings listed below. The information contained in these documents constitutes requirements under the defined Scope of Work:

Document Number/Description	Title	Date
95-F-201	Operations Building Fire Suppression System Schematic	June 2019
95-F-301	Operations Building Fire Suppression System Plan	June 2019
96-F-201	Maintenance Building Fire Suppression System Schematic	June 2019
96-F-301	Maintenance Building Fire Suppression System Plan	June 2019

1-9. Not used.

PART 2 - PRODUCTS

2-1. Sprinkler Systems.

2-1.01. General. This article covers the sprinkler fire suppression systems to be designed, furnished, and installed under these specifications.

The Subcontractor shall furnish complete fire suppression systems, including all spray nozzles, sprinkler heads, valves, piping, fittings, strainers, pipe supports, expansion joints, and instrumentation as required for complete systems, from the Purchaser's piping connections as indicated on the drawings through sprinkler heads and/or spray nozzles. Each system shall be designed to provide the minimum required protection for the specific hazard. All equipment and devices furnished shall be designed to meet code requirements specified herein.

2-1.02. System Requirements. The fire protection equipment shall be arranged to adequately protect the plant and equipment in the event of fire. The minimum

systems to be provided for protection of equipment and areas is indicated on the Fire Suppression System Plan drawing.

2-1.03. Arrangement. The minimum fire suppression systems to be provided, locations of the equipment to be protected, and other pertinent information are indicated on the drawings listed herein and on manufacturer's drawings. Any manufacturer's drawings the bidder may wish to review are available at the Purchaser's office by appointment only.

After contract award, the Subcontractor will be furnished Purchaser-prepared pertinent building, structural steel, electrical tray, lighting, piping composite, and area drawings as they are developed, updated, or revised. The Subcontractor shall develop and update the fire suppression system design and drawings as required to accommodate the plant design indicated by the Purchaser's drawings, including subsequent changes made by the Purchaser as work progresses.

2-1.03.01. Piping Arrangement. The Subcontractor's piping arrangement shall take into consideration and provide for such adjustment as may be required to avoid interference with the separately specified piping and equipment as indicated on the originally submitted drawings and subsequent revised drawings thereafter.

Automatic or manual fire protection valves shall be located in the areas indicated on the drawings. The Subcontractor’s piping configuration shall be such that water hammer forces are at acceptable levels not to rupture the piping during expected operation of the systems. When requested, calculations shall be provided by Subcontractor to verify that water hammer forces were taken into account in the design provided.

Prior to installation, the Subcontractor's piping arrangement, and design data shall be submitted to the Purchaser for review and acceptance in accordance with the submittal requirements.

The Subcontractor shall revise and reroute piping if interferences are discovered either by the Purchaser or in the field during installation. Review of Subcontractor-furnished designs does not indicate a thorough review of all dimensions, quantities, and details of the equipment, materials, devices or items indicated or the accuracy of the information submitted; nor shall review by the Purchaser be construed as relieving the Subcontractor from any responsibility for errors or deviations from the requirements of the contract documents.

The Subcontractor's piping shall be arranged with adequate slope and valved vents and drains so as to be completely drainable.

The Subcontractor shall furnish all piping, pipe supports, valves, and fittings required for complete fire protection systems in compliance with code and these specifications.

Field joint locations and configuration of the section shall be selected with consideration given to field erection problems. Wherever possible, field joints shall be placed in convenient locations. Locations of field joints shall be acceptable to the Purchaser.

The external surface of all black steel piping and all exposed components of shop fabricated piping supports shall be given one coat of primer.

2-1.04. Fire Water Supply. The fire protection water supply system will be furnished and installed by the Purchaser under separate specifications.

The Subcontractor must perform water flow test of the potable water supply system to be used as water supply for the fire protection system scoped for this Section. The Subcontractor must design the fire suppression system based on the test data to meet flow and pressure requirement for the fire protection system per applicable standards.

The Subcontractor shall provide wall type post indicator valve at the water supply connection inside the Building; the water supply connection will be provided by Others. All penetrations through the wall assembly for installation of wall type post indicator valve shall maintain fire resistance rating of the wall using listed material.

2-1.05. Design Requirements. The following design requirements apply to the design of fire suppression systems.

2-1.05.01. Qualifications. The fire suppression systems shall be designed by or under the direct supervision of a registered professional engineer qualified to practice fire protection engineering in Indiana. Such qualification shall be evidenced by either of the following:

Having successfully passed a professional engineering license examination in the discipline of fire protection engineering.

Holding the qualification of Member Grade in the Society of Fire Protection Engineers.

All drawings shall bear the seal of said registered professional engineer. All calculations or submittals other than drawings shall be submitted as securely bound documents and shall also bear the seal of said registered professional engineer.

2-1.05.02. Location. Each system shall be located and shall provide coverage of areas as indicated on the drawings and per applicable federal, state, and local codes.

2-1.05.03. Environment. Each system shall take into account the site location, temperature, seismic, and environmental conditions.

Exterior piping, equipment, and enclosures subject to wind loading shall be designed to resist the wind loads specified in the project site characteristics section.

2-1.05.04. Design Parameters. The Subcontractor shall design each sprinkler and spray system to meet or exceed the requirements of these specifications and the required codes and standards. Each system shall be designed for the specific hazard and shall have UL- or FM-approved equipment and devices. Special emphasis shall be given to the design of the fire suppression systems to prevent water supply and sprinkler piping and nozzles from interfering with required plant repairs or routine maintenance.

Valves installed between water supply and the fire suppression system shall be supervised and provided with tamper switches. Where required, sprinklers shall be included under obstructions or concealed spaces.

Maximum water velocity in sprinkler and spray system piping shall be 20 ft/s (6 m/s).

The Subcontractor shall verify that the physical locations of automatic or manual valves with respect to the proximity and elevation of the branches are acceptable to avoid hydraulic shock when the valves are actuated.

All components in fire protection systems shall be able to operate at 175 psig (1207 kPag), or at a higher design pressure if indicated within this document or on Purchaser's drawings or if Subcontractor’s flow test shows higher.

2-1.06. System Types. The following are various types of sprinkler and spray systems that can be selected. Each system can be designed for manual or automatic activation as allowed per codes. The suppression type selected has been determined to be the most effective method of protection for that hazard:

Sprinkler Systems
Wet-pipe

A permanently attached placard shall be provided on each valve station indicating the location and all hydraulic information as required by NFPA 13.

2-1.06.01. Not used.

2-1.06.02. Not used.

2-1.06.03. Not used.

2-1.06.04. Minimum Wet-pipe Sprinkler Systems. Each wet-pipe sprinkler system shall be designed to provide the minimum coverage density stated in this Section. The wet-pipe sprinkler systems shall be in accordance with the following requirements:

Trouble horn and fire alarm bell shall operate on low voltage dc.

The following equipment shall be provided for each wet-pipe sprinkler system:

Isolation gate valve with tamper switch.

One minimum 4 inch (100 mm) FDC in accordance with NFPA 13, and local requirements complete with check valve, automatic drip, siamese connection, and caps [for each system exceeding 2,000 ft^2 (609.6 m^2)]. Only one FDC required per header.

Strainer (one per header).

Alarm check valve with retard chamber and trim (flow switches are acceptable on systems with 6 heads or less).

Paddle type flow switches in each cross main, for multizone systems only.

Fixed piping system with all necessary pipe, fittings, sprinkler heads, and pipe supports.

Drains and other appurtenances required, including drain piping and isolation valves from system equipment including strainers. Drains and drain piping terminated 12 inches (300 mm) above grade unless specified otherwise.

Inspector's test connection(s) at the end of most remote branch for each flow switch zone.

Trouble alarm horn and fire alarm bell (to be connected with fire alarm system provided by Section 16723)

Minimum system design parameters and sizing requirements as indicated shall be met by wet-pipe sprinkler systems.

2-1.06.05. Not used.

2-1.07. Manufacturing and Material Requirements. Manufacturing and material requirements shall be specified herein.

2-1.07.01. Sprinkler and Spray Fittings. Fittings such as tees, coupling, crosses, elbows, cap, and reducers shall be used for changes in direction, intersections, size changes, and end closures of piping. Bushings or similar fittings are not acceptable.

2-1.07.02. Flanges. Welded or threaded steel flanges shall be provided at sprinkler riser branches, valves, and strainers. Flanges welded to galvanized pipe shall be hot-dip galvanized following welding.

Flanges, fittings, and valves manufactured in the People's Republic of China shall meet following requirements as specified in Q400.

2-1.07.03. Strainers. An FM-approved strainer shall be furnished for the main water supply to each system or set of systems. Strainer shall be of the pipeline, self-cleaning type, complete with blowoff valves and flanged ends.

2-1.07.04. Gate Valves. Water supply gate valves shall be of the OS&Y type with flanged ends. All system isolation and header isolation valves shall be furnished with tamper switches wired to the Local control panel.

2-1.07.05. Water Supply Control Valves. Indicator post shall be wall type with cast-iron body, windows for target plates that indicate valve position, extension rod and coupling, locking device, hand wheel operator, wall flange, and red enamel finish shall be furnished. Gate valve for use with wall indicator posts shall be provided with flanged ends and electric tamper switch rated for outdoor conditions.

2-1.07.06. Alarm Check Valves. Alarm check valves shall be installed complete with trim including retard chambers. Each valve shall have a pressure switch to indicate system actuation.

The alarm pressure switch shall have an adjustable range of 2 to 20 psi (0.1 to 1.4 bar) with differential of plus or minus 2 psi (0.1 bar).

2-1.07.07. Backflow Preventer. Install backflow preventer upstream of sprinkler system valve station to prevent back flow of fire water into municipal water supply. Backflow prevent assembly shall use OS&Y gate valve for check valve isolation and provided with tamper switches to be connected and monitored by fire alarm system control panel. Backflow preventer assembly shall meet local water municipality and AHJ requirements.

2-1.07.08. Not used.

2-1.07.09 Not used.

2-1.07.10. Sprinklers. Sprinklers shall be the ½ inch thermosensitive type, UL-listed for the intended service. Temperature ratings are specified on the Section 13930.4.

2-1.07.11. Not used.

2-1.07.12. Not used.

2-1.07.13. Water Shields. Every closed sprinkler head and every pilot head which are not installed close to a solid flat ceiling or which are subject to impingement from other nozzles or heads shall have a water shield attached. This includes, but is not limited to, pilot heads installed outside and all sprinkler heads installed under grating floors.

2-1.07.14. Plugs. Sprinkler system plugs shall have square heads and shall be of a metal dissimilar to the fitting to which they are attached.

2-1.07.15. Piping Supports. The Subcontractor shall furnish and install all required supports for piping erected under these specifications. The term "piping supports" includes all assemblies such as hangers, floor stands, anchors, brackets, and any supplementary steel required to attach piping supports. All pipe supports shall meet the minimum requirements of NFPA 13. Foundation for floor stand supports are by others.

Centering type beam clamps shall be used instead of end clamps for all piping 2 inches (50 mm) and above.

2-1.07.16. Fire Department Connections. Fire department connections (FDC) shall be double-clapper, siamese type, FM-approved for sprinkler systems, with two 2-1/2 inch (63.5 mm) connections and internal swivel fittings having National Hose Standard threads. Branding or wall plate shall be provided in accordance with NFPA 13. FDC locations shall be as shown on Purchaser's drawings and shall be accessible from outside the structure.

2-1.08. Inspection and Testing. Inspection and testing of the fabricated piping assemblies and piping base materials shall be as stated herein. Documentation of these inspections and tests shall be maintained and supplied to Purchaser. Defects found by these inspections and tests shall be re-inspected following repair by the same method and technique which originally identified the defect. Acceptance shall be based on identical acceptance criteria. Inspection and tests shall be in accordance with NFPA and as stated herein.

2-1.08.01. Hydrostatic Tests. Testing shall be performed on all water system piping and valves in accordance with NFPA 13. Each test shall be conducted for 2 hours at 200 psi (13.9 bar) or at 50 psi (3.5 bar) above the maximum static pressure, whichever is greater. The systems shall be visually inspected during the tests. There shall be no visible leakage or drop in gauge pressure during the tests.

The valves shall be tested along with the piping. Any blind flanges or removable plugs required for openings not closed by the valves and piping provided shall be furnished.

The pressurization equipment including water piping from the supply shall be furnished by the Subcontractor.

Any water remaining in piping after testing shall be protected from freezing until the system is placed into service.

2-1.08.02. Not used.

2-1.08.03. Flow Tests. Each water-based suppression system shall be flow tested.

Flow through the wet pipe systems shall be monitored at the inspector's test connection to verify adequate flow, proper alarm, and annunciation. Systems shall be tested in accordance with the manufacturer’s recommendations and to verify proper alarm and annunciation.

The results of these tests shall be recorded and submitted with the Subcontractor's Materials and Test Certificate.

2-1.08.04. Not used.

2-1.09. Welds. Welding methods that comply with all of the requirements of AWS D10.9 (Specification for Qualification of Welding Procedures and Welders for Piping and Tubing), to be used.

Level AR-3, are acceptable means of joining fire protection piping. Welds shall be inspected visually. This inspection shall assure that all welds are free of defects and comply with acceptable conditions as defined in NFPA 13, Figure A.6.5.2.4.1. This visual inspection shall also assure that all the requirements of these contract documents have been met. Personnel performing visual inspection of welds shall be qualified and certified as a Certified Welding Inspector (CWI) in accordance with AWS D10.9, Level AR-3, Standard for Qualification and Certification of Welding Inspector.

Holes in piping for outlets shall be cut to the full inside diameter of the fittings prior to the fittings being welded in place.

Disks shall be retrieved.

Openings cut into piping shall be smooth bore, and all internal slag and welding residue shall be removed.

Fittings shall not penetrate the internal diameter of the piping.

Steel plates shall not be welded to the ends of piping or fittings.

Fittings shall not be modified.

Nuts, clips, eye rods, angle brackets, or other fasteners shall not be welded to pipe or fittings.

Welders or welding machine operators shall, upon completion of each weld, stamp an imprint of their identification into the side of the pipe adjacent to the weld.

2-1.10. Protection During Shipment. Open ends and branches of shop fabricated pipe shall be securely closed to protect the interior cleanliness and end surfaces during shipment.

Weld ends larger than 2 inches (50 mm) shall be protected with suitable metal caps that have ends lined with 3/4 inch (19 mm) soft wood. The caps shall be securely attached and sealed with waterproof tape.

Nonflanged openings 2 inches (50 mm) and smaller shall be protected as follows:

Female openings, such as sockolets, shall be sealed using pressed-in light metal inserts retained with a seal of waterproof tape.

Nipples shall be sealed with light metal cap retained with a seal of waterproof tape.

Flanged openings shall be sealed with waterproof disks at least 1/2 inch (13 mm) thick bolted to the flange. A 1/8 inch (3 mm) thick rubber gasket shall be provided for sealing. Bolts used for securing the disk shall be a least 1/2 inch (13 mm) diameter, and at least one-half the required bolting shall be used.

Miscellaneous loose items shall be suitably packed in heavy wooden boxes with waterproof linings.

PART 3 - EXECUTION

Erection and installation of fire protection systems equipment and piping shall be in accordance with the requirements of the environmental criteria in the front end sections of this document.

13930.4 Minimum Fire Protection Systems Specification Sheets

General Data	
Subcontractor's scope	
Engineer	Yes
Furnish	Yes
Construct	Yes
Type of system(s) required	
Sprinkler	Yes
Detection	No
Suppression/Detection Systems	
Wet-Pipe Sprinkler	
System designation	
Area or equipment protected	Operations Building
Detection or actuation device	Thermosensitive sprinkler heads [rated at 135° F(57° C)]
Notification device	Electric Bell
Coverage density	0.1 gpm/sqft over 1,500 sqft
Wet-Pipe Sprinkler	

System designation	
Area or equipment protected	Maintenance Building
Detection or actuation device	Thermosensitive sprinkler heads [rated at 175° F(79° C)]
Notification device	Electric Bell
Coverage density	0.2 gpm/sqft over 1,500 sqft

End of Section

Section 26 05 11

ELECTRICAL

PART 1 – GENERAL

1-1. SCOPE. This section covers the furnishing and installation of all equipment and materials needed for the electrical requirements of this Contract. It also covers conduit, wiring, and terminations for electrical equipment installed under Electrical Equipment Installation section.

This section covers the installation and interconnection of electrical equipment furnished under other sections, except electrical items designated to be installed under those sections.

See Scope of Supply Section for requirements.

1-2. GENERAL. Electrical apparatus on all equipment shall be installed complete and placed in readiness for proper operation.

Electrical materials furnished and installed 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, unless exceptions are noted by Design-Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment provided under this section. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Coordination. Electrical work shall conform to the construction schedule and the progress of other trades.

1-2.04. Anchor Bolts and Expansion Anchors. All anchor bolts, nuts, washers, and expansion anchors shall comply with Anchorage in Concrete and Masonry section, except smaller than 3/4 inch 19 mm will be permitted to match NEMA standard size bolt holes on motors and electrical equipment.

1-2.05. Drawings. Supplementing this section, the Drawings indicate locations of equipment and enclosures and provide one-line and schematic diagrams regarding the connection and interaction with other equipment.

1-3. CODES AND PERMITS. All work shall be performed and materials shall be furnished in accordance with the NEC - National Electrical Code, the NESC - National Electrical Safety Code, and the following standards where applicable:

AEIC	The Association of Edison Illuminating Companies
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
Fed Spec	Federal Specification
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
NEIS	National Electrical Installation Standards
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
UL	Underwriters' Laboratories
CEC	California Electrical Code

Equipment covered by this section shall be listed by UL,.

1-4. SEISMIC DESIGN REQUIREMENT.

1-4.01. Seismic Design Requirements. Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-5. IDENTIFICATION.

1-5.01. Conduit. Conduits in manholes, handholes, building entrance pull boxes, junction boxes, and equipment shall be provided with identification tags.

1-5.02. Conductors. All conductors in power, control, and instrumentation circuits shall be identified and color coded as described herein.

1-5.02.01. Conductor Identification Number. Except for lighting and receptacle circuits, each individual conductor in power, control, and instrumentation circuits shall be provided with wire identification markers at the point of termination.

The wire numbers shall be as indicated on the equipment manufacturer's drawings.

The wire markers shall be positioned to be readily visible for inspection.

1-5.02.02. Conductor Color Coding. Power conductors shall be color coded as indicated below. For conductors 6 AWG and smaller, the color coding shall be the insulation finish color. For sizes larger than 6 AWG, the color coding may be by marking tape. The equipment grounding conductor shall be green or green with one or more yellow stripes if the conductor is insulated.

The following color coding system shall be used:

120/240V single-phase — black, red, and white
120/208V, three-phase — black, red, blue, and white
120/240V, three-phase — black, orange, blue, and white
277/480V, three-phase — brown, orange, yellow, and gray

Where 120/240 and 120/208 volt systems share the same conduit or enclosure, the neutral for either the 120/240 volt system or the 208 volt system shall be white with a permanent identifiable violet stripe.

1-5.03. Motor Starters. Motor starters shall be provided with nameplates identifying the related equipment. Pilot controls and indicating lights shall have engraved or etched legends ("start", "stop", etc.). Nameplates shall be laminated black-over-white plastic, with 1/8 inch 3 mm engraved letters, and shall be securely fastened to the motor starters.

1-5.04. Control Stations.Control stations shall be provided with nameplates identifying the related equipment. Pilot controls and indicating lights shall have engraved or etched legends ("start", "stop", etc.). Nameplates shall be laminated black-over-white plastic, with 1/8 inch 3 mm engraved letters, and shall be securely fastened to the control stations.

1-5.05. Circuit Breakers. Circuit breakers shall be provided with nameplates identifying related equipment. Nameplates shall be laminated black-over-white plastic, with 1/8 inch 3 mm engraved letters, and shall be securely fastened to the circuit breakers.

1-5.06. Disconnect Switches. All switches shall have front cover-mounted permanent nameplates that include switch type, manufacturer's name and catalog number, and horsepower kW rating. An additional nameplate, engraved or etched, laminated black-over-white plastic, with 1/8 inch 3 mm letters, shall be provided to identify the associated equipment. Both nameplates shall be securely fastened to the enclosure.

1-5.07. Arc Flash Hazard Labels. Lighting panels, power panels, power centers, switchgear, switchboards, motor control centers, motor control line ups, transfer switches, industrial control panels, adjustable frequency drives, fused switches, meter socket enclosures, local panels with local starters/drive, and other electrical equipment likely to be worked on energized shall be provided with permanent labels warning the risk of arc flash and shock hazard. Labels shall be designed in accordance with ANSI Z535.4 and shall include the following:

WARNING
Arc Flash and Shock Hazard

Appropriate personal protection equipment (PPE) required. SEE NFPA 70E.
Equipment must be accessed by qualified personnel only.
Turn off all power sources prior to working on or inside equipment.

Additional information shall be provided on the labels where specified in the Arc Flash Hazard Analysis section of this section.

1-6. SUBMITTALS. Complete assembly, foundation, and installation drawings, together with complete engineering data covering the materials used, parts, devices, and accessories forming a part of the work performed by the Design-Builder, shall be submitted in accordance with the Submittal Procedures section. The drawings and data shall include, but shall not be limited to, the following:

Drawings and data.
Operating manuals.
Samples.
Test reports
Studies

1-6.01. Submittal Identification. Information covering all materials and equipment shall be submitted for review in accordance with the Submittal Procedures section. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment as follows:

a. Lamp fixture descriptive sheets shall show the fixture schedule letter, number, or symbol for which the sheet applies.

b. Equipment and materials descriptive literature and drawings shall show the specification paragraph for which the equipment applies.

c. Sheets or drawings covering more than the item being considered shall have all inapplicable information crossed out.

d. A suitable notation shall identify equipment and materials descriptive literature not readily cross-referenced with the Drawings or Specifications.

e. Schematics and connection diagrams for all electrical equipment shall be submitted for review. A manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted, unless it is clearly marked to show the intended connections.

f. Surge protective device submittals shall include drawings (including unit dimensions, weights, component and connection locations, mounting provisions, and wiring diagrams), equipment manuals that detail the installation, operation and maintenance instructions for the specified unit(s), and manufacturer's descriptive bulletins and product sheets.

1-6.02. Seismic Design Requirements. Submitted confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-7. PROTECTION AND STORAGE. During construction, the insulation on all electrical equipment shall be protected against absorption of moisture, and metallic components shall be protected against corrosion by strip heaters, lamps, or other suitable means. This protection shall be provided immediately upon receipt of the equipment and shall be maintained continuously.

PART 2 - PRODUCTS

2-1. POWER SERVICE ENTRANCE. 2-1 is only applicable to the Electrical Installer. Electrical Installer shall consult the local electric utility regarding their service installation requirements, and shall furnish the service equipment in compliance with these requirements.

Power service equipment to be furnished by Electrical Installer shall include, but is not limited to, meter board, meter socket, meter test cabinet, meter transformer cabinet, disconnecting means ,grounding materials, riser conduits, and other service entrance fittings required by the utility and for compliance with local codes and regulations.

Electrical Installer shall also provide trenching and backfill, conduits,service cables, concrete for duct banks, transformer pads, and other underground service entrance fittings required by the utility for underground service installation.

A weatherhead shall be provided on each service riser conduit.

2-2. TELEPHONE SERVICE ENTRANCE. 2-2 is only applicable to the Electrical installer. Electrical Installer shall consult the local telephone utility regarding their service installation requirements.

Electrical Installer shall install telephone lines for the Operations Building office connection and for the main fire alarm control panel located in the Operations Building.

2-3. CABLE. All cables of each type (such as lighting cable or 600 volt power cable) shall be from the same manufacturer.

All types of cable shall conform to the Cable Data Figures at the end of this section and as described herein.

2-3.01. Lighting Cable. Lighting cable (Figure 1-26 05 11THHN-THWN) shall be provided only in lighting and receptacle circuits operating at 277 volts or less. Lighting and receptacle circuits, 8 AWG 10 mm2 or larger, shall be as specified for 600 volt (Figure 2-26 05 11XHHW-2)(Figure 3-26 05 11THHN-THWN)(Figure 13-26 05 11 RHH-RHW-USE) power cable.

2-3.02. 600 Volt Power Cable. Cable in power, control, indication, and alarm circuits operating at 600 volts or less, except where lighting, multiconductor control, and instrument cables are required, shall be 600 volt (Figure 2-26 05 11 XHHW-2)(Figure 3-26 05 11 THHN-THWN)(Figure 13- RHH-RHW-USE) power cable.

2-3.03. Instrument Cable. Cable for electronic circuits to instrumentation, metering, and other signalling and control equipment shall be two- or three-conductor instrument cable twisted for magnetic noise rejection and protected from electrostatic noise by a total coverage shield. Types of instrument cables shall be (Figure 4-26 05 11 single pair), (Figure 5-26 05 11 single triad), or (Figure 6-26 05 11 multiple pair and/or triad).

2.3.04. Multiconductor Control Cable. Cable shall be (Figure 7-26 05 11 14 AWG THHN-THWN) or (Figure 8-26 05 11 12 AWG THHN-THWN).

2-3.05. Medium Voltage Power Cable. Not used

2-3.06. Tray Cable. Not used.

2-3.07. Metal Clad Lighting Cable. Metal clad lighting cable (Figure 14-26 05 11 16050 Metal Clad THHN) shall be provided only in lighting and receptacle circuits operating at 277 volts or less, concealed in interior partition walls and above suspended ceilings of finished office and administration areas.

2-4. RACEWAY. Conduit and cable tray shall be as described in the following paragraphs:

2-4.01. Rigid Steel Conduit. Rigid steel conduit shall be heavy wall, hot-dip galvanized, shall conform to NEMA C80.1, and shall be manufactured in accordance with UL 6.

2-4.02. Intermediate Metal Conduit (IMC). IMC shall be hot-dip galvanized, shall conform to NEMA C80.6, and shall be manufactured in accordance with UL 1242.

2-4.03. Liquidtight Flexible Metal Conduit. Liquidtight flexible metal conduit shall be hot-dip galvanized steel, shall be covered with a moistureproof polyvinyl chloride jacket, and shall be UL labeled.

2-4.04. Utility (PVC) Duct. 2-4.04 is only applicable to the Electrical Installer. Utility duct with concrete encasement shall be polyvinyl chloride (ASTM F-512 designation DB-120) and shall conform to NEMA TC-6, NEMA TC-8, and ASTM F-512.

2-4.05. Rigid Nonmetallic (PVC) Conduit. 2-4.05 is only applicable to the Electrical Installer. PVC conduit shall be heavy wall, Schedule 408040 and 80, UL labeled for aboveground and underground uses, and shall conform to NEMA TC-2 and UL 651.

2-4.06. PVC-Coated Rigid Steel Conduit. The conduit shall be rigid steel. Before the PVC coating is applied, the hot-dip galvanized surfaces shall be coated with a primer to obtain a bond between the steel substrate and the coating. The PVC coating shall be bonded to the primed outer surface of the conduit. The bond on conduit and fittings shall be stronger than the tensile strength of the PVC coating.

Every female conduit opening shall have a PVC sleeve extending one conduit diameter or 2 inches 50 mm, whichever is less, beyond the opening. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit before coating.

All fittings, condulets, mounting hardware, and accessories shall be PVC-coated. All hollow conduit fittings shall be coated with the interior urethane coating described above. The screw heads on condulets shall be encapsulated by the manufacturer with a corrosion-resistant material.

2-4.07. Electrical Metallic Tubing (EMT). 2-4.07 is only applicable to the Electrical Installer. EMT shall be hot-dip galvanized, shall conform to NEMA C80.3, and shall be manufactured in accordance with UL 797.

2-4.08. Rigid Aluminum Conduit (RAC). Not used.

2-4.09. Cable Tray. Not used.

2-5. WIRING DEVICES, BOXES, AND FITTINGS. Concealed conduit systems shall have flush-mounted switches and convenience outlets. Exposed conduit systems shall have surface-mounted switches and convenience outlets.

2-6. JUNCTION BOXES, PULL BOXES, AND WIRING GUTTERS. Indoor boxes (larger than switch, receptacle, or fixture type) and gutters shall be constructed of sheet steel, shall be galvanized after fabrication, and shall be rigidly supported by hot-dip galvanized hardware and framing materials, including nuts and bolts.

Indoor boxes and gutters in corrosive areas and outdoor boxes and gutters shall be NEMA Type 4X, ABS or stainless steel and shall be rigidly supported by PVC-coated or stainless steel framing materials. Mounting hardware, which includes nuts, bolts, and anchors, shall be stainless steel. All damaged coatings shall be repaired according to the manufacturer's instructions.

Bolt-on junction box covers 3 feet 900 mm square or larger, or heavier than 25 lbs 11 kg, shall have rigid handles. Covers larger than 3 by 4 feet 900 by 1200 mm shall be split.

Junction and pull boxes with a removable side opposite the underground conduits shall be provided over building ends of underground conduit banks. Boxes shall be sized in accordance with the National Electrical Code, including space for full size continuations of all underground conduits not originally continued. Conduit arrangement shall leave maximum space for future conduits.

2-7. LIGHTING FIXTURES. 2-7 is only applicable to the Electrical Installer. Lighting fixtures shall be furnished. Lighting fixtures shall be furnished complete with lamps. Pendant fixtures shall have swivel type box covers and threaded conduit pendants unless otherwise specified. Lighting fixtures shall be provided with disconnects in accordance with NEC requirements.

2-7.01. Electronic Drivers. Electronic drivers furnished with LED type lighting fixtures shall be certified as meeting requirements of ANSI C82.77 with a THD level of not more than 20 percent.

2-8. LIGHTING PANELS. 2-8 is only applicable to the Electrical Installer. Each lighting panel shall be a dead-front, 120/240 volt, single phase or 120/208 volt, three phase panelboard with circuit breakers, in accordance with the following:

2-8.01. Cabinet. The wall-mounted enclosure shall have a flush-mounted or surface-mounted enclosure with a NEMA designation appropriate for the location

where it will be installed. The enclosure shall have a hinged trim (cover). Breaker operating handles shall be accessible through a latched, lockable, door. At the completion of the Contract, a neatly printed or typed directory listing the panel and circuit identities shall be mounted inside the door.

Outdoor enclosure housing any electrical equipment like variable frequency drive, motor starter, or control equipment shall be free-standing with legs rated for NEMA 4 or with a NEMA designation appropriate for the location where it will be installed. It shall be air-conditioned to maintain the enclosure temperature for the electrical equipment and/or electronic device to operate within its allowable operating temperature range. The enclosure shall have local disconnect switch with operating handle accessible through a latched, lockable, door. Separate enclosure shall be provided for 480Vac equipment and 120Vac equipment. The enclosure shall have corrosion protection in the outdoor environment. All external conduit entry shall be at the bottom.

Indoor enclosure shall be free-standing with legs rated for NEMA 4 or with a NEMA designation appropriate for the location where it will be installed. The enclosure shall have local disconnect switch with operating handle accessible through a latched, lockable, door. Separate enclosure shall be provided for 480Vac equipment and 120Vac equipment. The enclosure shall have corrosion protection appropriate for the location where it will be installed. All external conduit entry shall be at the bottom.

2-8.02. Circuit Breakers. Circuit breakers shall be thermal-magnetic, bolt-in, individually front replaceable, and shall indicate "On", "Off", and "Tripped". Breakers indicated as multiple-pole shall be common trip. Breakers shall have interrupting ratings not less than 10,000 amperes. Handle clips to prevent casual operation of breakers shall be provided for 10 percent (at least two) of the breakers and applied to the circuits directed. Breakers and provisions for future breakers shall be provided in the quantities, number of poles, and ampere ratings

Circuit breakers shall include arc-fault circuit interrupter (AFCI) and/or ground fault circuit interrupter (GFCI) protection functions. Where GFCI breakers dedicated to protect heat tracing circuits, GFCI breakers shall be configured for equipment protection with a ground fault trip threshold of 30 mA. Otherwise, GFCI breakers shall be configured for personnel protection with a ground fault trip threshold of 5 mA.

2-8.03. Buses. The panel shall have main and neutral buses insulated from the cabinet, and a ground bus. Buses shall be copper, with ampere ratings and main lugs or breaker as indicated. The ground bus shall be similar to a neutral bus and shall have a good ground connection to the cabinet, a removable bond to the neutral bus, clamp type lugs for the ground cable in each supply conduit, and connections for a ground cable in each load conduit.

2-8.04. Interior Lighting. Free-standing enclosure with electrical equipment inside shall have ceiling mounted lamp fixtures with a door activated switch and on/off switch.

2-8.05. Air-Conditioned Equipment. Outdoor free-standing enclosure with electrical equipment inside shall have temperature regulated air conditioning equipment to maintain the enclosure temperature within the allowable operating temperature range for the electrical equipment. It shall have temperature regulated anti-condensation heater.

2-8.06. Transformer. A single 480Vac power feed will be provided for 480Vac rated enclosure. The enclosure shall be provided with step-down transformer(s) if other voltage levels other than 480Vac is needed.

2-9. POWER PANELS. Unless otherwise specified, each power panel, without a neutral, shall be dead-front, 3 phase panelboard with circuit breakers, in accordance with the Drawings and the following:

2-9.01. Cabinet. The panel shall have a flush-mounted or surface-mounted enclosure with a NEMA designation appropriate for the location where it will be installed. The enclosure shall have a door with latch and lock. At the completion of the Contract, a neatly printed or typed directory listing the panel and circuit identities shall be mounted inside the door.

2-9.02. Circuit Breakers. Circuit breakers shall be thermal-magnetic, bolt-in, individually front replaceable, and shall indicate "On", "Off", and "Tripped". Breakers indicated as multiple-pole shall be common trip type. Breakers up to 240 volts shall have interrupting ratings not less than65,000 amperes. Breakers for 277 volts shall have interrupting ratings not less than 65,000 amperes. Breakers for 480 volts shall be rated 600 volts, with interrupting ratings not less than 65,000 amperes at 480 volts. Handle clips to prevent casual operation of breakers shall be provided for 10 percent (at least two) of the breakers and applied to the circuits directed.

2-9.03. Buses. The panel shall have 3 phase buses and a ground bus. Buses shall be copper, with ampere and voltage ratings and main lugs or breakers as indicated. The ground bus shall be similar to a neutral bus and shall have a good ground connection to the cabinet, a removable bond to the neutral bus, clamp type lugs for the ground cable in each supply conduit, and connections for a ground cable in each load conduit.

2-10. SURGE PROTECTIVE DEVICES.

2 -10.01. Scope. Surge protective devices (SPD) shall be provided as specified herein. Each unit shall be designed for parallel connection to the wiring system

and shall utilize non-linear voltage-dependent metal oxide varistors (MOV) in parallel.

Each SPD shall be furnished and installed for the electrical equipment as specified herein. All new lighting and power panels shall be furnished with an integral SPD.

Lighting panels shall be rated for the low exposure level capacity unless otherwise noted.

Power panels shall have SPD's rated for a medium-highexposure levels.

2-10.02. Standards. The specified unit shall be designed, manufactured, tested and installed in compliance with the following standards:

ANSI/IEEE C62.41 and C62.45;

ANSI/IEEE C62.1 and C62.11;

IEEE C62.62;

National Electrical Manufacturers Association (NEMA LS1 Guidelines);

National Fire Protection Association (NFPA 20, 70 NEC, 75, and 780);

Underwriters Laboratories UL 1449 and 1283

The unit shall be UL 1449 Listed as a Type 2 Surge Protective Device and UL 1283 Listed as an Electromagnetic Interference (EMI) Filter.

2-10.03. Environmental Requirements.

a. Operating Temperature: 0°F to +140°F -18°C to +60°C.
b. Relative Humidity: Reliable operation with 5 percent to 95 percent non-condensing.

2-10.04. Electrical Requirements.

a. Unit Operating Voltage. The nominal unit operating voltage and configuration shall be as indicated on the Drawings.
b. Maximum Continuous Operating Voltage (MCOV). The SPD shall be designed to withstand a MCOV of not less than 115 percent of nominal RMS voltage.
c. Operating Frequency. Operating frequency range shall be 47 to 63 Hertz.
d. Protection Modes. Four-wire configured systems shall provide, Line-to-Neutral (L-N), Line-to-Ground (L-G), and Neutral-to-Ground (N-G), and Line-to-Line (L-L) protection. Three-wire configured systems shall

provide, Line-to-Line (L-L) protection and Line-to-Ground (L-G) protection.

e. Rated Single Pulse Surge Current Capacity. The rated single pulse surge current capacity, in amps, for each mode of protection of the unit shall be as required and shall be no less than listed in the following table.

	L-N	L-G	N-G	L-L
High Exposure Level	120 kA	120 kA	120 kA	120 kA
Medium-High Exposure Level	100 kA	100 kA	100 kA	100 kA
Medium Exposure Level	80 kA	80 kA	80 kA	80 kA
Low Exposure Level	60 kA	60 kA	40 kA	60 kA

f. UL 1449 Voltage Protection Rating (VPR). The maximum VPR per mode for the device (inclusive of disconnect) shall be as required and shall not exceed the following:

Voltage	L-N	L-G	N-G	L-L
120/240 1-phase	800 V	800 V	800 V	1200 V
120/208 3-phase	800 V	800 V	800 V	1200 V
240 V 3W		800 V		1500 V
240 V 4W	800 V	800 V	800 V	1500 V
480 V 3W		1200 V		2000 V
480 V 4W	1200 V	1200 V	1200 V	2000 V

g. Noise Attenuation. The unit shall be capable of a minimum -30 dB attenuation at 100kHz when tested per the 50 ohm insertion loss method as defined by MIL-STD-220C.

h. Nominal Discharge Current. Each SPD shall have a nominal discharge current rating of 20 kA.

i. Overcurrent Protection. At high and medium-high exposure levels, the SPD shall incorporate internal fusing capable of interrupting, at minimum, up to 200 kA symmetrical fault current with 600 volts ac applied.

At medium and low exposure levels, the SPD shall incorporate internal fusing capable of interrupting, at minimum, up to 65kA symmetrical fault current with 600 volts ac applied.

The device shall be capable of allowing passage of the rated maximum surge current for every mode without fuse operation.

j. Unit Status Indicators. The unit shall include long-life, externally visible phase indicators that monitor the on-line status of the unit. When furnished integral to the panelboard, the status indicators shall be viewable when the panelboard door is opened.

2-10.05. Installation. Each SPD shall be installed according to the manufacturer's recommendations. If possible for the integral units, provide direct bus connections.

2-10.06. Miscellaneous.

a. Disconnect Switch. Each SPD shall be furnished with an integral disconnect switch. The unit shall be UL 1449 listed as such, and the UL 1449 Voltage Protection Ratings shall be provided. The disconnect switch shall be fused and capable of withstanding, without failure, the published maximum surge current magnitude without failure or damage to the switch.

b. Enclosure. For the SPD units to be mounted externally of the protected electrical equipment, provide NEMA rated enclosures suitable for the locations.

c. Dual Form "C" Dry Contacts.

2-11. SEPARATELY ENCLOSED MOTOR STARTERS. Separately enclosed motor starters, unless otherwise specified, shall be full voltage, magnetic, non-reversing and NEMA rated. The starter enclosures shall have NEMA type designations appropriate for the locations where they will be installed. Unless otherwise noted, NEMA Type 4X stainless steel enclosures shall be provided for outdoor locations.

Heaterless overload protection shall be provided by three current sensors monitored by a microprocessor. The overload device shall also include phase loss and unbalance protection, trip class selection, Class II ground fault protection, and manual reset

Each starter shall include auxiliary contacts as required, plus one spare NO and one spare NC contact.

Supplier shall match the sizes of control power transformers, overload devices, heaters, and starters to the equipment furnished, as they may differ from the values indicated on the Drawings. Control power transformers shall have both primary leads fused, one secondary lead fused, and one secondary lead grounded.

All starters shall be provided with control terminal blocks. Terminal blocks shall be pull-apart type rated 20 amperes. All current carrying parts shall be tin-plated. The removable portion of the terminal blocks shall be used for factory installed wiring.

All push buttons, selector switches, and pilot lights to be provided on or in the starter enclosure shall be 30.5 mm heavy-duty, oiltight construction. Pilot lights shall be full voltage type with LED lamps. Push buttons on starters located outdoors shall be provided with protective caps.

2-11.01. Three Phase Starters. Three phase starters shall be circuit breaker combination type consisting of 3 phase, 60 Hz contactors with heaterless overloads, a 120 volt ac coil, a dry type control power transformer where required, and a circuit breaker disconnect. Control power transformers shall be sized to handle all simultaneous loads. .

Circuit breakers shall be 600 volt magnetic motor circuit protectors for motors smaller than 100 horsepower 75 kW and 600 volt thermal-magnetic type for 100 horsepower 75 kW and larger motors. Each breaker shall be manually operated with a quick-make, quick-break, trip-free toggle mechanism.

Three phase starters shall be furnished with external manual breaker operating handles and provisions for up to three padlocks. The access door shall be interlocked with the motor circuit protector, so that the door cannot be opened, except by an interlock override, while the breaker is closed.

The complete 3 phase starter shall have an interrupting rating of at least 25,000 amperes at 480 volts.

2-11.02. Single Phase Starters. Single phase starters shall consist of single phase, 60 Hz contactors with thermal overloads and an integral or separately enclosed short-circuit protection device. Starters shall be at least NEMA Size 0, or shall be sized. Integral short-circuit protection devices for single-phase starters shall be 120/240 volt, magnetic motor circuit protectors.

Separately enclosed short-circuit protection devices for single phase starters shall be molded-case circuit breakers for motor loads 6 amperes and higher and fused switch disconnects for motor loads lower than 6 amperes. Circuit breaker disconnects shall be 120/240 volt, molded-case, thermal-magnetic circuit breakers. Fused switch disconnects shall have quick-make, quick-break mechanisms and 250 volt, dual-element, time-delay fuses.

The short-circuit protection devices shall have external operating handles capable of being padlocked in the open position, and shall have an interrupting rating of at least22,000 amperes at 240 volts.

2-12. SEPARATELY ENCLOSED MANUAL STARTERS. Not used

2-13. CONTROL STATIONS. Control stations shall be provided as indicated on the one-line diagrams or schematics or as required by the equipment furnished. Pilot devices shall be 30.5 mm heavy-duty, oiltight construction, and shall

perform the functions indicated. Pilot lights shall be full voltage type with LED lamps. Indoor control stations shall have NEMA Type 13 enclosures. Control stations outdoors or indicated to be weatherproof shall have NEMA Type 4X stainless steel enclosures with protective caps on the control devices. Control stations in NEC Class I, Division 1 and Division 2, Group D hazardous areas shall have NEMA Type 7 enclosures, or be factory sealed type,.

2-13.01. Emergency Break-Glass Switch. 2-13.01 is only applicable to the Electrical Installer. Each break-glass switch for HVAC emergency shutoff shall be furnished with a NEMA enclosure as specified herein with hammer, hammer clip, and chain.

2-14. SEPARATELY ENCLOSED CIRCUIT BREAKERS. Circuit breakers shall be 3 pole, 480 volt, molded-case circuit breakers of not less than65,000 amperes interrupting rating at 480 volts ac, complete with thermal and instantaneous trip elements. Breaker enclosures shall have NEMA designations appropriate for the locations where they will be installed. NEMA Type 4X stainless steel enclosures shall be provided for outdoor locations. Each breaker shall be manually operated with a quick-make, quick-break, trip-free toggle mechanism. Bimetallic thermal elements shall withstand sustained overloads and short-circuit currents without injury and without affecting calibration.

Circuit breakers shall have "On", "Off", and "Tripped" indication and padlockable exterior handles.

2-15. DISCONNECT SWITCHES. Unless otherwise specified, each disconnect switch shall be 3 pole, nonfusible, 600 volts, with a continuous current rating as indicated on the Drawings.

Where indicated on the Drawings, fused switches shall be furnished complete with fuses. Fuse sizing shall be as indicated on the Drawings, as required by the results of the protective device study, or as recommended by the respective protected equipment manufacturer.

Switches located indoors shall have NEMA type enclosure designations as required by the locations where they will be installed. Switches located outdoors shall have NEMA Type 4X enclosures. Switches in chlorine rooms, or in other areas where contact with caustic substances may occur, shall have NEMA Type 4X enclosures of molded reinforced polyester.

Switches shall have high conductivity copper, visible blades; nonteasible, positive, quick-make, quick-break mechanisms; and switch assembly plus operating handle as an integral part of the enclosure base. Each switch shall have a handle whose position is easily recognizable and which can be locked in the "Off" position with three padlocks. The "On" and "Off" positions shall be clearly marked.

All switches shall be UL listed and horsepower kilowatt rated, and shall meet the latest edition of NEMA KS1. Switches shall have defeatable door interlocks that prevent the door from being opened while the operating handle is in the "On" position.

2-16. LIGHTING AND AUXILIARY POWER TRANSFORMERS. 2-16 is only applicable to the Electrical Installer. Separately mounted transformers shall be provided in the phases, kVA, and voltages indicated on the Drawings. Transformers shall be self-air-cooled, dry type, wall- or floor-mounted, and enclosed for wiring in conduit. Transformers installed outdoors shall be weatherproof. Transformers shall have at least four full capacity voltage taps, two above and two below rated voltage. Transformers shall meet DOE 10 CFR 431 guidelines for energy efficiency.

2-17. POWER CENTERS. Not used

2-18. POWER FACTOR CORRECTION CAPACITORS. Not used

2-19. LIGHTING CONTACTORS. 2-19 is only applicable to the Electrical Installer. Remote control lighting contactors shall be provided. Contactors shall have positive locking features and shall be mechanically held in both positions. Main contacts shall be double-break, continuous-duty rated 20 amperes, 600 volts ac, for all types of loads. Terminals shall accept 18 through 10 AWG conductors. Contactors shall operate in any position and may be manually operated for testing and maintenance. Contactor control panels shall be UL 508A listed. The short circuit current rating shall meet or exceed the available short circuit current indicated on the bus feeding the contactor.

2-20. PHOTOELECTRIC CONTROLS. 2-20 is only applicable to the Electrical Installer. Photoelectric controls shall be weatherproof, swivel adjustable, with built-in time delay to prevent accidental turnoff by momentary brightness. The photocell shall be rated 1800 VA, 120 volts ac, and shall be field adjustable from 1 ft/c 11 lux turn-on to 15 ft/c 161 lux turn-off.

2-21. RELAY ENCLOSURES. 2-21 is only applicable to the Electrical Installer. Relay enclosures shall be furnished. The enclosure shall have a NEMA designation appropriate for the location where it will be installed. Pilot devices shall be heavy duty, oiltight construction. Relays and timers shall have 120 volt, 60 Hz coils rated for continuous duty in 40 C ambient and 10 ampere, 120 volt ac contacts. Intrinsically safe relays shall be installed within the enclosures in accordance with NEC requirements.

2-22. ALARM HORN AND BEACON. Not used

2-23. HEAT-TRACED PIPING. 2-23 is only applicable to the Electrical Installer. Outdoor exposed piping shall be heat-traced described herein. Heat tracing shall be sized to maintain pipe temperatures at 40°F with an outdoor ambient temperature of -20°F. Heat tracing shall be of the self-regulating type and shall be suitable for single-phase, 120 volt service. Each run of heat tracing tape shall be provided with a circuit controller, an end-of-line indicating light, junction boxes, mounting accessories, insulation and all other equipment for a complete, properly operating system. Hazardous areas, as indicated on the Drawings and Specifications, shall have heat tracing and associated accessories that are rated for the location. The insulation for all heat tracing shall be as specified in Mechanical Insulation section. Each heat-tracing circuit shall be provided with a microprocessor-based circuit controller to monitor temperature and ground fault current. . On all plastic pipe equipped with heat tracing, a layer of conducting tape shall be installed on the pipe before heating cable installation and then again following installation of the heating cable.

2-24. DOOR ENTRY SWITCHES. 2-24 is only applicable to the Electrical Installer. Door entry switches shall be provided as specified herein. Switches shall be heavy-duty industrial, adjustable, magnetic wide gap type. Switch and magnet housings located in NEC Class I, Division 1 and 2, Group D hazardous areas shall be die-cast aluminum, explosionproof. Switch and magnet housings located in other areas shall be anodized aluminum.

PART 3 - EXECUTION

3-1. INSTALLATION, TESTING, AND COMMISSIONING. 3-1 is only applicable to the Electrical Installer. All material, equipment, and components specified herein shall be installed, tested, and commissioned for operation in compliance with NECA 1000 – NEIS Specification System. Where required in NECA 1000, testing and commissioning procedures shall be followed prior to energizing equipment.

3-2. ARC FLASH HAZARD ANALYSIS. Electrical Installer and/or Equipment Supplier shall commission an Arc Flash Hazard Analysis for each piece of electrical equipment including lighting panels, power panels, power centers, switchgear, switchboards, motor control centers, motor control line ups, transfer switches, industrial control panels, variable frequency drives, fused switches, local panel with local starters/drives, and other electrical equipment likely to be worked on energized, in accordance with OSHA 29 CFR Part 1910, NEC, NFPA 70E, and IEEE 1584.

Equipment below 240 volts need not be considered unless it involves at least one 125KVA or larger transformer in its immediate power supply.

The Arc Flash Hazard Analysis shall be performed in association with, or as a continuation of, the short circuit study and protective device study.

3-2.01. Arc Flash Labeling. Electrical Installer and/or Equipment Supplier shall furnish and install arc flash labels on the applicable electrical equipment. The arc flash labels shall comply with ANSI Z535.4 and NFPA 70E requirements. Labels shall include, at a minimum, the nominal system voltage, the arc flash boundary distance, worst-case incident energy and the corresponding working distance, date of the analysis, and equipment name.

Equipment with arc reduction maintenance mode switches shall include a dual label with the worst-case calculated incident energy level with and without the switch enabled. The label shall clearly identify the associated maintenance mode switch that shall be enabled in order for the lower incident energy level to apply.

3-3. PROTECTIVE DEVICE STUDY. 3-3 is only applicable to the Electrical Installer. Electrical Installer shall commission a short circuit study and protective device study of relays, fuses, circuit breakers, and all other protective devices and shall submit a coordination and protective device settings report as specified herein. The study shall be in compliance with IEEE 242 and include the entire distribution system, including any and all existing power distribution components which will impact the results of the protective device study, starting with the smallest – 480 volt, 3 phase, 60 Hz – circuit protective device on the load end, to the nearest protective device on the power company's line side.

Electrical Installer shall be responsible for and shall ensure that all relays, protective devices and circuit breakers shown on the Drawings and Specifications are sized and set according to the study results.

3-4. POWER AND SERVICE ENTRANCE INSTALLATION. 3-4 is only applicable to the Electrical Installer. Electrical installer shall consult the local electric utility regarding their service installation requirements, and shall install the service equipment in compliance with these requirements. Electrical Installer shall install all power service equipment components except for components installed by the utility as directed in the utility service installation requirements.

Electrical Installer shall coordinate details and timing of service entrance installations with the utility. Electrical Installer shall complete and submit service applications to the electric utility as necessary.

3-5. TELECOMMUNICATIONS SERVICE ENTRANCE INSTALLATION. 3-5 is only applicable to the Electrical Installer. Electrical Installer shall consult the local telephone utility regarding their service installation requirements, and shall install the service equipment in compliance with these requirements.

Electrical Installer shall coordinate details and timing of service entrance installations with the utility. Electrical Installer shall complete and submit service applications to the telephone utility as necessary.

3-6. CABLE INSTALLATION. 3-6 is only applicable to the Electrical Installer.

3-6.01. General. Except as otherwise specified cable shall be installed according to the following procedures, taking care to protect the cable and to avoid kinking the conductors, cutting or puncturing the jacket, contamination by oil or grease, or any other damage. Circuits to supply electric power and control to equipment and devices, communication and signal circuits shall be installed continuous and may not be spliced unless approved by the Design-Builder.

a. Stranded conductor cable shall be terminated by lugs or pressure type connectors. Wrapping stranded cables around screw type terminals is not acceptable.

b. Stranded conductor cable shall be spliced by crimp type connectors. Twist-on wire connectors may only be used for splicing solid cable and for terminations at lighting fixtures.

c. Splices may be made only at readily accessible locations.

d. Cable terminations and splices shall be made as recommended by the cable manufacturer for the particular cable and service conditions.

e. All 5,000 volt rated cable and above shielded cable stress cone terminations shall be IEEE Class 1 molded rubber type. Shielded cable splices shall be tape or molded rubber type as required. Shielded cable splices and stress cone terminations shall be made by qualified splicers.

f. Cable shall not be pulled tight against bushings nor pressed heavily against enclosures.

g. Cable-pulling lubricant shall be compatible with all cable jackets; shall not contain wax, grease, or silicone.

h. Cables operating at more than 2000 volts shall be fireproofed in all cable vaults, manholes, and handholes.

i. Where necessary to prevent heavy loading on cable connections, in vertical risers, the cable shall be supported by woven grips.

j. Spare cable ends shall be taped, coiled, and identified.

k. Cables shall not be bent to a radius less than the minimum recommended by the manufacturer. For cables rated higher than 600 volts, the minimum radius shall be 8 diameters for nonshielded cable and 12 diameters for shielded cable.

l. All cables in one conduit, over 1 foot 305 mm long, or with any bends, shall be pulled in or out simultaneously.

m. Circuits to supply electric power and control to equipment and devices are indicated on the one-line diagrams. Conductors in designated numbers and sizes shall be installed in conduit of designated size.

n. Instrument cable shields and drain wires shall be continuous over the entire length of the circuit and grounded at one end only. In general, the field end of the shield shall be ungrounded. At the ungrounded termination of the circuit, the shield and drain wire shall be insulated by taping to prevent grounding.

o. Cables operating at more than 2,000 volts which terminate at medium-voltage padmounted equipment bushings shall include a metal oxide varistor surge protective elbow terminator conforming to IEEE Standard 386. Elbows shall provide a weatherproof, dead-front, hot-stick operable separable connection. Surge protector rating shall be as recommended by the terminator supplier.

3-6.02. Underground Cable Pulling Procedure. Care shall be taken to prevent excessive physical stresses that would cause mechanical damage to cables during pulling.

3-6.03. Medium-Voltage Cable Insulation Test. Not used.

3-7. RACEWAY INSTALLATION. 3-7 is only applicable to the Electrical Installer. Electrical Installer shall be responsible for routing all raceway. This shall include all conduits indicated on the one-lines, riser diagrams, conduit schedules, and home-runs shown on the plan Drawings. Conduits shall be routed as defined in these Specifications. Where conduit routing is shown on plans, it shall be considered a general guideline and shall be field verified to avoid interferences.

Except as otherwise specified, conduit installation and identification shall be completed according to the following procedures.

3-7.01. Installation of Interior and Exposed Exterior Conduit. This section covers the installation of conduit inside structures, above and below grade, and in exposed outdoor locations. In general, conduit inside structures shall be concealed. Large conduit and conduit stubs may be exposed unless otherwise specified. No conduit shall be exposed in water chambers.

Unless otherwise indicated on the Drawings, Design-Builder shall be responsible for routing the conduit to meet the following installation requirements:

a. Conduit installed in all exposed indoor locations, except corrosive areas, and in floor slabs, walls, and ceilings of hazardous (classified) locations, shall be rigid steel. Exposed conduit shall be rigidly supported by hot-dip galvanized hardware and framing materials, including nuts and bolts.

b. Conduit installed in floor slabs and walls in non-hazardous locations shall be rigid Schedule 40 PVC.

c. Conduit installed in all exposed outdoor locations shall be PVC-coated rigid steel, rigidly supported by PVC-coated framing materials. Mounting hardware, which includes nuts, bolts, and anchors, shall be stainless steel. All damaged coatings shall be repaired according to the manufacturer's instructions.

d. Final connections to dry type transformers, to motors without flexible cords, and to other equipment with rotating or moving parts shall be liquidtight flexible metal conduit with watertight connectors installed without sharp bends and in the minimum lengths required for the application, but not longer than 6 feet.

e. Terminations and connections of rigid steel and intermediate metal conduit shall be taper threaded. Conduits shall be reamed free of burrs and shall be terminated with conduit bushings.

f. Exposed conduit shall be installed either parallel or perpendicular to structural members and surfaces.

g. Two or more conduits in the same general routing shall be parallel, with symmetrical bends.

h. Conduits shall be at least 6 inches 150 mm from high temperature piping, ducts, and flues.

i. Conduit installed in corrosive chemical feed and storage areas as indicated by Area Type shall be rigid Schedule 80 PVC. Exposed conduit in corrosive areas shall be supported by FRP framing materials with stainless steel hardware, including nuts and bolts.

j. Rigid Schedule 40 and 80 PVC conduit shall have supports and provisions for expansion as required by NEC Article 352.

k. Metallic conduit connections to sheet metal enclosures shall be securely fastened by locknuts inside and outside.

l. Rigid Schedule 40 and 80 PVC conduit shall be secured to sheet metal device boxes using a male terminal adapter with a locknut inside or by using a box adapter inserted through the knockout and cemented into a coupling.

m. Conduits in walls or slabs, which have reinforcement in both faces, shall be installed between the reinforcing steel. In slabs with only a single layer of reinforcing steel, conduits shall be

placed under the reinforcement. Conduits larger than 1/3 of the slab thickness shall be concrete encased under the slab.

n. Conduits that cross structural joints where structural movement is allowed shall be fitted with concretetight and watertight expansion/deflection couplings, suitable for use with metallic conduits and rigid Schedule 40 or 80 PVC conduits. .

o. Conduit shall be clear of structural openings and indicated future openings.

p. Conduits through roofs or metal walls shall be flashed and sealed watertight.

q. Conduit installed through any openings cut into non-fire rated concrete or masonry structure elements shall be neatly grouted. Conduit penetrations of fire rated structure elements shall be sealed in a manner that maintains the fire rating.

r. Conduits shall be capped during construction to prevent entrance of dirt, trash, and water.

s. Exposed conduit stubs for future use shall be terminated with galvanized pipe caps.

t. Concealed conduit for future use shall be terminated in equipment or fitted with couplings plugged flush with structural surfaces.

u. Future duplication of equipment wired hereunder, concealed portions of conduits for future equipment shall be provided.

v. Horizontal conduit shall be installed to allow at least 7 feet 2.1 m of headroom, except along structures, piping, and equipment or in other areas where headroom cannot be maintained.

w. Conduit shall not be routed across the surface of a floor, roof, or walkway unless approved by Design-Builder.

x. PVC-coated rigid steel conduit shall be threaded and installed as recommended by the conduit manufacturer's installation procedure using appropriate tools.

y. All conduits that enter enclosures shall be terminated with acceptable fittings that will not affect the NEMA rating of the enclosure.

z. Conduit which turns out of concrete slabs or walls, shall be connected to a 90 degree elbow of PVC-coated rigid steel conduit before it emerges. Conduits shall have PVC-coated rigid steel coupling embedded a minimum of 3 inches when emerging from slabs or walls and the coupling shall extend 2 inches from the wall.

aa. Conduit for Heliax type foam dielectric coaxial cable shall be installed as follows:

Heliax Size inches	mm	Minimum Conduit Size inches	mm	Minimum Conduit Bend Radius inches	mm
1/2	13	1-1/2	40	10	250
7/8	22	2	50	18	450
1-1/4	32	4	100	22	550
1-5/8	42	4	100	28	700

ab. Power conductors to and from adjustable frequency drives shall be installed in steel conduit.

3-7.02. Underground Conduit Installation. All excavation, backfilling, and concrete work shall conform to the respective sections of these Specifications. Underground conduit shall conform to the following requirements:

a. Concrete encasement within 15 feet of building entrances, under and within 5 feet of roadways, and within 10 feet of indicated future excavations shall be reinforced.

b. Concrete encased conduit shall be PVC utility duct or schedule 40 PVC. Conduits shall have PVC-coated rigid steel coupling embedded a minimum of 3 inches when emerging from walls and the coupling shall extend 2 inches from the wall. All PVC joints shall be solvent welded in accordance with the recommendations of the manufacturer.

c. Concrete encasement on exposed outdoor conduit risers shall continue to 6 inches 150 mm above grade, with top crowned and edges chamfered.

d. Conduit and concrete encasement installed underground for future extension shall be terminated flush at the bulkhead with a coupling and a screw plug.

e. Underground conduits indicated not to be concrete encased shall be rigid Schedule 40 PVC.

f. Underground conduit bend radius shall be at least 2 feet at vertical risers and at least 3 feet elsewhere.

g. Underground conduits and conduit banks shall have at least 2 feet of earth cover, except where indicated otherwise.

h. Underground conduit banks through building walls shall be cast in place, or concreted into boxouts, with water stops on all sides of the boxout. Water stops are specified in the Cast-In-Place

Concrete section.

i. Underground nonmetallic conduits, which turn out of concrete or earth in outdoor locations, shall be connected to 90 degree elbows of PVC-coated rigid steel conduit before they emerge.

j. Conduits not encased in concrete and passing through walls, which have one side in contact with earth, shall be sealed watertight with special rubber-gasketed sleeve and joint assemblies or with sleeves and modular rubber sealing elements.

k. Underground conduits shall be sloped to drain from buildings to manholes.

l. Each 5 kV or higher voltage cable, each 250 kcmil or larger cable, and each conduit group of smaller cables shall be supported from manhole walls by fiberglass reinforced polyester cable saddles.

m. Telephone cables shall not be installed in raceways, conduits, boxes, manholes, or handholes containing other types of circuits.

n. Intercommunication and instrument cables shall be separated the maximum possible distance from all power wiring in pull-boxes, manholes, and handholes.

3-7.03. Sealing of Conduits. After cable has been installed and connected, conduit ends shall be sealed by forcing nonhardening sealing compound into the conduits to a depth at least equal to the conduit diameter. This method shall be used for sealing all conduits at handholes, manholes, and building entrance junction boxes, and for 1 inch and larger conduit connections to equipment.

Conduits entering chlorine feed and storage rooms shall be sealed in a junction box or conduit body adjacent to the point of entrance.

3-7.04. Reuse of Existing Conduits. Not Used

3-8. WIRING DEVICES, BOXES, AND FITTINGS INSTALLATION. Metallic and nonmetallic conduit boxes and fittings shall be installed in the following locations:

3-8.01. Conduit Boxes and Fittings.

a. Galvanized or cadmium plated, threaded, malleable iron boxes and fittings shall be installed in concrete walls, ceilings, and floors; in the outdoor faces of masonry walls; and in all locations where weatherproof device covers are required. These boxes and fittings shall also be installed in exposed rigid steel and intermediate metal conduit systems.

b. Galvanized or cadmium plated sheet steel boxes shall be

installed in the indoor faces of masonry walls, in interior partition walls, and in joist supported ceilings.

c. Rigid PVC device boxes shall be installed in exposed nonmetallic conduit systems.

d. PVC coated boxes and fittings shall be installed in PVC coated conduit systems.

e. Telephone conduit shall be provided with separate junction boxes and pull fittings.

3-8.02. Device Plates. Oversized plates shall be installed where standard-sized plates do not fully cover the wall opening.

3-8.03. Wall Switches.

a. Wall switches shall be mounted 3'-6" above floor or grade.

b. After circuits are energized, all wall switches shall be tested for proper operation.

3-8.04. Receptacles.

a. Convenience outlets shall be 18 inches above the floor unless otherwise required.

b. Convenience outlets outdoors and in garages; in basements, shops, storerooms, and rooms where equipment may be hosed down; shall be 4 feet above floor or grade.

c. Welding receptacles shall be surface-mounted 4 feet above the floor.

d. After circuits are energized, each receptacle shall be tested for correct polarity and each GFCI receptacle shall be tested for proper operation.

e. Conduit and wire for convenience outlet installation is not shown on the Drawings and shall be sized, furnished, and installed by Electrical Installer. Conductors shall be minimum 12 AWG and conduit shall be minimum 3/4 inch for convenience outlet installation.

3-8.05. Special Outlets. Not Used

3-9. EQUIPMENT INSTALLATION. 3-9 is only applicable to the Electrical Installer. Except as otherwise specified or indicated on the Drawings, the following procedures shall be used in performing electrical work.

3-9.01. Setting of Equipment. All equipment, boxes, and gutters shall be installed level and plumb. Boxes, equipment enclosures, metal raceways, and similar items mounted on water- or earth-bearing walls shall be separated from the wall by at least 1/4 inch thick corrosion-resistant spacers. Where boxes, enclosures, and raceways are installed at locations where walls are not suitable or available for mounting, concrete equipment pads, framing material, and associated hardware shall be provided.

3-9.02. Sealing of Equipment. All outdoor substation, switchgear, motor control center, and similar equipment shall be permanently sealed at the base, and all openings into equipment shall be screened or sealed with concrete grout to keep out rodents and insects the size of wasps and mud daubers. Small cracks and openings shall be sealed from inside with silicone sealant.

3-10. GROUNDING. 3-10 is only applicable to the Electrical Installer.

3-10.01. General. The electrical system and equipment shall be grounded in compliance with the National Electrical Code and the following requirements:

a. All ground conductors shall be at least 12 AWG 4 mm^2 soft drawn copper cable or bar, bare or green-insulated in accordance with the National Electrical Code.

b. Ground cable splices and joints, ground rod connections, and equipment bonding connections shall meet the requirements of IEEE 837.

c. Ground cable through exterior building walls shall enter within 3 feet below finished grade and shall be provided with a water stop. Unless otherwise indicated, installation of the water stop shall include filling the space between the strands with solder and soldering a 12 inch copper disc over the cable.

d. Ground cable near the base of a structure shall be installed in earth and as far from the structure as the excavation permits, but not closer than 24 inches . The tops of ground rods and ground cable interconnecting ground rods shall be buried a minimum of 30 inches below grade, or below the frost line, whichever is deeper.

e. All powered equipment, including lighting fixtures and receptacles, shall be grounded by a copper ground conductor in addition to the conduit connection.

f. Ground connections to equipment and ground buses shall be made with copper or high conductivity copper alloy ground lugs or clamps. Connections to enclosures not provided with ground buses or ground terminals shall be made with irreversible high-compression type lugs inserted under permanent assembly bolts or under new bolts drilled and inserted through enclosures, other than explosion proof enclosures, or by grounding locknuts or bushings. Ground cable connections to anchor bolts; against gaskets, paint, or varnish; or on bolts holding removable access covers will not be acceptable.

g. The grounding system shall be bonded to the station piping by connecting to the first flange inside the building, on either a suction or discharge pipe, with a copper bar or strap. The flange shall be drilled and tapped to provide a bolted connection.

h. Ground conductors shall be routed as directly as possible, avoiding unnecessary bends. Ground conductor installations for equipment ground connections to the grounding system shall have turns with minimum bend radii of 12 inches .

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i. Ground rods not described elsewhere shall be a minimum of 3/4 inch in diameter by 10 feet long, with a copper jacket bonded to a steel core.

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j. Test wells and covers for non-traffic areas shall be molded high density polyethylene. Test wells for traffic areas shall be precast concrete construction rated for traffic duty with concrete or cast iron covers.

3-10.02. Grounding System Resistance. The ground system resistance shall comply with National Electrical Code.

3-10.03. Grounding System Testing. The grounding system of each new building or structure shall be tested to determine the resistance to earth. Testing shall be completed after not less than three full days without precipitation and without any other moistening or chemical treatment of the soil.

3-10.03.01. New Grounding Systems. Grounding systems of each new building or structure shall be tested for resistance to earth utilizing the three-point fall of potential test as defined by IEEE 81. Testing shall be completed prior to installation of the electrical distribution equipment to ensure the grounding system is isolated from the utility grounding system and the systems of other structures. The current source probe for the test shall be placed in soil at a distance of 5 to 10 times the distance of the widest measurement across the grounding system ring or grid to ensure adequate measurements outside of the

grounding system's sphere of influence. Test probe measurements shall be taken at a distance of one foot from the grounding system reference connection and at each 10 percent increment from the grounding system reference connection to the current source probe location. Test results shall be documented on a graphical plot with resistance in ohms on the vertical axis and distance in feet on the horizontal axis. The results shall clearly indicate a system resistance plateau which confirms a valid test procedure.

3.10.03.02. Existing Grounding Systems. Not used

3.10.03.03. Grounding System Test Report. A report shall be prepared and submitted in accordance with the Submittal Procedures section. The final report shall include complete testing results for each building or structure, graphical representation of the test point results for the three-point fall of potential method, and complete observations of all site weather conditions and other environmental conditions that may affect the test results. Final acceptance of the results reported shall be subject to the review and approval of Design-Builder.

3-11. LIGHTING FIXTURE INSTALLATION. The Drawings indicate the general locations and arrangements of the lighting fixtures. Fixtures in rows shall be aligned both vertically and horizontally unless otherwise specified. Fixtures shall be clear of pipes, mechanical equipment, structural openings, indicated future equipment and structural openings, and other obstructions.

Conduit and wire for lighting fixture installation is not shown on the Drawings and shall be sized, furnished and installed by Electrical Installer. Circuits to emergency lighting units, exit signs, and fixtures indicated to be night lights shall not be switched. Circuits to lighting fixtures indicated to have emergency battery packs shall include an additional un-switched hot conductor. Conductors shall be minimum 12 AWG and conduit shall be minimum 3/4 inch for lighting fixture installation.

3-12. POWER FACTOR CORRECTION CAPACITOR INSTALLATION. Not used

3-13. HEAT-TRACED PIPING INSTALLATION. Factory inspections and tests for heat tracing cables shall include but are not limited to the following:

a. Testing shall be done in accordance with IEEE 515 test section and applicable manufacturer's standards.

b. Megger test of heater cables shall be at jobsite when received before installation.

c. Megger test of heater cables shall be performed after installation, but before insulation is applied.

d. Megger test of heater cables shall be performed after insulation has been installed.

e. All three of the above field megger readings shall be greater than 20 megohms. If any heater cable does not pass the megger test it shall be replaced at the installer's expense.

f. Field megger tests shall be recorded for each heater cable, and certified reports shall be submitted to the Design-Builder.

3-14. MODIFICATIONS TO EXISTING EQUIPMENT. Not used

End of Section

STANDARD SPECIFICATIONS

REFERENCE: UL 83, ICEA S-95-658 (NEMA WC70).

CONDUCTOR: Solid, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.

INSULATION: Polyvinyl chloride, UL 83, Type THHN and THWN, ICEA S-95-658.

SHIELD: None.

JACKET: Conductor: Nylon, 4 mils (100 µm) minimum thickness, UL 83.

FACTORY TESTS: Cable shall meet the requirements of UL 83 for Type THHN and THWN.

Cable Details

Size		Number of Strands	Conductor Insulation Thickness*		Maximum Outside Diameter	
AWG or kcmil	mm^2		in.	µm	in.	mm
12	4.0	1	0.015	380	0.17	4.32
10	6.0	1	0.020	510	0.20	5.08

*The average thickness shall be not less than that indicated above. The minimum thickness shall not be less than 90 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, THWN or THHN, conductor size, and 600 volt.

600 Volt, Single Conductor Lighting Cable (600-1-PVC-THHN-THWN)

BLACK & VEATCH	Cable Data	Figure 1-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: ICEA S-95-658 (NEMA WC 70).

CONDUCTOR: Concentric-lay, uncoated copper; strand Class B. Wet/dry maximum operating temperature 90°C.

INSULATION: Cross-linked thermosetting polyethylene, ICEA S-95-658, Paragraph 3.6.

SHIELD: None.

JACKET: None.

FACTORY TESTS: Cable shall meet the requirements of ICEA S-95-658.

Cable Details

Size		Number of Strands	Conductor Insulation Thickness*		Maximum Outside Diameter	
AWG or kcmil	mm^2		in.	μm	in.	mm
14	2.5	7	0.030	760	0.17	4.32
12	4.0	7	0.030	760	0.19	4.83
10	6.0	7	0.030	760	0.21	5.33
8	10.0	7	0.045	1140	0.27	6.86
6	16.0	7	0.045	1140	0.31	7.87
4	25.0	7	0.045	1140	0.36	9.14
2	35.0	7	0.045	1140	0.42	10.67
1	40.0	19	0.055	1400	0.48	12.19
1/0	50.0	19	0.055	1400	0.52	13.21
2/0	70.0	19	0.055	1400	0.57	14.48
4/0	95.0	19	0.055	1400	0.68	17.27
250	120.0	37	0.065	1650	0.75	19.05
350	185.0	37	0.065	1650	0.85	21.59
500	300.0	37	0.065	1650	0.98	24.89
750	400.0	61	0.080	2030	1.22	31.00
1,000	500.0	61	0.080	2030	1.37	34.80

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 90 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, XLP, XHHW-2, conductor size, and voltage class.

600 Volt, Single Conductor Lighting/Power Cable (600-1-XLP-NONE-XHHW-2)

BLACK & VEATCH	Cable Data	Figure 2-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: UL 83, ICEA S-95-658 (NEMA WC 70).

CONDUCTOR: Stranded, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.

INSULATION: Polyvinyl chloride, UL 83, Type THHN and THWN, ICEA S-95-658.

SHIELD: None.

JACKET: Conductor: Nylon, 4 mils (100 μm) minimum thickness, UL 83.

FACTORY TESTS: Cable shall meet the requirements of UL 83 for Type THHN and THWN.

Cable Details

Size		Number of Strands	Conductor Insulation Thickness*		Maximum Outside Diameter	
AWG or kcmil	mm^2		in.	μm	in.	mm
14	2.5	19	0.015	381	0.12	3.05
12	4.0	19	0.015	381	0.14	3.56
10	6.0	19	0.020	508	0.17	4.32
8	10.0	19	0.030	762	0.23	5.84
6	16.0	19	0.030	762	0.26	6.60
4	25.0	19	0.040	1016	0.33	8.38
2	35.0	19	0.040	1016	0.39	9.91
1	40.0	19	0.050	1270	0.44	11.18
1/0	50.0	19	0.050	1270	0.50	12.70
2/0	70.0	19	0.050	1270	0.54	13.72
4/0	95.0	19	0.050	1270	0.66	16.76
250	120.0	37	0.060	1520	0.72	18.29
350	185.0	37	0.060	1520	0.83	21.08
500	300.0	37	0.060	1520	0.96	24.38
750	400.0	61	0.070	1780	1.17	29.72
1,000	500.0	61	0.070	1780	1.32	33.53

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 90 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, THWN or THHN, conductor size, and 600 volt.

600 Volt, Single Conductor Power Cable (600-1-PVC-THHN-THWN)

BLACK & VEATCH	Cable Data	Figure 3-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: UL 66, UL 1277.

CONDUCTOR: 16 AWG (1.5 mm^2), 7-strand, concentric-lay, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.

INSULATION: Polyvinyl chloride, not less than 15 mils (380 μm) average thickness; 13 mils (330 μm) minimum thickness, UL 66, Type TFN.

LAY: Twisted pair with 1-1/2 inch to 3 inch (38.10 mm - 63.5 mm) lay.

SHIELD: Cable assembly, combination aluminum-polyester tape and 7-strand, 20 AWG (0.5 mm^2) minimum size, tinned copper drain wire, shield applied to achieve 100 percent cover over insulated conductors.

JACKET: Conductor: Nylon, 4 mils (100 μm) minimum thickness, UL 66.

Cable assembly: Black, flame-retardant polyvinyl chloride, UL 1277, applied over tape-wrapped cable core.

CONDUCTOR IDENTIFICATION: One conductor black, one conductor white.

FACTORY TESTS: Insulated conductors shall meet the requirements of UL 66 for Type TFN. Assembly jacket shall meet the requirements of UL 1277. Cable shall meet the vertical-tray flame test requirements of UL 1277.

Cable Details

	Assembly Jacket Thickness*		**Maximum Outside Diameter**	
	in.	**μm**	**in.**	**mm**
Single Pair	0.045	1140	0.34	8.64

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 80 percent of the value indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, Type TC, Type TFN, conductor size, single pair, and voltage class.

600 Volt, Single Pair, Shielded Instrument Cable (600-SINGLE-PAIR-SH-INSTR)

BLACK & VEATCH	**Cable Data**	**Figure 4-26 05 1116050**

STANDARD SPECIFICATIONS

REFERENCE:	UL 66, UL 1277.
CONDUCTOR:	16 AWG (1.5 mm^2), 7-strand, concentric-lay, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.
INSULATION:	Polyvinyl chloride, not less than 15 mils (380 µm) average thickness; 13 mils (330 µm) minimum thickness, UL 66, Type TFN.
LAY:	Twisted triad with 1-1/2 inch to 3 inch (38.10 mm - 63.5 mm) lay.
SHIELD:	Cable assembly, combination aluminum-polyester tape and 7-strand, 20 AWG (0.5 mm^2) minimum size, tinned copper drain wire, shield applied to achieve 100 percent cover over insulated conductors.
JACKET:	Conductor: Nylon, 4 mils (100 µm) minimum thickness, UL 66. Cable assembly: Black, flame-retardant polyvinyl chloride, UL 1277, applied over tape-wrapped cable core.
CONDUCTOR IDENTIFICATION:	One conductor black, one conductor white, one conductor red.
FACTORY TESTS:	Insulated conductors shall meet the requirements of UL 66 for Type TFN. Assembly jacket shall meet the requirements of UL 1277. Cable shall meet the vertical-tray flame test requirements of UL 1277.

Cable Details

	Assembly Jacket Thickness*		Maximum Outside Diameter	
	in.	**µm**	**in.**	**mm**
Single Triad	0.045	1140	0.35	8.87

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 80 percent of the value indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, Type TC, Type TFN, conductor size, single triad, and voltage class.

600 Volt, Single Triad, Shielded Instrument Cable (600-SINGLE-TRIAD-SH-INSTR)

BLACK & VEATCH	**Cable Data**	**Figure 5-26 05 1116050**

STANDARD SPECIFICATIONS

REFERENCE: UL 66, UL 1277.

CONDUCTOR: 18 AWG (0.75 mm^2), 7-strand, concentric-lay, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.

INSULATION: Polyvinyl chloride, not less than 15 mils (380 μm) average thickness; 13 mils (330 μm) minimum thickness, UL 66, Type TFN.

LAY: Twisted pairs or triads with 1-1/2 inch to 3 inch (38.10 - 63.5 mm) lay.

SHIELD: Each pair or triad and cable assembly: Combination aluminum-polyester tape and 7-strand, 20 AWG (0.5 mm^2) minimum size, tinned copper drain wire, shield applied to achieve 100 percent cover over insulated conductors. Shield tape on pair and/or triad assemblies shall be applied in such a way as to give total shield isolation from all other pairs' or triads' shields.

JACKET: Conductor: Nylon, 4 mils (100 μm) minimum thickness, UL 66.

Cable Assembly: Black, 90°C, flame-retardant polyvinyl chloride, UL 1277, Table 10.17, applied over tape-wrapped cable core.

CONDUCTOR IDENTIFICATION:

Pair: One conductor black, one conductor white.

Triad: One conductor black, one conductor white, one conductor red.

PAIR Identification: Each pair and/or triad numbered.

FACTORY TESTS: Insulated conductors shall meet the requirements of UL 66 for Type TFN. Assembly jacket shall meet the requirements of UL 1277. Cable shall meet the vertical-tray flame test requirements of UL 1277.

Cable Details

	Assembly Jacket Thickness*		**Maximum Outside Diameter**	
	in.	**μm**	**in.**	**mm**
Number of Pairs				
4	0.045	1140	0.554	14.07
8	0.060	1520	0.749	19.02
12	0.060	1520	0.896	22.76
24	0.060	1520	1.256	31.90
Number of Triads				
4	0.060	1520	0.648	16.46
8	0.060	1520	0.823	20.99
12	0.080	2030	1.030	26.16
24	0.080	2030	1.393	35.38

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 80 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, Type TC, Type TFN, conductor size, number of pairs or triads, and voltage class.

600 Volt, Multiple Pair and/or Triad, Shielded Instrument Cable
(600-MULTI-PAIRS-TRIADS-SH-INSTR)

BLACK & VEATCH	**Cable Data**	**Figure 6-26 05 1116050**

STANDARD SPECIFICATIONS

REFERENCE: UL 83, UL 1277, ICEA S-73-532, ICEA S-58-679.

CONDUCTOR: 14 AWG (2.5 mm^2), 7 or 19 strands, concentric-lay, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.

INSULATION: Polyvinyl chloride, not less than 15 mils (380 μm) average thickness; 13 mils (330 μm) minimum thickness, UL 83, Type THHN and THWN.

SHIELD: None.

JACKET: Conductor: Nylon, 4 mils (100 μm) minimum thickness, UL 83.

Cable assembly: Black, flame-retardant polyvinyl chloride, UL 1277, applied over tape-wrapped cable core.

CONDUCTOR IDENTIFICATION: ICEA S-58-679, Method 1, Table 2 or ICEA S-58-679, Method 3, Table 2. White or green conductors shall not be provided.

FACTORY TESTS: Insulated conductors shall meet the requirements of UL 83 for Type THHN-THWN. Assembly jacket shall meet the requirements of UL 1277. Cable shall meet the flame test requirements of UL 1277 for Type TC power and control tray cable.

Cable Details

Number of Conductors	Assembly Jacket Thickness*		Maximum Outside Diameter	
	in.	μm	in.	mm
2	0.045	1140	0.38	9.65
3	0.045	1140	0.39	9.91
4	0.045	1140	0.44	11.18
5	0.045	1140	0.46	11.68
7	0.045	1140	0.49	12.45
9	0.045	1140	0.61	15.49
12	0.060	1520	0.66	16.76
19	0.060	1520	0.77	19.56
24	0.060	1520	0.93	23.62
30	0.080	2030	0.98	24.89
37	0.080	2030	1.05	26.67

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 80 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, Type TC, Type THWN or THHN, conductor size, number of conductors, and voltage class.

600 Volt, Multiconductor 14 AWG (2.5 mm^2) Control Cable (600-MULTI-THHN-THWN)

BLACK & VEATCH	Cable Data	Figure 7-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: UL 83, UL 1277, ICEA S-73-532, ICEA S-58-679.

CONDUCTOR: 12 AWG (4 mm²), 7 or 19 strands, concentric-lay, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.

INSULATION: Polyvinyl chloride, not less than 15 mils (380 μm) average thickness; 13 mils (330 μm) minimum thickness, UL 83, Type THHN and THWN.

SHIELD: None.

JACKET: Conductor: Nylon, 4 mils (100 μm) minimum thickness, UL 83.

Cable assembly: Black, flame-retardant polyvinyl chloride, UL 1277, applied over tape-wrapped cable core.

CONDUCTOR IDENTIFICATION: ICEA S-58-679, Method 1, Table 2 or ICEA S-58-679, Method 3, Table 2. White or green conductors shall not be provided.

FACTORY TESTS: Insulated conductors shall meet the requirements of UL 83 for Type THHN-THWN. Assembly jacket shall meet the requirements of UL 1277. Cable shall meet the flame test requirements of UL 1277 for Type TC power and control tray cable.

Cable Details

Number of Conductors	Assembly Jacket Thickness*		Maximum Outside Diameter	
	in.	μm	in.	mm
2	0.045	1140	0.46	11.68
3	0.045	1140	0.49	12.45
4	0.045	1140	0.56	14.22
5	0.045	1140	0.60	15.24
7	0.045	1140	0.66	16.76
9	0.060	1520	0.77	19.56
12	0.060	1520	0.91	23.11
19	0.060	1520	1.05	26.67
24	0.060	1520	1.22	30.99
30	0.080	2030	1.29	32.77
37	0.080	2030	1.40	35.56

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 80 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, Type TC, Type THWN or THHN, conductor size, number of conductors, and voltage class.

600 Volt, Multiconductor 12 AWG (4 mm^2) Control Cable (600-MULTI-THHN-THWN)

BLACK & VEATCH	Cable Data	Figure 8-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE:	ICEA S-93-639 (NEMA WC 74), AEIC CS-8, ICEA P-45-482.
CONDUCTOR:	Concentric-lay, uncoated or coated copper, strand Class B. Normal maximum operating temperature 90°C.
CONDUCTOR SHIELD:	Extruded semiconducting thermosetting material, ICEA S-93-639, Section 3.
INSULATION:	Ethylene-propylene rubber, ICEA S-93-639, Section 4, not less than 115 mils (2920 μm) average thickness; 103.5 mils (2630 μm) minimum thickness.
INSULATION SHIELD:	Extruded semiconducting thermosetting material, and nonembedded coated copper tape or coated copper wires, ICEA S-93-639, Section 5. Extruded material shall be tested in accordance with ICEA S-93-639 and AEIC CS-8. Shield area shall be not less than that of one helically applied 5 mil (130 μm) copper tape with a 10 percent overlap when calculated according to Formula 3 in ICEA P-45-482.
JACKET:	Black polyvinyl chloride, ICEA S-93-639, Paragraph 7.1.9.
FACTORY TEST:	Cable shall meet the requirements of ICEA S-93-639 and AEIC No. CS-8.

Cable Details

Size		Number of Strands	*Jacket Thickness		Maximum Outside Diameter	
AWG or kcmil	mm²		in.	μm	in.	mm
6	16	7	0.060	1520	0.74	18.8
4	25	7	0.060	1520	0.78	19.81
2	35	7	0.060	1520	0.84	21.34
1	40	19	0.060	1520	0.88	22.35
1/0	50	19	0.060	1520	0.92	23.37
2/0	70	19	0.080	2030	1.01	25.65
4/0	95	19	0.080	2030	1.12	28.45
250	120	37	0.080	2030	1.18	29.97
350	185	37	0.080	2030	1.29	32.77
500	300	37	0.080	2030	1.45	36.88
750	400	61	0.080	2030	1.65	41.91
1000	500	61	0.080	2030	1.81	45.97

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 80 percent of the values indicated above.

The conductor shield, insulation, and insulation shield shall be applied in a triple extrusion process with all three components being cured at the same time.

The color of the insulation shall be in contrast to the color of the semiconducting paint. The semiconducting paint shall be readily removable for terminating.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, insulating material, conductor size, and voltage class.

Voltage Test After Installation: DC Test Voltage - 36 kV
Duration of Test - 15 Minutes

8000 Volt, Single Conductor Power Cable
100 Percent Insulation Level (8000-1-EPR-PVC-SH)

BLACK & VEATCH	Cable Data	Figure 9-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: ICEA S-93-639 (NEMA WC 74), AEIC CS-8, ICEA P-45-482.

CONDUCTOR: Concentric-lay, uncoated or coated copper, strand Class B. Normal maximum operating temperature 90°C.

CONDUCTOR SHIELD: Extruded semiconducting thermosetting material, ICEA S-93-639, Section 3.

INSULATION: Ethylene-propylene rubber, ICEA S-93-639, Section 4, not less than 220 mils (5590 μm) average thickness; 198 mils (5030 μm) minimum thickness.

SHIELD: Extruded semiconducting thermosetting material, and nonembedded coated copper tape or coated copper wires, ICEA S-93-639, Section 5. Extruded material shall be tested in accordance with ICEA S-93-639 and AEIC CS-8. Shield area shall be not less than that of one helically applied 5 mil (130 μm) copper tape with a 10 percent overlap when calculated according to Formula 3 in ICEA P-45-482.

JACKET: Black polyvinyl chloride, ICEA S-93-639, Paragraph 7.1.9.

FACTORY TEST: Cable shall meet the requirements of ICEA S-93-639 and AEIC CS-8.

Cable Details

Size		Number of Strands	*Jacket Thickness		Maximum Outside Diameter	
AWG or kcmil	mm^2		in.	μm	in.	mm
2	35	19	0.080	2030	1.14	28.96
1	40	19	0.080	2030	1.17	29.72
1/0	50	19	0.080	2030	1.21	30.73
2/0	70	19	0.080	2030	1.25	31.75
4/0	95	19	0.080	2030	1.30	33.02
250	120	37	0.080	2030	1.43	36.32
350	185	37	0.080	2030	1.53	38.86
500	300	37	0.080	2030	1.66	42.16
750	400	61	0.110	2790	1.95	49.53
1000	500	61	0.110	2790	2.19	55.63

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 80 percent of the values indicated above.

The conductor shield, insulation, and insulation shield shall be applied in a triple extrusion process with all three components being cured at the same time.

The color of the insulation shall be in contrast to the color of the semiconducting paint. The semiconducting paint shall be readily removable for terminating.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, insulating material, conductor size, and voltage class.

Voltage Test After Installation: DC Test Voltage - 53 kV
Duration of Test - 15 Minutes

15,000 Volt, Single Conductor Power Cable
133 Percent Insulation Level (15-1-EPR-PVC-SH)

BLACK & VEATCH	Cable Data	Figure 10-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: ICEA S-95-658 (NEMA WC 70).

CONDUCTOR: Concentric lay, uncoated copper; strand Class B. Normal maximum operating temperature 90°C.

INSULATION: Cross-linked thermosetting polyethylene, ICEA S-95-658, Paragraph 3.6.

SHIELD: None.

JACKET: Cable assembly; black, flame-retardant polyvinyl chloride, UL1277, applied over tape-wrapped cable core.

FACTORY TEST: Cable shall meet the requirements of ICEA S-95-658, UL1277 and IEEE Standard 1202 ribbon burner flame test.

Cable Details

Size		Number of Strands	*Conductor Insulation Thickness		**Assembly Jacket Thickness		Maximum Outside Diameter	
AWG or kcmil	mm^2		in.	mm	in.	μm	in.	mm
12	4	7	0.030	0.76	0.045	1140	0.46	11.68
10	6	7	0.030	0.76	0.045	1140	0.51	12.95
8	10	7	0.045	1.14	0.060	1520	0.68	17.27
6	16	7	0.045	1.14	0.060	1520	0.76	19.30
4	25	7	0.045	1.14	0.060	1520	0.91	23.11
2	35	7	0.045	1.14	0.060	1520	1.03	26.16
1	40	19	0.055	1.40	0.080	2030	1.16	29.46
1/0	50	19	0.055	1.40	0.080	2030	1.26	32.00
2/0	70	19	0.055	1.40	0.080	2030	1.36	34.54
4/0	95	19	0.055	1.40	0.080	2030	1.60	40.64

*The average thickness shall be not less than indicated above. The minimum thickness shall be not less than 90 percent of the values indicated above.

**The average thickness shall be not less than indicated above. The minimum thickness shall be not less than 80 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, XLP, XHHW-2, Type TC, conductor size, and voltage class.

600 Volt, 3 Conductor With Ground Power Tray Cable (600-3-XLP-PVC-TC)

BLACK & VEATCH	Cable Data	Figure 11-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: ICEA S-95-658 (NEMA WC 70).

CONDUCTOR: Concentric-lay, uncoated copper; strand Class B. Wet/dry maximum operating temperature 90°C.

INSULATION: Cross-linked thermosetting polyethylene, ICEA S-95-658, Paragraph 3.6.

SHIELD: None.

JACKET: None.

FACTORY TESTS: Cable shall meet the requirements of ICEA S-95-658, UL and IEEE Standard 1202 ribbon burner flame tests.

Cable Details

Size		Number of Strands	Conductor Insulation Thickness*		Maximum Outside Diameter	
AWG or kcmil	mm^2		in.	μm	in.	mm
250	120	37	0.065	1650	0.72	18.29
350	185	37	0.065	1650	0.83	21.08
500	240	37	0.065	1650	0.95	24.13
750	400	61	0.080	2030	1.17	29.72
1000	500	61	0.080	2030	1.35	34.29

*The average thickness shall be not less than indicated above. The minimum thickness shall be not less than 90 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, VW-1, XHHW-2, Type TC, conductor size, and voltage class.

600 Volt, Single Conductor Power Tray Cable
(600-1-VW-1-NONE-XHHW-2-TC)

BLACK & VEATCH	Cable Data	Figure 12-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: ICEA S-95-658 (NEMA WC 70).

CONDUCTOR: Concentric-lay, uncoated copper; strand Class B. Normal maximum operating temperature 90°C.

INSULATION: Cross-linked thermosetting polyethylene, ICEA S-95-658, Paragraph 3.6.

SHIELD: None.

JACKET: None.

FACTORY TESTS: Cable shall meet the requirements of ICEA S-95-658.

Cable Details

Size		Number of Strands	Conductor Insulation Thickness*		Maximum Outside Diameter	
AWG or kcmil	mm^2		in.	μm	in.	mm
14	2.5	7	0.045	1140	0.19	4.83
12	4.0	7	0.045	1140	0.22	5.59
10	6.0	7	0.045	1140	0.24	6.10
8	10.0	7	0.060	1520	0.31	7.87
6	16.0	7	0.060	1520	0.35	8.89
4	25.0	7	0.060	1520	0.39	9.91
2	35.0	7	0.060	1520	0.46	11.68
1	40.0	19	0.080	2030	0.54	13.72
1/0	50.0	19	0.080	2030	0.59	14.99
2/0	70.0	19	0.080	2030	0.63	16.00
4/0	95.0	19	0.080	2030	0.74	18.80
250	120.0	37	0.095	2410	0.82	20.83
350	185.0	37	0.095	2410	0.91	23.11
500	300.0	37	0.095	2410	1.04	26.42
750	400.0	61	0.110	2790	1.28	32.51
1,000	500.0	61	0.110	2790	1.44	36.58

*The average thickness shall be not less than that indicated above. The minimum thickness shall be not less than 80 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, XLP, RHH or RHW or USE, conductor size, and voltage class.

600 Volt, Single Conductor Power Cable (600-1-XLP-NONE-RHH-RHW-USE)

BLACK & VEATCH	Cable Data	Figure 13-26 05 1116050

STANDARD SPECIFICATIONS

REFERENCE: Type MC, UL 83 and 1569.

CONDUCTOR: Solid, uncoated copper. Maximum operating temperature 90°C dry.

INSULATION: Polyvinyl chloride, UL 83, Type THHN.

GROUND: Copper conductor sized per NEC with green THHN insulation.

JACKET: Conductor: Nylon.

ARMOR: Galvanized interlocked steel.

FACTORY TESTS: Conductors shall meet the requirements of UL 83 for Type THHN. Assembly shall meet the requirements of UL 1569 for Type MC.

Cable Details

Size					Nominal Outside Diameter	
AWG or kcmil	mm²	Number of Conductors	Ground Size (AWG)	Number of strands per conductor	in.	mm
12	4.0	2	12	1	0.492	12.50
12	4.0	3	12	1	0.531	13.49
12	4.0	4	12	1	0.579	14.71
10	6.0	2	10	1	0.562	14.27
10	6.0	3	10	1	0.610	15.49
10	6.0	4	10	1	0.641	16.28

600 Volt, Type MC Metal Clad Lighting Cable (Metal Clad THHN)

BLACK & VEATCH	Cable Data	Figure 14-26 05 11

STANDARD SPECIFICATIONS

REFERENCE: ICEA S-95-658 (NEMA WC 70).

CONDUCTOR: Stranded, uncoated copper. Maximum operating temperature 90°C.

INSULATION: Cross-linked polyethylene, ICEA S-95-658.

GROUND: Copper conductor sized per NEC with green insulation.

SHIELD: Cable assembly: Copper tape or aluminum foil-polyester tape, shield applied to achieve 100 percent cover over insulated conductors.

JACKET: Cable assembly: Black, flame-retardant polyvinyl chloride, UL 1277, applied over tape-wrapped cable core.

FACTORY TEST: Cable shall meet the requirements of ICEA S-95-658, UL1277 and IEEE Standard 1202 ribbon burner flame test.

Cable Details

Size		Number of Strands	*Conductor Insulation Thickness		**Assembly Jacket Thickness		Maximum Outside Diameter	
AWG or kcmil	mm^2		in.	mm	in.	μm	in.	mm
12	4	7	0.060	1.52	0.060	1520	0.66	16.80
10	6	7	0.060	1.52	0.060	1520	0.71	18.14
8	10	7	0.070	1.78	0.060	1520	0.93	23.74
6	16	7	0.070	1.78	0.080	2030	1.04	26.40
4	25	7	0.070	1.78	0.080	2030	1.21	30.67
2	35	7	0.070	1.78	0.080	2030	1.35	34.40
1	40	7	0.070	1.78	0.080	2030	1.35	34.40
1/0	50	19	0.090	2.29	0.080	2030	1.70	43.07
2/0	70	19	0.090	2.29	0.080	2030	1.77	44.94
4/0	95	19	0.090	2.29	0.110	2800	2.02	51.34
250	120	37	0.105	2.67	0.110	2800	2.30	58.49
350	185	37	0.105	2.67	0.110	2800	2.63	66.70
500	300	37	0.105	2.67	0.110	2800	3.12	79.26

*The average thickness shall be not less than indicated above. The minimum thickness shall be not less than 90 percent of the values indicated above.

**The average thickness shall be not less than indicated above. The minimum thickness shall be not less than 80 percent of the values indicated above.

A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches (600 mm). Marking shall include manufacturer's name, XLP, RHW, Type TC, conductor size, and voltage class.

2000 Volt, 3 Conductor Adjustable Frequency Drive Cable (2000-3-AFD-XLP-PVC-SH-TC)

BLACK & VEATCH	Cable Data	Figure 15-26 05 1116050

Project and Location _____ Project No. _____

Circuit Designation _____ Date _____

DC TEST DATA

Time in Minutes After 100% Test Voltage Is Applied	Current, µA		
	Phase A	Phase B	Phase C
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
kV dc after 1 min Decay			

DC Test Voltage _____

Cable Installation: New ____ Used ___ Years____

Cable: Size _____ Length: _____

Oper. kV _____ Grounded _____ Ungrounded _____

Rated Cable Voltage _____

Insulation Wall _____
(Type & Thickness)

Conductor Jacket Wall _____
Type & Thickness)

Shield _____
(Type)

Cable Manufacturer _____

Temperature _____ Humidity_____

Type of Termination _____

Type of Splice & Location_____
_____

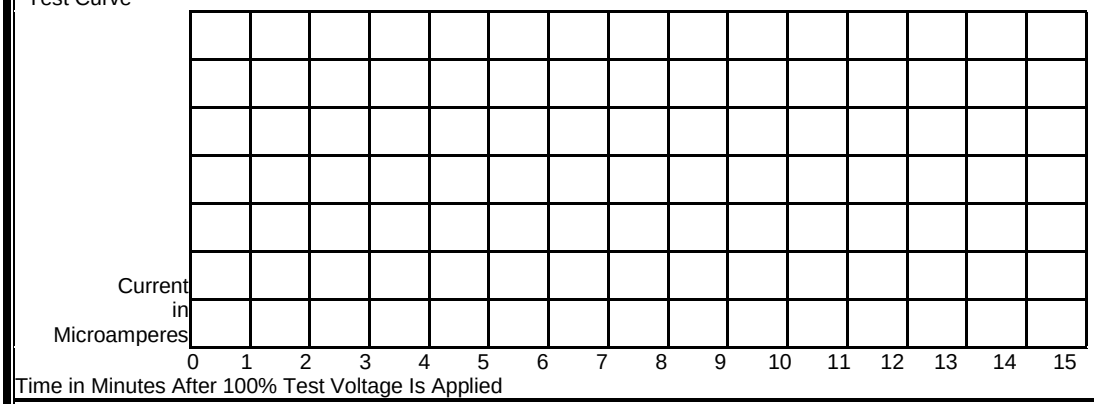
Remarks_____

100 Microamperes (µA) = 0.1 Milliampere

APPLICATION OF TEST VOLTAGE

The initially applied direct-current voltage shall be not greater than 3.0 times the rated alternating-current voltage. The rate of increase from the initially applied voltage to the specified test voltage shall be not over 100 percent in 10 seconds nor less than 100 percent in 60 seconds. The duration of the direct-current voltage test shall be 15 minutes for shielded cables and 5 minutes for nonshielded cables.

Test Curve



NOTES:
1. Plot results of tests on all three phases on this graph.
2. Assign and indicate values for each division on the microamperes scale as required for the circuit being tested.

Cable Test Data Form

BLACK & VEATCH	**Cable Data**	**Figure 16-26 05 1116050**

Section 26 05 83

ELECTRICAL EQUIPMENT INSTALLATION

PART 1 - GENERAL

1-1. SCOPE. This section covers the installation of electrical equipment.

1-2. GENERAL. Equipment specified to be installed under this section shall be erected, and placed in proper operating condition in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by **Design-Builder**.

1-2.01. Coordination. When manufacturer's field services are provided by the equipment manufacturer, Design-Builder and Electrical Installer shall coordinate together the services with the equipment manufacturer.

Submittals for equipment furnished by others will be furnished to Electrical Installer upon completion of review by Design-Builder. Electrical Installer shall review equipment submittals and coordinate with the requirements of the Work and the Contract Documents. Electrical Installer accepts sole responsibility for determining and verifying all quantities, dimensions, and field construction criteria.

1-3. DELIVERY, STORAGE, AND HANDLING.

1-3.01. Delivery. When sills are required for electrical equipment, they shall be shipped ahead of the scheduled equipment delivery to permit installation before concrete is placed.

1-3.02. Storage. Upon delivery, all equipment and materials shall immediately be stored and protected by Electrical Installer in accordance with Product Storage and Handling Requirements section, and in accordance with manufacturer's written instructions, until installed in the Work. Equipment shall be protected by Electrical Installer against damage and exposure from the elements. At no time shall the equipment be stored on earth or grass surfaces or come into contact with earth or grass. Electrical Installer shall keep the equipment clean and dry at all times. Openings shall be plugged or capped (or otherwise sealed by packaging) during temporary storage.

1-3.03. Handling. Electrical equipment shall be moved by lifting, jacking, or skidding on rollers as described in the manufacturer's instructions. Special lifting harness or apparatus shall be used when required. Lifting and jacking points shall be used when identified on the equipment. Electrical Install shall have required unloading equipment on site to perform unloading work on the date of equipment delivery.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3-1. INSTALLATION, TESTING, AND COMMISSIONING. All installation work shall be in accordance with manufacturer's written instructions.

All material, equipment, and components specified to be installed according to this section shall be installed, tested, and commissioned for operation in compliance with NECA 1000 – NEIS Specification System. Where required in NECA 1000, testing and commissioning procedures shall be followed prior to energizing equipment.

Electrical equipment cubicles and vertical sections shall be installed plumb and level. Drawout equipment carriages, circuit breakers, and other removable components shall operate free and easy without binding or distortion.

Unless otherwise indicated or specified, all indoor floor-mounted electrical equipment and control cabinets shall be installed on concrete equipment pads four inches [102 mm] in height.

Indoor metalclad switchgear shall be bolted to steel floor channels which are installed level and flush with the top of the concrete floor or equipment pad.

Outdoor metalclad switchgear and interrupter gear with integral floor channels or beams shall be secured to concrete pads with anchor bolts and clips.

Motor control centers with integral floor sills shall be secured to concrete floors or equipment pads with anchor bolts.

Adequate bracing shall be provided for seismic forces. The bracing shall be designed to meet the requirements of the Meteorological and Seismic Design Criteria section.

3-1.01. Cleaning. All deposits of oil, grease, mud, dirt or debris shall be cleaned from the electrical equipment following installation and field wiring. A detergent water based solution, or other liquid cleaners not harmful to material or equipment finishes, shall be used as recommended by the manufacturer.

End of Section

Section 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1-1. SCOPE. This section covers switchboard equipment, which shall be furnished as specified herein and as indicated on the Drawings. Switchboards shall meet the following requirements, and the design conditions and features.

Switchboards shall be designated and located as follows:

Tag number(s)	As per Electrical One-line 80-E-701
Switchboard designation(s)	As per Electrical One-line 80-E-701
Location of switchboard(s)	As per Electrical drawing 80-E-101

1-2. GENERAL. Equipment furnished and installed 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, unless exceptions are noted by Design-Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment furnished under this section. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Dimensional Restrictions. Layout dimensions will vary between manufacturers, and the layout area indicated on the Drawings is based on typical values. The supplier shall review the engineering Drawings, the manufacturer's layout drawings and installation requirements, and make any modifications required for proper installation subject to acceptance by Design Builder.

1-2.04. Workmanship and Materials. Equipment supplier shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with applicable governing standards. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable.

Equipment shall not have been in service at any time prior to delivery, except as required by tests.

1-2.05. Governing Standards. All equipment furnished under this section shall be designed, constructed, and tested in accordance with the following standards:

NEMA PB 2 and UL 891 (switchboards);
NEMA AB1 and UL 489 (molded-case circuit breakers);
ICS-6 (enclosures);
NEMA PD 2.2 (Ground Fault Protection).
NEC 240.87 (Arc Energy Reduction)

The equipment shall also conform to all the applicable standards of ANSI, IEEE, NEMA, UL, NEC and NFPA 70.

Equipment covered by this section shall be listed by UL.

1-2.06. Nameplates. Each switchboard section shall have a nameplate permanently affixed to it, listing the following information:

Name of manufacturer

System voltage

Main bus rating

Type

Manufacturer's shop order number and date

In addition, each circuit breaker and instrument on the front of the switchboard shall have a suitable nameplate. Each incoming line section shall be furnished with a nameplate to indicate the power source or substation from which it is fed. The nameplates for the distribution circuit breakers shall indicate the equipment fed through the breaker. Nameplates shall be black and white laminated phenolic material of suitable size, and shall be engraved with 3/4 inch [19 mm] high letters for section and circuit breaker identity and 1/8 inch [3 mm] letters for other information. The engraving shall extend through the black exterior lamination to the white center.

Each control device and each control wire terminal block connection inside the units shall be identified with a permanent nameplate or painted legend to match the identification on the manufacturer's wiring diagram.

1-2.07. System Characteristics. The switchboard will be connected to a power system with characteristics as specified below.

Voltage rating	480 V

Frequency	60 Hz
Type	Three phase and neutral
Grounding	Solid

1-3. SUBMITTALS. Complete assembly, foundation, and installation drawings, together with complete engineering data covering the materials used, parts, devices, and accessories forming a part of the switchboard, shall be submitted in accordance with the Submittal Procedure section. The drawings and data shall include, but shall not be limited to, the following:

Switchboard
- Elevation, plan, conduit entrance locations, and weight.
- Circuit breaker time-current characteristic curves.
- Nameplate legends and equipment schedule.
- Single-line and control wiring interconnection diagrams.
- Metering section details.
- Shop test report.
- Installation report.
- Surge protective device submittals shall include drawings (including unit dimensions, weights, component and connection locations, mounting provisions, and wiring diagrams), equipment manuals that detail the installation, operation and maintenance instructions for the specified unit(s), and manufacturer's descriptive bulletins and product sheets.

Seismic Design Requirements
- Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

Studies
- Short-Circuit Study
- Coordination Study
- Arc Flash Analysis

1-4. OPERATION AND MAINTENANCE DATA AND MANUALS. Operation and maintenance manuals shall be submitted in accordance with the Submittal Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-5. SPARE PARTS. Provide a manufacturer recommended spare part list to Design-Builder.

1-6. PROTECTIVE DEVICE STUDY. A protective device study of the power distribution system will be conducted as specified in the Electrical section. The equipment manufacturer shall provide the following information to Design Builder with the initial equipment drawing submittal:

Protective relay coordination curves for each solid-state trip device.

Time current curves shall be provided for the following circuit breakers:
Main breaker
Largest feeder breaker
Smallest breaker

Data for all devices with adjustable settings shall be submitted, with all literature necessary to determine the appropriate settings. This shall include, but shall not be limited to, Operation Manuals for each type of adjustable trip device.

1-7. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

Switchboards shall be equipped to be handled by a crane. Where cranes are not available, switchboards shall be suitable for skidding in place on rollers using jacks to raise and lower the groups.

1-8. Arc Flash Hazard Labels. Switchboards shall be provided with permanent labels warning the risk of arc flash and shock hazard. Labels shall be designed in accordance with ANSI Z535.4 and shall include the following:

WARNING
Arc Flash and Shock Hazard

Appropriate personal protection equipment (PPE) required. SEE NFPA 70E.
Equipment must be accessed by qualified personnel only.
Turn off all power sources prior to working on or inside equipment.

Additional information shall be provided on the labels as per the Arc Flash Hazard Analysis performed by the Supplier.

PART 2 - PRODUCTS

2-1. ACCEPTABLE MANUFACTURERS. The switchboard shall be manufactured by Eaton, General Electric, Schneider-Electric, or Siemens without exception.

2-2. CONSTRUCTION. All equipment furnished under this section shall be front connected, and shall be designed and constructed in accordance with the following requirements and as indicated on the Drawings.

2-2.01. Enclosure. The switchboard shall be of deadfront, modular type construction with the required number of vertical sections bolted together to form one rigid, NEMA Type 1 metal-enclosed unit. All sections shall be aligned in both front and rear. The switchboard frame shall be of formed UL gauge steel, rigidly bolted together to support all cover plates, buses, and circuit breakers. Steel

base channels shall be bolted to the frame. Each section shall have a removable top plate and an open bottom for installation and termination of conduit. All front covers shall be removable with a single tool and all doors shall be hinged, with removable hinge pins. Enclosures shall have frontaccess, and shall be designed to be installed against a wall. End sections shall include provisions for main, ground and neutral bus extensions and installation of future vertical sections.

Adequate bracing shall be provided for seismic forces. The bracing shall be designed to meet the requirements of the Meteorological and Seismic Design Criteria section.

2-2.02. Busing. The main a bus shall be tin-plated copper and shall be of sufficient size to limit the temperature rise to 65°C, based on UL tests. End sections shall be predrilled for units to be added in the future. The bus rating shall be as follows:

Bus current rating.	Per Drawing
Bus fault rating (symmetrical).	Per Drawing

2-2.02.01. Neutral Bus. Not used

2-2.02.02. Neutral Pad. The incoming line section shall be equipped with a neutral bond lug suitable to bond the service entrance neutral conductors. The service entrance neutral pad shall be equipped with a main bonding jumper to the switchboard ground bus in accordance with the National Electrical Code.

2-2.03. Ground Bus. The ground bus shall extend the entire length of the switchboard and shall be firmly secured to each vertical section. A ground lug shall be provided at each end of the ground bus for connection to building grounding system with 4/0 AWG bare copper cables. Other ground lugs for feeder circuits shall also be supplied as indicated on the Drawings.

2-2.04. Incoming Line Sections. Incoming line sections shall be provided as shown on the one-line diagram and as specified herein.

Number of incoming line sections	1
Service entrance rated	Yes
Incoming cable entrance	Bottom

2-2.04.01. Cable Pull Box. Each bussed pull section shall have compression type terminals for the number and size of copper conductors. The cable pull box shall include provisions for a power utility seal.

2-2.04.02. Nonsegregated Phase Bus Duct Entry Compartment. A nonsegregated phase bus duct entry compartment shall be provided. The

switchboard manufacturer shall be responsible for coordination, proper phasing, and internal bussing to the incoming bus duct. All hardware, splice plates, flexible connectors, and insulating material for connection to the switchboard shall be furnished.

2-2.04.03. Power Utility Metering Compartment. Not used.

2-2.04.04. Incoming Line Metering Compartment. The incoming line section(s) shall be provided with a microprocessor-based, digital power meter. Current transformers and potential transformers shall be provided for input of current and voltage signals to the metering package. Phase currents, phase voltages, watts, vars, power factor, frequency, watt-hours, watt demand , and total harmonic distortion waveforms shall be available for display. Metering units shall also include a display with touch screen monitor on the front of the equipment. The following alarm features shall be provided: undervoltage, power factor leading or lagging, kvar limit, voltage sequence reversal, underfrequency, and overcurrent. The metering package shall be capable of Ethernet/IP communication for remote monitoring.

Sufficient lengths of communication cable shall be provided for connection of metering units within the switchboard and.

2-2.04.05. Surge Protective Devices.

2-2.04.05.01. Scope. Surge Protective Devices (SPD) devices shall be provided as specified herein and as indicated on the Drawings. Each unit shall be designed for parallel connection to the facility's wiring system and shall utilize non-linear voltage-dependent metal oxide varistors (MOV) in parallel.

SPD’s shall be furnished and installed for the electrical equipment indicated on the Drawings and designated in this section as required and as specified herein. SPD’s shall be installed integral to each switchboard. SPD’s for switchboards shall be rated formedium-high exposure levels.

2-2.04.05.02. Standards. The specified unit shall be designed, manufactured, tested and installed in compliance with the following standards:

ANSI/IEEE C62.41 and C62.45;

ANSI/IEEE C62.1 and C62.11;

IEEE C62.62;

NEMA LS1;

NFPA 20, 70, 75, and 78;

UL 1449 and 1283

The unit shall be UL 1449 Listed as a Type 2 Surge Protective Device and UL 1283 Listed as an Electromagnetic Interference (EMI) Filter.

2-2.04.05.03. Environmental Requirements.

a. Operating Temperature: 0°F to +140°F (-18°C to +60°C).
b. Relative Humidity: Reliable operation with 5 percent to 95 percent non-condensing.

2-2.04.05.04. Electrical Requirements.

a. Unit Operating Voltage. The nominal unit operating voltage and configuration shall be as indicated on the Drawings.
b. Maximum Continuous Operating Voltage (MCOV). The SPD shall be designed to withstand a MCOV of not less than 115 percent of nominal RMS voltage.
c. Operating Frequency. Operating frequency range shall be 47 to 63 Hertz.
d. Protection Modes. Four-wire configured systems shall provide Line-to-Neutral (L-N), Line-to-Ground (L-G), and Neutral-to-Ground (N-G), and Line-to-Line (L-L) protection. Three-wire configured systems shall provide Line-to-Line (L-L) protection and Line-to-Ground (L-G) protection.
e. Rated Single Pulse Surge Current Capacity. The rated single pulse surge current capacity, in amps, for each mode of protection of the unit shall be no less than as follows:

	L-N	L-G	N-G	L-L
[Medium-High Exposure Level	100 kA	100 kA	100 kA	100 kA]

f. UL 1449 Voltage Protection Rating (VPR). The maximum VPR for the device (inclusive of disconnect) shall not exceed the following:

Voltage	L-N	L-G	N-G	L-L
[480 V 4W	1200 V	1200 V	1200 V	2000 V]

g. Noise Attenuation. The unit shall be capable of a minimum -30 dB attenuation at 100kHz when tested per the 50 ohm insertion loss method as defined by MIL-STD-220C.
h. Nominal Discharge Current. Each SPD shall have a nominal discharge current rating of 20 kA.

i. Overcurrent Protection. At high and medium-high exposure levels, the SPD shall incorporate internal fusing capable of interrupting, at minimum, up to 200 kA symmetrical fault current with 600 volts AC applied.
The device shall be capable of allowing passage of the rated maximum surge current for every mode without fuse operation.

j. Unit Status Indicators. The unit shall include long-life, externally visible phase indicators that monitor the on-line status of the unit.

2-2.04.05.05. Warranty. The manufacturer shall provide a standard Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

2-2.04.05.06. Installation. Each SPD shall be installed according to the manufacturer's recommendations. If possible for the integral units, provide direct bus connections.

2-2.04.05.07. Accessories

a. Disconnect Switch. Each SPD shall be furnished with an integral disconnect switch. The unit shall be UL1449 listed as such, and the UL1449 Voltage Protection Ratings shall be provided. The disconnect switch shall be fused and capable of withstanding, without failure, the published maximum surge current magnitude without failure or damage to the switch.

b. Dual Form "C" Dry Contacts. The SPD shall be provided with a set of form "C" dry contacts (normally open and normally closed) to facilitate connection to a plant control system or other remote monitoring system. The contacts shall be normally open or normally closed and shall change state upon any alarm condition.

2-2.04.06. Main Breaker. Each incoming line section shall include a fixed mounted insulated case power circuit breaker with a current rating as indicated on the Drawings and with a manually operated stored energy mechanism. Molded case circuit breakers shall have solid state electronic with short time delay trip mechanisms, and shall have ground fault protection.

Compression type terminals shall be provided for terminating the number and size of copper conductors indicated on the Drawings.

2-2.05. Tie Breaker Section. Not used.

2-2.06. Distribution Section. The distribution section shall be provided to house branch circuit breakers as indicated on the Drawings.

Circuit breakers shall be removable from the front without disturbing adjacent units. The switchboard shall contain space for future units as indicated on the Drawings. The cable entry for the distribution section shall be from the bottom.

2-2.07. Molded Case Circuit Breakers. Circuit breakers shall be rated to interrupt and withstand an available fault current of 65,000 A at the system line voltage. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break, over-center switching mechanism that is mechanically trip free. Circuit breakers shall have trip units as specified herein. Electronic trip units shall be complete with built-in current transformers. The ampere rating of the trip unit shall be as indicated on the Drawings.

The trip unit shall have adjustable settings for continuous amperes, instantaneous pickup, and short-time pickup. Where specified herein, the trip unit shall be provided with additional short delay trip time adjustment for better system coordination. Circuit breakers indicated to be rated less than 100 amperes shall be thermal-magnetic types.

Where specified herein, built-in ground fault protection shall be provided having adjustable pick-up ratings not exceeding 1,200 amperes, time delay adjustable from 0.1 to 0.5 seconds, and a neutral ground fault current transformer.

Solid-state electronic trip breakers shall have built-in test points for testing long delay, instantaneous, and ground fault functions of the breaker by means of a 120 volts AC operated test kit.

2-2.08. Insulated Case Power Circuit Breakers. Insulated case breakers shall be UL listed for operation at 100 percent of continuous current rating. The circuit breakers shall be rated to interrupt and withstand an available fault current of65,000 A at system line voltage. The breaker control faceplate shall include color-coded visual indicators for open and closed positions as well as mechanism charged and discharged positions. Manual push buttons shall be provided for opening and closing the breaker. Internal control power transformers shall be provided to furnish control power for insulated case power circuit breakers

Each breaker shall be furnished with a solid-state tripping system consisting of three current sensors, a solid-state trip device, and shunt trip. The solid-state element shall have long delay current pickup, short delay pickup, instantaneous pickup, ground fault pickup and fault trip indicators. All elements of the solid-state trip device shall be of the sealed potentiometer type providing adjustable current pickup in percentage of current sensor primary rating and time delay adjustments. The current sensor primary ampere rating shall be as indicated on the Drawings.

The breaker shall have built-in test points for testing long delay, short delay, instantaneous, and ground fault functions of the breaker by means of a 120 volts AC operated test kit.

2-2.09. Shop Painting. All iron and steel surfaces, except machined surfaces and stainless steel, shall be shop painted with the manufacturer's standard coating. Finish color shall be ANSI 61. Field painting, other than touchup painting, will not be required. A sufficient quantity of additional coating material and thinner shall be furnished for field touch up of damaged coatings.

2-2.10. Arc Energy Reduction. Arc energy mitigation system shall be provided for the equipment as per the NEC 240.87 requirements.

2-3. SHOP TESTS. After the equipment has been completely assembled, it shall be shop tested for general operating conditions, circuit continuity, and high potential and other standard tests for the particular class of equipment as defined by industry standards. Four certified copies of the test results shall be submitted to Design Builder before the equipment is shipped.

PART 3 - EXECUTION

3-1. INSTALLATION. Installation shall be in accordance with the Electrical Equipment Installation section.

3-2. TRAINING. The manufacturer’s representative shall provide training of Owner’s personnel as described in the Demonstration and Training specification. All costs for training services shall be included in the Contract Price.

End of Section

Section 26 24 23

600 VOLT CLASS MOTOR CONTROL CENTERS

PART 1 - GENERAL

1-1. SCOPE. This section covers motor control center (MCC) equipment which shall be furnished and installed as specified herein and as indicated on the Drawings. Motor control centers shall meet the following requirements, and the design conditions and features specified herein.

Motor control centers shall be designated and shall be located as follows:

Tag number(s)	As per the electrical one-line drawings, 50-E-701 to 702, 80-E-701 to 704
Motor control center designation(s)	As per the electrical one-line drawings above
Location of motor control center(s)	As per the electrical drawings

1-2. GENERAL. Equipment furnished and installed 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, unless Design Builder notes exceptions.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment furnished under this section. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.02. Dimensional Restrictions. Layout dimensions will vary between manufacturers and the layout area indicated on the Drawings is based on typical values. The supplier shall review the Drawings, the manufacturer's layout drawings and installation requirements, and make any modifications required for proper installation subject to acceptance by Design Builder.

1-2.03. Workmanship and Materials. Equipment supplier shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with applicable governing standards. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except when required by tests.

1-2.04. Governing Standards. All equipment furnished under this section shall be designed, constructed, and tested in accordance with the following standards:

NEMA ICS 18
UL 845.
NEC 240.87 (Arc Energy Reduction)

The equipment shall also conform to all the applicable standards of ANSI, IEEE, NEMA, UL, NEC, and NFPA 70.

Equipment covered by this section shall be listed by UL.

1-2.05. Nameplates. Nameplates with unit description and designation of each control or indicating device shall be provided on all hinged doors. Nameplates shall be black and white laminated phenolic material of suitable size, and shall be engraved with 3/8 inch [10 mm] high letters for compartment identity and 3/16 inch [5 mm] letters for other information. The engraving shall extend through the black exterior lamination to the white center.

Each control device and each control wire terminal block connection inside the units shall be identified with permanent nameplates or painted legends to match the identification on the manufacturer's wiring diagram.

1-2.06. System Characteristics. This equipment will be connected to a power system with characteristics as specified below.

Voltage	480 V
Frequency	60 Hz
Type	Three phase

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete assembly, foundation, and installation drawings, together with complete engineering data covering the materials used, parts, devices, and accessories forming a part of the motor control center shall be submitted in accordance with the Submittal Procedures section. The drawings and data shall include, but shall not be limited to, the following:

Motor Control Center

Elevation, plans, and weight.
Unit wiring diagrams showing devices, connections, and terminal designations.
Interconnection diagrams.
Control schematic diagrams.
Circuit breaker time-current characteristic curves.
Surge protective device submittals shall include drawings (including unit dimensions, weights, component and connection locations, mounting provisions, and wiring diagrams), equipment manuals that detail the installation, operation and maintenance instructions for the specified unit(s), and manufacturer's descriptive bulletins and product sheets.

Seismic Design Requirements

Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

Studies

Short-Circuit Study
Coordination Study
Arc Flash Analysis

1-3.02. Operation and Maintenance Data and Manuals. Operation and maintenance manuals shall be submitted in accordance with the Submittal Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-5. SPARE PARTS. Provide a manufacturer recommended spare part list to Design-Builder.

1-6. PROTECTIVE DEVICE STUDY. A protective device settings study of the power distribution system will be conducted in accordance with the Electrical section. The initial equipment drawing submittal shall include the circuit breaker coordination curves for the main breaker, the largest circuit breaker utilized in a combination starter and the smallest circuit breaker provided as a part of the motor control center assembly.

1-7. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and Storage shall be in accordance with the Product Storage and Handling Requirements section.

Motor control centers shall be equipped to be handled by a crane. Where cranes are not available, control centers shall be suitable for skidding in place on rollers using jacks to raise and lower the groups.

1-8. Arc Flash Hazard Labels. Switchboards shall be provided with permanent labels warning the risk of arc flash and shock hazard. Labels shall be designed in accordance with ANSI Z535.4 and shall include the following:

WARNING
Arc Flash and Shock Hazard

Appropriate personal protection equipment (PPE) required. SEE NFPA 70E.
Equipment must be accessed by qualified personnel only.
Turn off all power sources prior to working on or inside equipment.

Additional information shall be provided on the labels as per the Arc Flash Hazard Analysis performed by the Supplier.

PART 2 - PRODUCTS

2-1. ACCEPTABLE MANUFACTURERS. The equipment shall be manufactured by Allen-Bradley, Eaton, General Electric, Schneider-Electric, or Siemens without exception.

2-2. CONSTRUCTION. Each control center shall conform to the arrangement, one-line diagram, schematics, and requirements indicated on the Drawings or specified herein. End sections shall include provisions for main, ground and neutral bus extensions and installation of future vertical sections.

Motor control center wiring shall be NEMA Class ISand NEMA Type B. Construction shall be as specified below.

See electrical drawings for the MCC tags, bus sizes and rating. All MCC enclosure shall be NEMA Type 1.

Adequate bracing shall be provided for seismic forces. The bracing shall be designed to meet the requirements of the Meteorological and Seismic Design Criteria section.

2-2.01. Outdoor Enclosures. Not used.

2-2.02. Vertical Sections. The control center shall consist of standardized, freestanding structures bolted together to form a single dead-front panel assembly containing combination motor control units; feeder units; transformers; lighting panels; and metering, relaying, and interlocking, and miscellaneous control devices, as indicated on the Drawings. A removable lifting angle shall be mounted on the top of each shipping group. Removable front and rear bottom channel sills shall extend the full width of the motor control center.

Each vertical section shall be 90 inches [2250 mm] high and not less than 20 inches [500 mm] wide. Sections shall be 20 inches [500 mm] deep. Each 20 inch wide standard section shall have all necessary hardware and busing for modular plug-in units to be added and moved around. All unused space shall be covered by hinged blank doors and equipped to accept future units. Removable rear plates shall be sectionalized so that it is unnecessary to handle any plate larger than the section width or one-half the section height.

A metal barrier extending the full height and depth of the section shall be provided to isolate each section from the next section.

2-2.03. Compartmented Units. Each vertical section shall be constructed of modular components of various sizes. The modular components shall be designed to accommodate not more than six Size 1 or Size 2 full voltage combination motor starters per vertical section.

Removable circuit breaker and motor starter units shall be provided with a mechanical interlock to prevent insertion or withdrawal when in the "on" position.

Individual motor starter units, feeder breaker units, transformers, lighting panels, and control device compartments shall be isolated from each other by barriers of metal or a suitable insulating material.

Each vertical section shall have a vertical-wiring trough for power and control wiring, and wiring troughs on top and bottom, which are continuous through the entire control center. Wire ties shall be provided in the vertical wireways unless the wireways are separated from the plug-in units by a permanent wall.

2-2.04. Wiring Labels and Terminal Blocks. All internal wires shall be labeled at each termination. Terminals shall also be identified with labels showing the terminal block and terminal number.

All starter units shall be provided with unit control terminal blocks. Terminal blocks shall be pull-apart type rated 20 amperes. All current carrying parts shall be tin-plated. The removable portion of the terminal blocks shall be used for factory installed wiring.

2-2.05. Busing. The horizontal main bus and the vertical bus extensions shall be tin-plated copper mounted on supports formed of materials having high dielectric strength, low moisture absorbency, and high impact strength. The main bus shall extend the full length of the motor control center and shall have provisions for splicing additional sections onto either end. Both horizontal and vertical busing shall be braced against forces resulting from fault current.

The vertical bus connecting an incoming power feeder cable shall have the same ampere rating as the main horizontal bus. Each vertical bus extension shall be rated for the total connected load of the vertical section.

A tin-plated copper ground bus rated 300 amperes shall extend through the entire control center and shall be located where it will not interfere with pulling of external cable. Grounding connections shall be accessible from the front. The ground bus shall be provided with six 0.38 inch [10 mm] holes for each vertical section to accept ground lugs for any loads requiring a ground conductor. A solderless connector shall be provided on the ground bus in each end section for an external ground cable, sized from 1/0 AWG to 250 kcmil [50 to 120 mm^2].

Each vertical section shall have a vertical ground bus. The plug-in units shall engage the ground bus prior to engagement of the power stabs and shall disengage only after the power stabs are disconnected.

2-2.05.01. Neutral Bus. Not used

2-2.05.02. Neutral Pad. The incoming line section shall be equipped with a neutral bond lug suitable to bond the service entrance neutral conductors. The service entrance neutral pad shall be equipped with a main bonding jumper to the control center ground bus in accordance with the National Electrical Code.

2-2.06. Isolation of Buses. The main bus shall be isolated from the horizontal wiring trough. The entire vertical bus assembly shall be enclosed within grounded steel or glass filled polyester barriers. The barriers shall have openings for power stabs of plug-in units. Shutters shall be provided to close the openings when units are removed.

2-2.07. Combination Magnetic Starters. As indicated on the Drawings, control center starters shall be breaker combination, magnetic, reduced voltage, or across-the-line type as follows:

a. Starters shall be 3 phase, 60 Hz contactors with overloads, a 120 volts ac coil, a dry type control transformer, and a molded-case circuit breaker. Control transformers shall be mounted with the removable starters and shall have capacity for all simultaneous loads. Control transformers shall have both primary leads fused, one secondary lead fused, and one secondary lead grounded.

b. Contactors shall be NEMA rated and have an 8 hour current rating in accordance with the latest NEMA standards. Contactors of reversing or multispeed starters shall be mechanically and electrically interlocked.

c. One NO and one NC spare interlock contacts, whether on the starter or a relay, shall be wired separately to the unit terminal board.

d. Heaterless overload protection shall be provided by three current sensors monitored by a microprocessor. The overload device shall also include phase loss and unbalance protection, trip class selection, Class II ground fault protection, and manual reset.

e. An external manual breaker operating handle with provisions for up to three padlocks shall be provided on each starter. The access door shall be interlocked with the circuit breaker so that the door cannot be opened, except by an interlock override, while the breaker is closed.

f. Supplier shall match control transformers, overloads, and minimum sizes of starters to equipment furnished, which may differ from the estimated values indicated on the Drawings. Overload relay elements shall be sized to reflect reduced motor current caused by load-side power factor correction capacitors.

g. Unless otherwise specified, spare starters shall have breakers and overloads sized for the largest rated motor and 100 watts extra transformer capacity.

2-2.08. Combination Solid-State Starters. As indicated on the Drawings, control center starters shall be breaker combination, solid-state, reduced voltage type. Six back-to-back silicon controlled rectifiers shall be used to provide smooth, stepless motor acceleration. When the motor reaches full speed, a bypass contactor shall close and carry the continuous duty motor current.

a. Starters shall be 3 phase, 60 Hz, with overloads, a 120 volts ac bypass contactor coil, a dry-type control transformer, and a molded-case circuit breaker. Control transformers shall be mounted with the removable starters and shall have capacity for all simultaneous loads. Control transformers shall have both primary leads fused, one secondary lead fused, and one secondary lead grounded.

b. The bypass contactor shall have an 8 hour current rating in accordance with the latest NEMA standards.

c. One NO and one NC spare interlock contacts, whether on the starter or on a relay, shall be wired separately to the unit terminal board.

d. Starters shall include smooth starting and stopping, adjustable starting torque, adjustable ramp time, inverse time overload current trip, current limit, phase loss protection, and adjustable electronic overloads.

e. An external manual breaker operating handle with provisions for up to three padlocks shall be provided on each starter. The access door shall be interlocked with the circuit breaker so that the door cannot be opened, except by an interlock override, while the breaker is closed.

f. Supplier shall match control transformers, overloads, and the minimum sizes of starters to equipment furnished, which may differ from the estimated values indicated on the Drawings. Overload relay devices shall be adjusted to reflect reduced motor current caused by load-side power factor correction capacitors.

g. Unless otherwise specified, spare starters shall have breakers and overloads sized for the largest rated motor and 100 watts extra transformer capacity.

h. Starters shall include an auxiliary contactor for connection to a line-side power factor correction capacitor. The contactor shall be interlocked to prevent the capacitor from being connected before the bypass contactor has energized.

2-2.09. Variable Frequency Drives. Variable frequency drives shall be provided in the size and quantity shown on the Drawings. Each adjustable frequency drive shall be coordinated with the requirements of the driven equipment. Particular attention shall be directed toward the driven equipment torque requirements.

The motor control center supplier shall be responsible for coordinating the drive with the driven equipment to assure compatibility between the drive and motor. All equipment shall be derated as recommended by the drive and motor manufacturers for reduced speed operation with a variable frequency controller in addition to any derating requirements specified elsewhere.

Each drive shall be pulse-width modulated type and shall produce an adjustable ac voltage/frequency output. Each drive shall maintain a minimum displacement power factor of 0.95 over the entire speed range, and shall be equipped with an output voltage regulator to maintain correct output V/Hz despite incoming voltage variations.

Each drive shall be equipped with an input line reactor and a full-wave diode bridge rectifier to convert incoming fixed voltage/frequency to a fixed dc voltage. The pulse-width modulation technology shall be of the space vector type, implemented in a microprocessor, which generates a sine-coded output voltage.

The drive inverter output shall be generated by insulated gate bipolar transistors (IGBT) which shall be controlled by six identical base driver circuits. The drive shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque, and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation. Each drive shall be configurable for automatic and manual reset and shall have an adjustable carrier frequency to at least 6,000 Hz.

2-2.10. Contactors. Contactors for control of bus voltage loads other than motors shall be the same as contactors for combination magnetic starters, except overloads will not be required. Mechanically held contactors shall have 120 volts

ac coils with disconnecting contacts. Other contactors shall have 120 volt, continuous duty coils and contacts where indicated on the Drawings.

2-2.11. Relays and Timers. Auxiliary relays and timers shall have 120 volt, 60 Hz coils for continuous duty in 40°C ambient, and 10 ampere, 120 volts ac contacts. Auxiliary relays shall be NEMA rated.

2-2.12. Control Switches and Pilot Lights. Control switches and pilot lights shall be 30.5 mm heavy-duty, oiltight construction. Pilot lights shall be full voltage type with LED lamps.

2-2.13. Circuit Breakers. Control center disconnects shall be three pole, single-throw, 600 volt, molded-case air circuit breakers. Circuit breakers of combination starters shall be magnetic motor circuit protector type. Feeder circuit breakers shall be thermal-magnetic type and shall be manually operated, with quick-make, quick-break, trip-free toggle mechanism. Bimetallic thermal elements shall withstand sustained overloads and short-circuit currents without injury and without affecting calibration. Thermal elements shall trip the breaker at 125 percent of trip rating. The instantaneous elements of 225 ampere frame and larger breakers shall be adjustable and shall be set at 800 percent of trip rating.

Main circuit breakers and feeder circuit breakers 225 amperes and larger shall be furnished with a solid-state trip unit complete with built-in current transformers. The ampere rating of the trip unit shall be as indicated on the Drawings. The trip unit shall have adjustable settings for continuous amperes, and short-time pickup. The trip unit shall be provided with additional short delay trip time adjustment for better system coordination. Main circuit breakers shall be provided with instantaneous pickup and integral ground fault protection with shunt trip devices.

2-2.14 Surge Protective Devices.

2-2.14.01. Scope. Surge Protective Devices (SPD) shall be provided as specified herein and as indicated on the Drawings. Each unit shall be designed for parallel connection to the facility's wiring system and shall utilize non-linear voltage-dependent metal oxide varistors (MOV) in parallel.

SPD’s shall be furnished and installed for the electrical equipment indicated on the Drawings and designated in this section and as specified herein. SPD’s shall be installed integral to each MCC and MCC panelboard.

2-2.14.02. Standards. The specified unit shall be designed, manufactured, tested and installed in compliance with the following standards:

ANSI/IEEE C62.41 and C62.45;

ANSI/IEEE C62.1 and C62.11;

NEMA LS1;

NFPA 20, 70, 75, and 78;

UL 1449 and 1283

The unit shall be UL 1449 Listed as a Type 2 Surge Protective Device and UL 1283 Listed as an Electromagnetic Interference (EMI) Filter.

2-2.14.03. Environmental Requirements.

a. Operating Temperature: 0°F to +140°F [-18°C to +60°C].
b. Relative Humidity: Reliable operation with 5 percent to 95 percent non-condensing.

2-2.14.04. Electrical Requirements.

a. Unit Operating Voltage. The nominal unit operating voltage and configuration shall be as indicated on the Drawings.
b. Maximum Continuous Operating Voltage (MCOV). The SPD shall be designed to withstand a MCOV of not less than 115 percent of nominal RMS voltage.
c. Operating Frequency. Operating frequency range shall be 47 to 63 Hertz.
d. Protection Modes. Four-wire configured systems shall provide Line-to-Neutral (L-N), Line-to-Ground (L-G), Line-to-Line (L-L), and Neutral-to-Ground (N-G) protection. Three-wire configured systems shall provide Line-to-Line (L-L) protection and Line-to-Ground (L-G) protection.
e. Rated Single Pulse Surge Current Capacity. The rated single pulse surge current capacity, in amps, for each mode of protection of the unit shall be as required and shall be no less than listed in the following table. Lighting panels shall be rated for the low exposure level capacity unless otherwise noted.

	L-N	L-G	N-G	L-L
High Exposure Level	120 kA	120 kA	120 kA	120 kA
Medium-High Exposure Level	100 kA	100 kA	100 kA	100 kA
Medium Exposure Level	80 kA	80 kA	80 kA	80 kA
Low Exposure Level	60 kA	60 kA	40 kA	60 kA

f. UL 1449 Voltage Protection Rating (VPR). The maximum VPR for the device (inclusive of disconnect) shall be as required and shall not exceed the following:

Voltage	L-N	L-G	N-G	L-L
480 V 3W		1200 V		2000 V

g. Noise Attenuation. The unit shall be capable of a minimum -30 dB attenuation at 100kHz when tested per the 50 ohm insertion loss method as defined by MIL-STD-220C.
h. Nominal Discharge Current. Each SPD shall have a nominal discharge current rating of 20 kA.
i. Overcurrent Protection. At high and medium-high exposure levels, the SPD shall incorporate internal fusing capable of interrupting, at minimum, up to 200kA symmetrical fault current with 600 volts ac applied.
At medium and low exposure levels, the SPD shall incorporate internal fusing capable of interrupting, at minimum, up to 65kA symmetrical fault current with 600 volts ac applied.
The device shall be capable of allowing passage of the rated maximum surge current for every mode without fuse operation.
j. Unit Status Indicators. The unit shall include long-life, externally visible phase indicators that monitor the on-line status of the unit.

2-2.14.05. Warranty. The manufacturer shall provide a standard Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

2-2.14.06. Installation. Each SPD shall be installed according to the manufacturer's recommendations. If possible for the integral units, provide direct bus connections.

2-2.14.07. Accessories.

a. Disconnect Switch. Each SPD shall be furnished with an integral disconnect switch. The unit shall be UL1449 listed as such, and the UL1449 Voltage Protection Ratings shall be provided. The disconnect switch shall be fused and capable of withstanding the published maximum surge current magnitude without failure or damage to the switch.

b. Dual Form "C" Dry Contacts. Not used

2-2.15. Incoming Line Metering Compartment. The incoming line section(s) shall be provided with a microprocessor-based, digital power meter. Current transformers and potential transformers shall be provided for input of current and voltage signals to the metering package. Phase currents, phase voltages, watts, vars, power factor, frequency, watt-hours, watt demand , and total harmonic distortion waveforms shall be available for display. Metering units shall also include a display with touch screen monitor on the front of the equipment. The following alarm features shall be provided: undervoltage, power factor leading or lagging, kVAR limit, voltage sequence reversal, under frequency, and

overcurrent. The metering package shall be capable of Ethernet/IP communication for remote monitoring. .

Sufficient lengths of communication cable shall be provided for connection of metering units within the motor control center.

2-2.16. Miscellaneous. Other items indicated on the Drawings shall conform to the applicable provisions of NEMA ICS 2 and UL 845.

2-2.17. Lighting Transformers. Lighting and auxiliary power transformers shall be dry type, with at least two full capacity taps.

2-2.18. Panelboards. Panelboards shall have a main circuit breaker, buses, bolted thermal-magnetic breakers, and provisions for breakers in the sizes, quantities, and poles indicated on the Drawings. Breakers shall indicate "On", "Off", and "Tripped". Breakers indicated to be multiple pole shall be common trip. Circuit breakers shall be fully rated, with an interrupting rating of at least 10,000 amperes, and shall be coordinated with the control center short-circuit rating. The panel shall have main and neutral buses insulated from the enclosure, and a ground bus. Buses shall be copper, with ampere ratings and main lugs or breaker as indicated. The ground bus shall be similar to a neutral bus and shall have a good ground connection to the enclosure, and a removable bond to the neutral bus. Each panel shall be provided with a typewritten directory listing the load identities of all circuits. Six breaker handle clips shall be provided to prevent casual tripping. Panelboards shall be 120/208 V, 3-phaseand 480 V, 3-phase, 3W as per the drawings.

Power panels shall have SPD’s rated for a medium exposure levels. Lighting panels shall have SPD’s rated for a low exposure levels.

2-2.19. Special Panels. Not used.

2-2.20. Shop Painting. All iron and steel surfaces, except stainless steel and machined surfaces, shall be plated or shop painted with the manufacturer's standard coating. Finish color for both indoor and outdoor equipment shall be ANSI 61. Field painting, other than touchup painting, will not be required. A sufficient quantity of additional coating material and thinner shall be furnished to permit field touchup of damaged coatings.

2-2.21. Space Heaters. Not used

2-2.22. Arc Energy Reduction. Arc energy mitigation system shall be provided for the equipment as per the NEC 240.87 requirements.

2-3. SHOP TESTS. The complete control center shall be tested at the factory. All circuits, including power and control, shall be given dielectric tests in accordance with NEMA ICS 2-322.

PART 3 - EXECUTION

3-1. INSTALLATION. Installation shall be in accordance with the Electrical Equipment Installation section.

3-2. TRAINING. The manufacturer's representative shall provide training of Owner's personnel as described in the Demonstration and Training specification. All costs for training services shall be included in the Contract Price.

End of Section

Section 26 29 24

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1-1. SCOPE. This section covers pulse width modulated (PWM) type variable frequency drives (VFD) for the equipment and locations as specified. VFDs shall meet the design conditions and features specified herein.

1-2. GENERAL. Equipment furnished and installed under this section shall be fabricated, assembled, erected(ship-loosed VFD shall be installed by Design-Builder), and placed in proper operating condition in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer.

VFDs shall be designed, manufactured, supplied, and warranted as a complete system by the VFD manufacturer. Fabrication and assembly of the drive system not directly controlled by the VFD manufacturer will not be acceptable.

1-2.01. Coordination. The design of the variable frequency drive shall be coordinated with the driven equipment. Electrical Installer shall be responsible for coordinating the collection of data and the design effort to limit harmonics to the levels specified.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment furnished under this section. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence.

1-2.03. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.04. Dimensional Restrictions. Layout dimensions will vary between manufacturers and the layout area indicated on the Drawings is based on typical values. The supplier shall review the Drawings, the manufacturer's layout drawings and installation requirements, and make any modifications required for proper installation subject to acceptance by Design-Builder .

1-2.05. Workmanship and Materials. Equipment supplier shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with applicable governing standards. Individual parts shall be manufactured to

standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests.

1-2.06. Governing Standards. The adjustable frequency drive shall be designed, constructed, and tested in accordance with the applicable standards of NEMA, ANSI, UL, and IEEE, and shall be designed for installation in accordance with the NFPA 70.

The equipment covered by this section shall be listed by UL.

1-2.07. Nameplates. Nameplates with the description and designation of each control or indicating device shall be provided. Unless specified otherwise, each drive enclosure shall be provided with a nameplate bearing the unit designation as indicated above. Nameplates shall be black and white laminated phenolic material of suitable size, and shall be engraved with 3/8 inch [10 mm] high letters for the drive designation and 3/16 inch [5 mm] letters for other information. The engraving shall extend through the black exterior lamination to the white center.

Each control device and each control wire terminal block connection inside the enclosure shall be identified with permanent nameplates or painted legends to match the identification on the manufacturer's wiring diagram.

1-3. DESCRIPTION. The VFD shall produce an adjustable ac voltage/frequency output and shall be equipped with an output voltage regulator to maintain correct output V/Hz despite incoming voltage variations.

1-3.01. Six-Pulse Drives. Drives for motors rated below 100 horsepower, shall be of the pulse-width modulated type and shall consist of a full-wave diode or gated-open SCR bridge. The rectifier shall convert incoming fixed voltage and fixed frequency to a fixed dc voltage. The pulse-width modulation technology shall be of the space vector type, implemented in a microprocessor that generates a sine-coded output voltage.

The drive inverter output shall be generated by insulated gate bipolar transistors (IGBT) which shall be controlled by six identical base driver circuits. The drive shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque, and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation.

1-3.02. Eighteen-Pulse Drives and Active Front End Drives. Drives for motors rated 100 horsepower and above, shall be eighteen-pulse or active front end type.

1-3.02.01. Eighteen-Pulse Drives. Eighteen-pulse drives shall be of the pulse-width modulated type and shall consist of an 18-pulse, full-wave diode or

gated-open SCR bridge. The rectifier shall convert incoming fixed voltage and fixed frequency to a fixed dc voltage. The pulse-width modulation technology shall be of the space vector type, implemented in a microprocessor that generates a sine-coded output voltage.

The phase shifting transformer required to produce the phase shifted input to the 18-pulse rectifier shall be factory wired and mounted within the drive enclosure as an integral part of the drive assembly. External transformers shall not be required.

The VFD inverter output shall be generated by insulated gate bipolar transistors (IGBT) which shall be controlled by identical base driver circuits. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque, and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation.

1-3.02.02. Active Front End Drives. Active front end drives shall be of the pulse-width modulated type and shall consist of an active front end with insulated gate bipolar transistors (IGBTs). Incoming power shall be filtered by an integral inductor-capacitor-inductor (LCL) filter. The filter shall filter out the high frequency content of the IGBT front end. The drive shall be able to boost the incoming voltage by 20% and ride through voltage dips of 35%. Power factor shall be adjustable as leading or lagging by up to 20%. The main control board for the IGBT input shall be identical to the main control board for the IGBT output. The drive shall be equipped with an integral input contactor that opens when the drive is not running and closes when a drive run signal is initiated.

The VFD inverter output shall be generated by IGBTs which shall be controlled by identical base driver circuits. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque, and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation.

1-4. SUBMITTALS. Complete assembly, foundation, and installation drawings, together with complete engineering data covering the materials used, parts, devices, and accessories forming a part of the drive shall be submitted in accordance with the Submittal Procedures section. The drawings and data shall include, but shall not be limited to, the following:

a. Name of manufacturer.
b. Types and model numbers.
c. Rated drive input kVA and output kVA.
d. Percent efficiency at 100 percent speed and 60 percent speed.
e. Maximum Btu [kJ] heat release data and verification of the drive cooling requirements.
f. Total weight and lifting instructions, height, mounting, and floor space required.

g. Panel interior and front and side exterior view details showing maximum overall dimensions of all transformer, bypass contactor, ac line filter, ac line reactor, and drive compartments.
h. Schematics, including all interlocks.
I. Wiring diagrams, including all internal and external devices and terminal blocks.
j. Locations and sizes of electrical connections, ground terminations, and shielded wires.
k. List of diagnostic indicators.
l. List of fault and failure conditions that the drive can recognize and indicate for simultaneous occurrence.
m. List of standard features and options.
n. List of spare parts to be furnished.
o. Input line protection model numbers and manufacturer's data sheets.
p. Output filter model number and manufacturer's data sheets.
q. UL 508C Certificate of Compliance for short circuit current rating.
r. Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-5. OPERATION AND MAINTENANCE DATA AND MANUALS. Adequate operation and maintenance information shall be supplied. Operation and maintenance manuals shall be submitted in accordance with the Submittal Procedures section.

Operation and maintenance manuals shall include the following:

a. Manufacturer's operation and maintenance manual for each size of adjustable frequency drive.
b. Manufacturer's standard manuals for each size and type of bypass contactor, transformer, line reactor, and filter.
c. Schematics, wiring diagrams, and panel drawings in conformance with construction record.
d. Model numbers and up-to-date cost data for spare parts.
e. Troubleshooting procedures, with a cross-reference between symptoms and corrective recommendations.
f. Connection data to permit removal and installation of recommended smallest field-replaceable parts.
g. Information on testing of power supplies and printed circuit boards and an explanation of the drive diagnostics.

The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-6. SPARE PARTS. Provide a manufacturer recommended spare part list to Design-Builder.

1-6. PROTECTIVE DEVICE STUDY. A protective device study of the power distribution system will be conducted as specified in the Electrical section. The equipment manufacturer shall provide the following information to Design Builder with the initial equipment drawing submittal:

Protective relay coordination curves for each solid-state trip device.
Time current curves for each circuit breaker.

Data for all devices with adjustable settings shall be submitted, with all literature necessary to determine the appropriate settings. This shall include, but shall not be limited to, Operation Manuals for each type of adjustable trip device.

1-7. Arc Flash Hazard Labels. Switchboards shall be provided with permanent labels warning the risk of arc flash and shock hazard. Labels shall be designed in accordance with ANSI Z535.4 and shall include the following:

WARNING
Arc Flash and Shock Hazard

Appropriate personal protection equipment (PPE) required. SEE NFPA 70E.
Equipment must be accessed by qualified personnel only.
Turn off all power sources prior to working on or inside equipment.

Additional information shall be provided on the labels as per the Arc Flash Hazard Analysis performed by the Supplier.

PART 2 - PRODUCTS

2-1. ACCEPTABLE MANUFACTURERS. All drives shall be pulse-width modulated type, as manufactured by ABB, Eaton, Rockwell Automation, Siemens W-Series, Schneider-Electric, or Toshiba without exception. Active front end drives shall be as manufactured by ABB without exception. The products of other manufacturers will not be acceptable.

All VFDs shall be a product of the same manufacturer.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS.

2-2.01. Performance. The variable frequency drive controller shall be of sufficient capacity and shall produce a quality output waveform for stepless motor control from 10 to 100 percent of base speed. See Electrical drawings for the VFD load type and voltage for each piece of equipment.

The VFD’s shall be suitable for operation at an elevation below 3300 ft and shall meet the following ratings and parameters:

Input frequency	60 Hz
Input voltage and frequency variation	±10 percent voltage variation, ±2 Hz; imbalance, 2 percent maximum. Continued operation with additional momentary 25 percent voltage dip of 0.5 second duration from nominal input voltage level.
Minimum drive efficiency	95 percent at 100 percent speed, 90 percent at 60 percent speed.
Ambient temperature	0 to 40°C.
Relative Humidity	0 to 95 percent non-condensing.
Displacement Power Factor	95 percent or higher throughout the entire operating speed range, measured at drive input terminals.
Drive service factor	1.0.
Overcurrent capability	110 percent for 1 minute for variable torque; 150 percent for 1 minute for constant torque.
Volts/Hz ratio	Voltage varies as the square of frequency over the entire range of the unit for variable torque drives, linear over the entire range of the unit for constant torque drives; except under voltage boost condition.
Acceleration/deceleration time	Adjustable over a range that meets the requirements of the drive equipment.
Output speed regulation	0.5 percent.
Output frequency stability	0.5 percent of nominal.

2-2.02. Adjustments. The following drive adjustments shall be provided:

Maximum speed.

Minimum speed.

Linear acceleration time.

Linear deceleration time.

Volts/Hz ratio; linear, squared, and automatic settings.

Voltage boost.

Process follower gain, offset, and bias.

Torque limit.

Critical frequency avoidance with adjustable bandwidth.

2-2.03. Fault Protection. Design of the power circuit shall include provisions for protection against fault conditions as follows.

2-2.03.01. Input Protection.

The drive assembly shall be UL 508C listed. A UL Certificate of Compliance shall be submitted to confirm product compliance with UL 508C and to indicate the short circuit current rating. The short circuit current rating shall meet or exceed the available short circuit current indicated on the Drawings.

Solid state instantaneous overcurrent trip set at 180 percent.

Adjustable overvoltage and undervoltage protection with automatic restart.

Phase loss and reverse phase trip with manual restart.

2-2.03.02. Internal Protection.

AC line, phase-to-phase transient voltage surge suppression utilizing metal oxide varistors. Drive shall meet the requirements of IEEE C62.41.

Power device snubbers.

Power devices rated 2.5 times line voltage.

Instantaneous overcurrent.

Static overspeed (overfrequency) protection.

DC bus overvoltage trip.

Components and labeling that comply with UL 508 requirements. Drives shall be equipped with an automatic discharge circuit to deplete the charge on the DC capacitor bank to less than 50 volts within 60 seconds after main input power is removed. Labels indicating derivative voltage sources and required wait time for servicing after power removal shall be placed on all applicable enclosures.

Individual transistor overtemperature and overcurrent protection.

Control logic circuit malfunction indication.

2-2.03.03. Output Protection.

Inverse-time motor overload protection adjustable from 10 percent to 100 percent.

Overvoltage protection.

Overfrequency protection.

Short circuit protection (three phase, phase to phase, and ground fault protection).

Protection against opening or shorting of motor leads.

Static overspeed protection.

Stall protection on overload with inverse time overcurrent trip, adjustable current limit from 10 percent to 120 percent.

2-3. CONSTRUCTION.

All MCC mounted VFD's shall follow the MCC enclosure NEMA rating. All non-MCC mounted VFD's located in electrical room shall be NEMA Type 1. All non-MCC mounted VFD's located in the process area shall be NEMA Type 12. All non-MCC mounted VFD's located in outdoors shall be NEMA 4.

Adequate bracing shall be provided for seismic forces. The bracing shall be designed to meet the requirements of the Meteorological and Seismic Design Criteria section.

2-3.01. Fabrication and Assembly. The adjustable frequency drive system shall be shop assembled in a single enclosure using interchangeable plug-in printed circuit boards and power conversion components wherever possible. Shop assembly shall be performed by the drive manufacturer, or a manufacturer approved assembly center under the direction and control of the drive manufacturer; systems fabricated, assembled, and supplied in whole or in part by parties other than the drive manufacturer will not be acceptable. Changes to the drive manufacturer's product by a distributor or system integrator are not allowed.

Input line reactors, fuses, circuit breakers, and filters, where required, shall be mounted within the drive enclosure, without exception. Isolation/voltage matching transformers, where required, may be enclosed separately from the remaining drive equipment.

The variable frequency drive system shall be designed to fit in the space indicated on the Drawings.

2-3.02. Wiring. Internal cabinet wiring shall be neatly installed in wireways or with wire ties where wireways are not practical. Where wireway is used, they are to be mounted to the panel surface with a continuous run of industrial two-sided adhesive strip. For 12 AWG wire sizes and smaller, and in bundles of six or less, wire tie-down square mounting straps shall be permitted. Tie-down mounts shall be installed at 8" increments or less. All mounting surfaces shall be pre-cleaned with isopropyl alcohol to ensure proper adhesion over the life of the equipment.

Terminal blocks shall be non-brittle, interlocking, track-mounted type, complete with a marking strip, covers, and pressure connectors. Screw terminals will not be acceptable. A terminal shall be provided for each conductor of external circuits, plus one ground for each shielded cable. In freestanding panels, 8 inches [200 mm] of clearance shall be provided between terminals and the panel base for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Terminals shall be labeled to agree with the identification on the submittal drawings. Each control loop or system shall be individually fused, clearly labeled, and located for ease of maintenance.

All grounding wires shall be attached to the sheet metal enclosure with a ring tongue terminal. The surface of the sheet metal shall be prepared to ensure good conductivity and corrosion protection.

Wires shall not be kinked or spliced and shall be color coded or marked on both ends. The markings or color coding shall agree with the submittal drawings.

With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, insulated for at least 600 volts, with a moisture-resistant and flame-retardant covering rated for at least 90°C.

2-3.03. Enclosures. The drive shall consist of factory mounted and wired components within an enclosure, arranged so no electrically live components, terminals, or conductors are accessible on the front panel or door when the enclosure door is open.

The complete drive package, including accessories, shall fit into the space indicated on the Drawings.

Freestanding panels shall be suitable for mounting on a concrete pad and shall include provisions for anchoring to the supporting structure. Suitable lifting facilities shall be provided for handling and shipment.

Relays, terminals, and special devices inside the control enclosure shall have permanent markings to match the identification on the manufacturer's wiring diagrams.

2-3.04. Printed Circuit Boards.

All plug-in type boards shall be mechanically held at the circuit board connector. Compression fit only at the connector will not be acceptable.

2-3.05. Shop Painting. All iron and steel surfaces, except machined surfaces and stainless steel, shall be shop cleaned in accordance with the coating manufacturer's recommendations, and finished with the drive manufacturer's standard coating. Finish color shall be manufacturer’s standard color. Dry film

thickness of the finish coat shall be at least 4 mils [100 µm]. Field painting, other than touch up, will not be required. A sufficient quantity of additional coating material and thinner shall be furnished for field touch up of damaged coatings.

All intermediate and finish coating materials shall be fumeproof and suitable for a wastewater treatment plant atmosphere that contains hydrogen sulfide. Documentation verifying that the coating material is fumeproof shall be submitted. Coatings shall be lead-free and mercury-free.

2-4. OPTIONAL EQUIPMENT. – Not Used.

2-5. CONTROLS.

2-5.01. Features. Each drive shall include the following features in addition to those indicated on the Drawings:

a. A door mounted membrane keypad with integral two-line, 24 character minimum LCD display that is capable of controlling the AFD and setting drive parameters. The keypad module shall be programmed with factory set drive parameters in nonvolatile EEPROM or FLASH memory and shall be resettable in the field through the keypad.
b. Control switches and pilot lights shall be provided as indicated on the schematic diagrams. Manual-automatic and start-stop controls included as features of the drive keypad shall be password protected or disabled to prevent override of control switches and safety interlocks shown on the schematic diagrams.
c. Not Used
d. Not Used
e. Input thermal-magnetic molded-case circuit breaker disconnect with interrupting capacity rated in RMS symmetrical amperes as required, and labeled in accordance with UL standard 489. The disconnect shall be mounted inside the controller enclosure and shall have door interlocks and a handle with provisions for padlocking in the "Off" position.
f. Manual speed adjustment.
g. Indications of power "On", drive "Run", and drive "Fault". Indication of these parameters shall be provided by full voltage type LED pilot lights. Lamps shall be easily replaceable from the front of the indicating light.
h. Not Used
i. Speed indication - calibrated in percent rpm.
j. Control circuits of not more than 115 volts supplied by internal control power transformers. Control power transformers shall have additional capacity as required by external devices indicated on the Drawings. Control power transformers shall be equipped with two primary leads fused, one secondary lead fused, and one secondary

lead grounded.

k. Automatic controller shutdown on overcurrent, overvoltage, undervoltage, motor overtemperature and other drive fault conditions. Controller shutdown shall be manually reset type. Terminals shall be provided for control wiring from motor temperature switches, or a motor protection relay located in the drive enclosure.

l. Diagnostic indicators that pinpoint failure and fault conditions. Indicators shall be manually reset to restore operation after abnormal shutdown.

m. Accept a remote 4-20 mA speed control signal.

n. Process control output for remote 4-20 mA speed indication, rated 0 to 100 percent speed.

o. Spare interlock contacts rated 5 amperes at 120 volts ac, wired separately to the unit terminal board. One NO and one NC isolated spare interlock shall be furnished with each drive. Additional interlock contacts shall be provided as indicated on the Drawings.

p. Drive fault and run status contacts for remote indication, rated 5 amperes at 120 volts ac.

q. Speed droop feature, which reduces the speed of the drive on transient overloads. The drive shall return to set speed after the transient is removed. If the acceleration or deceleration rates are too rapid for the moment of inertia of the load, the drive shall automatically compensate to prevent drive trip.

r. Individual adjustable speed profile settings for start, stop, entry, slope, and minimum and maximum speed points.

s. Coast, controlled ramp, or dc injection selectable modes of stopping.

t. Not used

u. Adjustable PWM carrier frequency. The inverter output section shall be provided with adjustable PWM carrier frequency from 500 Hz to at least 8 kHz.

v. Noise level of installed equipment shall not exceed 85 dB, as measured by an appropriate calibrated instrument. The required sound level limit shall be met at a minimum of four locations, each not more than 3 feet [0.9 m] above the floor and not more than 10 feet [3 m] from the equipment. This requirement shall apply to all drives, motors, filters, reactors, and transformers supplied with the drive.

2-5.02. Diagnostics. Diagnostic indicators on the face of the drive shall display the type of fault responsible for drive shutdown, warning, or failure. If two or more faults occur simultaneously, the diagnostic segment shall record or indicate each condition. The drive shall be capable of storing 6 events.

2-5.03. Motor Protection Relay. Not used.

2-6. TESTING. All power switching components shall be pre-run under anticipated operating temperature and load conditions. Any alternative testing procedures shall be submitted and pre-approved before proceeding.

2-6.01. Factory Testing. After the drive system has been assembled at the manufacturer's facility, it shall be tested for at least 4 hours before it is shipped. The complete drive system, including all peripherals, shall be factory tested under simulated operating conditions, including normal operating sequences and fault conditions. Contact closure inputs and simulated driven-outputs shall be connected to the system input/output modules.

A test report summary indicating satisfactory final test results shall be submitted to Design-Builder before shipment of the equipment.

2-6.02. Secondary Factory Testing. Section 2-6.02 shall only be applicable to the Equipment Supplier who is furnishing both the drive and the driven equipment within the same procurement package. The drive units shall be assembled with the driven equipment for shop testing. The drive manufacturer shall provide the services of a qualified representative to work with the equipment manufacturer at the equipment manufacturer's facility. The representative shall advise and assist in assembling and testing the equipment and drive unit packages.

Personnel conducting the tests shall be competent, authorized representatives of the equipment and drive manufacturers who are familiar with operation of the equipment furnished and who have satisfactory experience in conducting similar tests. Qualified personnel shall perform the tests, record the data, make the required calculations, and prepare a report on the results. Five copies of the report shall be submitted in accordance with the Submittal Procedures section. The information collected shall be used as a basis for determining acceptability of the manufacturer's test results. In case of conflict, interpretations and calculations made by Design-Builder will govern.

Testing shall be conducted in a manner acceptable to Design-Builder. At least 2 weeks before the proposed testing date, the Design-Builder shall be notified of the testing date and shall submit a report from the equipment manufacturer detailing the proposed performance testing.

PART 3 - EXECUTION

3-1. INSTALLATION. Installation shall be in accordance with Electrical Equipment Installation section.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, set all relays in accordance with the settings designated in the coordination study, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Commissioning Requirements section, and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily.

3-2.02. Installation Supervision. Installation supervision by the manufacturer is not required.

3-3. FIELD HARMONIC DISTORTION TEST. Not used.

3-4. TRAINING. The manufacturer’s representative shall provide training of Owner’s personnel as described in the Demonstration and Training specification.

End of Section

Section

ENGINE-GENERATOR

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of one (1) diesel fuel fueled engine-driven electric generator unit, designated GEN-EG-1. The engine-generator shall be located outdoors in its own weather proof sound attenuated enclosure as indicated on the Drawings.

The engine-generator Supplier shall be fully responsible to furnish a complete and coordinated skid mounted package system including engine-generator, generator line circuit breaker, generator controls, exhaust silencer, batteries and chargers, sub-base fuel storage tank, automatic transfer switch, emergency shutdown control station, and all accessories required for a complete and operating system.

The engine-generator manufacturer shall provide an ATS and accessories as specified in Section 26 36 26. The ATS shall be designated 80-ELEC-ATS-0001. All coordination requirements between the ATS and the engine-generator shall be provided.

1-2. GENERAL. Equipment furnished under this section shall be assembled in full conformity with Drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by Design-Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Metrological and Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Coordination. All equipment specified in this section shall be furnished through a single engine-generator manufacturer who shall be responsible for the design, manufacture, coordination, and proper installation and operation of the entire system.

The engine-generator unit shall be a standard product of the manufacturer and shall be a packaged type unit, fully shop assembled, wired and tested, requiring no field assembly of critical moving parts.

Design-Builder shall verify that each component of the system is compatible with all other parts of the system; that all piping, materials, and motor sizes are appropriate; and that all devices necessary for a properly functioning system have been provided.

Design-Builder shall arrange for and obtain all necessary permits as required for the package system, inspections, and approval by the proper authorities in local jurisdiction of such work.

Design-Builder shall properly coordinate the work between the suppliers of equipment to be used with or connected to each engine-generator, to ensure that all required provisions for mounting the accessories are included.

Equipment furnished under this section will be assembled and erected by the Supplier.

Design-Builder shall provide field services specified to assist in commission, testing and placing the unit in operation in full conformity with equipment manufacturer's specifications.

1-2.04. Governing Standards. Except where modified or supplemented by these specifications, all equipment and materials shall be designed and constructed in accordance with the latest applicable requirements of the standard specifications and codes of ANSI, ASTM, NEMA, IEEE, EEI, EGSA, HEI, ISO, NFPA, SAE, STI, UL, and other such regularly published and accepted standards as well as state and local codes.

1-2.05. Equipment Identification. All equipment, valves, devices, panels, and control equipment denoted by a symbol and an identifying number shall be provided with equipment identification tag or nameplate. Equipment identification shall be as indicated in the Equipment and Valve Identification Section.

1-2.06. Manufacturer's Nameplates. Each major component of equipment shall have the manufacturer's name, address, and catalog number on a nameplate securely affixed in a conspicuous place. The nameplate of a distributing agent only will not be acceptable.

1-2.07. Power Supply. Site power supply provided will be a 480 volt, 60 Hz, three-phase, 50 amp feeder circuit to a transformer and panelboard provided by the manufacturer and installed in the engine-generator enclosure. Additional requirements for the panelboard are as indicated herein and in the Electrical Section.

The engine (starting and controls) will operate from batteries specified herein. When required, a control transformer shall be provided within the powerpanel for control supply.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete assembly and installation drawings, together with detailed specifications and data covering materials, drive unit, parts, devices and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section. The data and specifications for each unit shall include, but shall not be limited to, the following:

Manufacturer, model, and type:
- Engine.
- Alternator.
- Enclosure.
- Battery charger and battery.
- Fuel oil cooler (if required by engine design).
- Silencer.
- Sub-base fuel storage tank.
- Surge Protection.

Engine output horsepower at rated capacity.
Fuel consumption at rated capacity.
Ratings at specified conditions:
- Engine (net horsepower).
- Engine (maximum performance horsepower bare engine).
- Engine-Generator kW at specified power factor.
- Volts.
- Amperes.

Overall dimensions and weight:
- Length.
- Width.
- Height.
- Net weight.

Wiring diagrams and schematics, including the engine control panel.
Generator line circuit breaker data (Elevation plan, weight, bill of material, component data sheets, breaker time-current characteristic curves).
Alternator insulation class and temperature ratings.
Alternator winding pitch.
Confirmation or test results showing compliance with specified motor starting and voltage dip requirements as well as unloading the specified loads.
Generator line circuit breaker rating.
Control panel layout, identifying location of all instrumentation being supplied.

Operation instructions.
Letter from the engine-generator manufacturer confirming that the unit will provide the specified minimum kW rating at the specified design conditions and time duration, including ambient air temperature rise from all equipment located inside the enclosure.
Confirmation that the starting batteries provide the specified number of start attempts for the specified time period.
Confirmation that the battery charger is sized to recharge the batteries for the specified condition and time period.
Maximum output short circuit kvA available.
Exhaust gas emission data, maximum values at loads of 1/2, 3/4, and full:
    Carbon Monoxide (CO), lb/hr
    Nitrogen Oxides (NO_x), lb/hr
    Particulate Matter (PM), lb/hr
    Sulfur Dioxide (SO_2), lb/hr
    Unburned Hydrocarbons (UHC_s), lb/hr
    Temperature, °F
    Flow, acfm
Equipment skid Drawing including material list.
Confirmation that the exhaust through the exhaust silencer does not exceed the specified maximum pressure loss at the specified output capacity of the unit.
Letter from the engine-generator manufacturer confirming that the enclosure is suitable for the specified wind velocity and is designed as specified for rain penetration when the unit is operating.
Name, address, and phone number of manufacturer's repair facility.
Name, address, and phone number of who will troubleshoot electrical problems.
Color chart showing available options for the enclosure color. The color of the enclosure shall be as directed by Owner during shop Drawing review.
Drawing to show location of grounding system for electrical grounding of the engine-generator package.

Drawings showing engine-generator inside the enclosure that shows location of all enclosure mounted and engine-generator mounted equipment. Drawings to indicate maintenance access clearances for electrical and mechanical equipment. Drawing to show location of all enclosures bracing and location of doors, access platforms, stairs, sub-base tank fill access door and removable panels.

Identification of all field connections for electrical, control, or other service and associated connection requirements to be performed.

Detailed procedures and instrument calibration reports for all items associated with the shop and field testing activities.

Letter from the engine-generator manufacturer confirming that the unit is in full compliance with Federal EPA, State, and local air emission requirements.

Confirmation that the engine-generator unit, including the enclosure, louvered openings, and exhaust system will limit the noise not to exceed the specified decibel reading at the specified distance from any point from the enclosure when operating at the specified capacity.

Provide recommendation for mounting the engine-generator for the specified seismic parameters.

Automatic Transfer Switch.

Anchor Bolts.

Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-3.02. Operation and Maintenance Manuals. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-4. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirement Section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements Section.

1-5. SPARE PARTS.

A list of recommended spare parts shall be provided by the manufacturer in accordance with the general Terms and Conditions.

All spare parts shall be provided in waterproof packages suitable for export service, labeled with its description and part numbers. Each item or set of parts expected to be installed at one time shall be in an individual package. The spare parts shall be stored as directed.

1-5.01. Spare Keys. Three (3) sets of identical keys for locks on the enclosure and all cabinets shall be provided.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. The engine-generator unit shall be designed to operate under the Seismic wind and snow design requirements including importance factor, ambient air temperature range and site elevation as listed in the Meteorological and Seismic Design Criteria section.

The engine-generator unit will be used as a power unit for selected electrical loads for standby operation when the utility supplied power fails.

The engine-generator shall automatically start, and connect to the plant's electrical system via a remote signal from the plant control system or when initiated from the automatic transfer switch controls.

Fuel for the engine-generator unit will be furnished from a sub-base fuel tank. The engine-generator Supplier shall provide the correct amount and grade of crankcase oil, coolant, and other fluids (except fuel) necessary for initial testing and operation.

2-1.01. Engine Mounting. The engine-generator shall be attached to an associated skid suitable for mounting on top of the sub-base fuel storage tank that is anchored to a reinforced concrete base. The skid shall be constructed of heavy duty steel. Designed and built to resist deflection and to maintain alignment during lifting and operation during any range of operation. Mounting holes in the structural skid shall be suitable sized to accommodate thermal expansion of the unit and shall be drilled prior to setting the unit.

Unless otherwise recommended by the manufacturer, the engine-generator sub-base fuel storage tank package shall be attached to the reinforced concrete base using suitable number of hold down lugs and anchor bolts. Use of clamping devices to secure the sub-base fuel storage tank will not be acceptable. Anchor bolts may be pre-cast in the reinforced concrete base or holes drilled into the concrete base at the required location and the anchor bolts secured with epoxy resin. Unless otherwise recommended by the manufacturer, the nuts for the anchor bolts shall be hand tighten.

2-1.02. Anchor Bolts. All field assembly bolts, anchor bolts, nuts, and washers shall be stainless steel as specified in the Anchorage in Concrete and Masonry Section. All anchor bolts, nuts, and washers required for installation shall be provided by the Supplier.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. The engine-generator unit shall be designed for the operating conditions and requirements as follows:

Designation	GEN-EG-1	
Generator		
Minimum power rating capacity with accessories, for generator voltage output and service conditions specified herein.	973	kW
Output frequency.	60	Hz
Output voltage.	480	VAC
Output power factor.	0.8	
Output phase and configuration.	Three phase, 4 wire, solid grounded wye configuration	
Engine		
Fuel supply.	No. 2 ultra-low sulfur diesel	
Maximum speed.	1,800	rpm
Minimum piston displacement.	1,860	in^3
Black start required.	Yes	
Maximum outside length of the engine-generator including air intake plenums and radiator discharge plenums but not including access platforms or stairs.	327	in
Maximum outside width of the engine-generator package including air intake plenums but not including access platforms or stairs.	98	in

The engine-generator shall be designed to be operated during a power outage for a maximum of 24 continuous hours and a maximum of 100 hours per year for maintenance and testing. Unit shall be certified for stationary emergency use in accordance with NSPS.

Engine-generators submitted with ratings in excess of current published data will not be acceptable.

The entire engine-generator package system shall be electrically grounded with provisions to connect to a grounding system installed by others.

Engine performance, cooling, and all accessories to account for the outside ambient air temperature increase from heat rejected from all equipment located inside the enclosure.

The engine-generator unit furnished shall be of a design that can be accommodated in the space as indicated on the Drawings. Maximum outside dimensions of the engine-generator enclosure including any air intake or discharge plenums shall be as specified and as noted on the Drawings.

The engine-generator shall meet all local air emission requirements and at a minimum, meet the required Environmental Protection Agency New Source Performance Standard emission regulations. The unit shall be certified at the factory prior to shipping.

The engine-generator Supplier shall coordinate with the local air quality management authority to ensure the equipment meets all current local air emission requirements. The engine-generator Supplier shall guarantee the equipment supplied meets all local air emissions requirements in place at the time of startup.

Field testing of actual emissions will be required per Section 3-3 to verify compliance with the emission requirements.

The engine-generator shall at minimum meet the specified maximum allowable noise emission specified herein and any local noise emission requirements, whichever is more stringent.

2-2.01. Performance Tables.

2-2.01.01 Load Requirements. The engine-generator shall satisfactorily start the following loads in the listed order, while meeting the specified voltage dip:

Step	Load Description	Load	Maximum Voltage Dip (%)	Comments
Table to be completed				

2-2.01.02. Unloading Requirements. The engine-generator shall satisfactorily unload the loads indicated above in any order one at a time while not exceeding overspeed, frequency deviation, and voltage deviation.

2-3. ACCEPTABLE MANUFACTURERS. The engine-generator shall be a current production model. The engine-generator shall be manufactured by the Supplier Caterpillar, Cummins, MTU or Kohler without exception.

The complete engine-generator package shall be assembled by the engine-generator manufacturer or their representative.

The manufacturer of the engine-generator unit shall have a full-time factory trained technical staff and an equipped twenty-four (24) hour service facility having all personnel and all equipment required to maintain, repair, or overhaul the engine-generator unit and associated equipment.

2-4. ENGINE-GENERATOR UNIT.

2-4.01. Engine. The engine shall be reciprocating 4-stroke cycle compression ignition type and shall be equipped with the following:

Electronic governor for isochronous regulation of engine speed from no load to full load alternator output.

Dry type air cleaner with replaceable elements.

2-4.02. Alternator. The engine-generator alternator shall be a 4 pole, revolving field design with temperature compensated solid state voltage regulator, brushless rotating rectifier exciter system, and drip-proof construction with amortisseur windings. The alternator shall be directly connected to the engine flywheel housing, and the rotor shall be driven through a semi-flexible driving flange to ensure permanent alignment.

Frequency regulation shall be isochronous ±0.15 Hz from no load to rated load. Voltage regulation shall be within ±2 percent of rated voltage, steady state, from no load to full load. The momentary voltage drop shall not exceed the specified percent without starter coils dropping out or stalling the engine at any time when applying or starting the specified loads. Recovery to stable operation shall occur within 2 seconds.

The alternator shall have Class F insulation as defined by NEMA MG1-1.65 and temperature rise shall be within NEMA MG1-22.40 definition at rated condition.

An alternator winding heater shall be furnished as an integral part of the engine-generator unit. Alternator winding heater shall be rated 208 volts, single phase. The alternator winding heater control system shall include an interlock with the engine-generator units so that the heaters are de-energized at all times that the

generator field is energized. The Supplier shall provide all internal alternator winding heater wiring and fused branch circuit protection.

The winding pitch shall be 2/3 pitch.

2-4.02.01. Surge Protection. The engine-generator shall be provided with a voltage surge protection system installed in the generator terminal box that is located inside the enclosure.

The surge protection system shall include a surge capacitor and surge arrestor. All cable required to connect the surge protection system to the generator terminals shall be furnished and installed under this section.

2-4.03. Fuel System. The engine-generator unit shall be furnished with a complete fuel system including engine-driven fuel pump, double wall sub-base fuel storage tank, engine supply and return lines, and all accessories required for proper operation. All items shall be suitable for the specified fuel and located inside the enclosure and serviceable from inside the enclosure. The engine driven fuel pump shall transfer the fuel from the sub-base fuel storage tank to the engine-generator and maintain prime regardless of fuel level in the sub-base fuel storage tank.

The fuel system and all fuel piping shall be suitable for the specified fuel and shall meet all NFPA, State, and local requirements.

2-4.03.01 Sub-Base Fuel Storage Tank. The sub-base fuel storage tank shall be a rectangular sub-base type double wall and shall be located below the engine-generator and shall be constructed to permit access to the electrical stub-up area. The primary tank and secondary tank shall meet all EPA, State, and local requirements, be vented, and shall normally be used to store diesel fuel at atmospheric pressure. The primary internal steel tank and the secondary outer steel tank shall each be of welded construction throughout and each shall be UL 142 listed and labeled.

The sub-base fuel storage tank shall have a minimum usable capacity to provide for storage for 24 hours of continuous operation of the engine-generator when operating at 100 percent capacity but not less than 2,000 gallons.

The secondary tank shall be closed top, encircle the tank, prevent the containment area from being contaminated, and be sized to contain minimum 110 percent of the tank's capacity. Closed top dike tanks are not acceptable. All connections required for field-testing the secondary tank shall be furnished.

The fuel storage tank shall be provided with the following:

Primary tank vent cap.

Secondary tank vent cap.

Primary tank emergency vent.

Secondary tank emergency vent.

Level gauge that is capable of measuring the fuel level without engine running and is viewable from the manual fill connection.

Fill spill containment box.

Automatic shutoff valve on the fill line.

Check valve in the fill line.

Cap for pump out connection.

Quick Fill Coupling.

2-4.03.02. Fuel Tank Connections. All connection for the sub-base fuel storage tank shall be located inside the enclosure and on top of the tank and shall include the following:

Engine fuel supply.

Engine fuel return.

Primary tank vent.

Secondary tank vent.

Primary tank emergency vent.

Secondary tank emergency vent.

Secondary tank testing port with cap.

Manual fill with dry type quick fill coupling.

Level gauge with transmitter for remote level indication on the engine control panel and near fill door.

Low level switch.

Leak detection.

Minimum 2-inch tank manual pump out with cap. Pump out line to extend to within 2 inches of the bottom of the tank.

Three, 2-inch diameter spare primary tank connections with caps.

Minimum 3-inch diameter spare primary tank connection with blind flange.

High level switch with externally mounted alarm horn and silence button located near the fill connection.

High-High level switch if required for automatic shutoff of the fuel fill.

2-4.03.03 Fuel Tank Instrumentation. The fuel storage tank shall have instrumentation suitable for the geometric configuration of the tank that includes, but not limited to the following:

Level indication readout on the engine control panel with contacts for transmission of a remote 4-20mA signal for remote level indication. Power, if required, shall be pre-wired and fed from the engine-generator local control panel.

Level switch with electrically isolated dry contacts for remote leak detection of the primary tank and shall be provided with feedback to the engine-generator control panel.

Low level switch with electrically isolated dry contacts for remote low level annunciation on the engine control panel. The Low Fuel alarm shall be set to annunciate when 25 percent or less of the tank's capacity is remaining in the tank above the engine supply connection.

High level switch for annunciating audible alarm at 90 percent capacity in the fuel storage tank. Audible alarm horn with silence button shall be located near the fill connection.

High-high level switch with electrically isolated contacts to shut off an electrically operated valve if used in the full line at 95 percent capacity in the fuel storage tank.

One common, isolated, dry contact to close for any fuel system alarm.

The fuel system controls shall be pre-wired and powered from the panelboard.

2-4.03.04 Fuel Tank Fill Station. Tank fill connection, pump out, and level gauge, and overfill alarm shall be accessible at ground level through a lockable access door in the enclosure. A fill spill containment box shall be provided for containment of spillage during tank full or tank pump out.

The fill system including piping, fittings and the automatic shutoff valve, shall be suitable for a pump flow from a fill truck. The fill connection shall include a dry type quick disconnect coupling sized to accommodate the local fuel distributor.

A ground stud for the fuel supply truck shall also be supplied.

Tank fuel fill location shall be located as specified in Section 2-4.07.01 and as indicated on the Drawings.

2-4.03.05 Fuel Tank Overfill Protection System. A comprehensive fuel tank overfill protection system shall be provided as a described herein. All devices

and components shall be pre-wired from the system control panel with feedback to the engine-generator control panel as indicated.

Set at 90 percent capacity, the High Fuel alarm shall provide an audible alarm near the fill connection to alert the fill operator to prevent overfill of the fuel storage tank. A silence push button shall be provided to silence the alarm horn, automatically resetting when the fuel tank level has dropped below the high level conditions.

The fuel storage tank remote fill line shall include a suitable means for automatic shutoff of the fill line when 95 percent of the tank capacity has been reached. If electric operated valve is used, it shall be AC powered and be interlocked with the High-High level switch. The fill system including piping, fitting, and the automatic shut off valve shall be suitable for a pumped flow from a fill truck.

2-4.03.06 Fuel Tank Vent System. A suitable sized vent connection and vent cover shall be provided for the primary tank and secondary tank vent. Each vent cover shall be installed outside the enclosure. The cover shall have an aluminum body, screen over the outlet, and shall prevent rain from entering the vent line.

Suitable sized emergency vent connections for the primary and secondary tank and emergency vents shall be provided for the fuel storage tank. Each emergency relief vent shall be installed outside the enclosure and shall be designed as required to relieve excessive internal pressure caused by fire exposure.

Each vent line and each emergency relief vent line shall be routed up on the inside of the enclosure and shall terminate just above the enclosure.

2-4.03.07. Fuel Line Flexible Connectors. Stainless steel flexible connectors shall be provided for the diesel fuel supply and return lines and at a minimum shall be located at each connection to the engine, upstream of the combination fuel filter/separator, and in the return line to the sub-base fuel tank. The stainless steel flexible connectors shall be U.S. Hose “Model 401M” or equal.

2-4.03.08 Fuel Filter. A combination fuel filter/separator shall be located inside the enclosure and installed on the fuel supply line between the sub-base fuel storage tank and the engine driven fuel pump, upstream from the flexible connectors. The combination fuel filter/separator shall be a manifold unit with shutoff valves and shall permit servicing the filter/separator without needing shutdown. This shall permit valving off the filter/separator and bypassing the fuel to the other filter/separator. Filter separator shall be manufactured by Racor or equal.

2-4.03.09 Fuel Coolers. Fuel oil coolers shall be provided if the engine fuel system absorbs heat from the unit injectors and surrounding jacket water. The

fuel cooler shall be a radiator mounted, air cooled that uses the air flow from the radiator for cooling air flow. To prevent overheating of the fuel in the sub-base fuel storage tank, the fuel oil cooler shall be adequately sized to cool the return fuel from the engine to the required fuel inlet temperature.

2-4.04. Exhaust System. The engine-generator unit shall be furnished with a complete exhaust system including an exhaust silencer, all stainless steel exhaust piping, stainless steel bellows expansion joints, and accessories required for a complete operating system.

Exhaust piping shall be Schedule 10S, AISI Type 304L stainless steel with buttwelded fittings.

The exhaust silencer shall be all welded AISI Type 304L stainless steel construction. The exhaust silencer shall be furnished with suitable stainless steel bracket supports for horizontal mounting either on top of or inside the enclosure. The silencer shall be sized so that the back pressure at rated capacity of the engine does not exceed one half the manufacturer's maximum allowable back pressure. The exhaust from the engine shall enter either the bottom or side of the silencer. Silencer shall be Maxim, Nelson or equal.

A silencer shall be provided in order to meet the overall engine-generator unit noise emissions requirements specified in Section 2-4.13.

The exhaust silencer, if located inside the enclosure, and all exhaust piping inside the enclosure shall be thermally and acoustically insulated with removable insulation.

The exhaust shall discharge vertically at the silencer outlet. A rain cap shall be provided to prevent rain from entering the exhaust pipe. The rain cap shall open from exhaust pressure from the engine and shall close when exhaust flow stops. The cap shall be stainless steel counter-balancing with vertical discharge.

Exhaust emission test ports shall be provided in the exhaust piping after the silencer. Ports shall be threaded and shall be provided with stainless steel threaded plugs or caps.

2-4.05. Starting System and Control Power. The engine-generator unit shall be furnished with a complete electric motor start system including starting motors, battery pack with rack, cables, and battery charger.

The batteries shall be of the high-rate, lead acid type and have a 24 volt output. The batteries shall be sized for five 10 second cranks with battery and engine oil temperature of 30°F, and a battery end voltage of 70 percent of system voltage.

The battery charger shall float-charge the battery pack and shall be solid state, full wave bridge rectified type, utilizing silicon controlled rectifiers for power control.

The battery charger shall be suitable for the lead acid battery pack. The charger shall have a minimum DC output of 20 amperes. The battery charger shall be provided with a NEMA 2 corrosion resistant enclosure and shall be provided with the following: on/off switch, DC ammeter, DC voltmeter, AC input and DC output circuit breakers or fuses, floating voltage equalization, equalizing timer, and relays with form c contacts for remote annunciation of loss of AC power, low battery voltage, and high battery voltage.

The batteries, battery rack, and battery charger shall be located inside the engine-generator enclosure. The battery rack frame shall be constructed of corrosion resistant material.

The engine-generator shall automatically supply power to the remote bus that powers the battery charger when it is operating and when utility power is not available.

An electric pad type heater shall be provided with the batteries. The pad heater shall be thermostatically controlled and be sized to maintain the batteries at 50°F with a winter ambient temperature as specified. The strip heaters shall be powered from the panelboard specified herein and shall be wired by the engine-generator supplier.

2-4.06. Cooling System. The engine-generator unit shall be cooled with unit-mounted radiator cooling system complete with radiator, expansion tank, water pump, belt-driven fan, fan guard, thermostatic temperature control, high-water temperature cutout, electric jacket water heater and all accessories required for proper operation. The radiator shall be sized with sufficient capacity for cooling of the engine and all other accessories required for proper operation including the ambient air temperature rise inside the enclosure. The fan shall draw air over the engine and discharge through the radiator.

The cooling system shall be filled with a permanent antifreeze mixture of the ethylene glycol type with rust inhibitor suitable for the service conditions specified herein.

The electric jacket water heater shall be furnished to maintain jacket water at 90°F with a winter ambient temperature as specified herein. The jacket water heater shall be thermostatically controlled.

The jacket water heater shall be powered from the panelboard supplied in this section and shall be wired by the engine-generator Supplier.

2-4.07. Engine-Generator Enclosure. The engine-generator unit, including control panel, battery rack, battery charger, panelboard, sub-base fuel storage

tank, and other ancillary equipment, shall be housed in a weatherproof and sound Attenuated enclosure. The enclosure shall be shop mounted on the engine generator skid or field erected by the Supplier.

The enclosure shall be designed to withstand the specified conditions as defined in the Meteorological and Seismic Design Criteria Section.

The enclosure shall be as manufactured by Pritchard-Brown or equal.

2-4.07.01. Enclosure Fabrication. The enclosure shall consist of two side walls, two end walls, and roof. The roof shall be braced as necessary to support the exhaust system. All bracing and reinforcing members shall be integral to the enclosure.

Roof penetrations for the installation of the silencer shall be gasketed to prevent the entrance of rain.

The enclosure shall be constructed of either steel or aluminum. Steel enclosures shall be constructed with a support frame of not less than 14 gage steel and roof panels of 16 gage. Aluminum enclosures shall be formed sheet aluminum construction, made of modular panels and louvers. Post, rails, channels, and roof bows shall be 6061-T6 extruded aluminum. The panels shall be 0.04 inch thick aluminum.

Access service platforms along each long side shall be provided for access to the engine-generator if the sub-base fuel storage tank height exceeds twenty four (24) inches. Platforms shall be as tall as the sub-base tank.

Access platforms and stairs shall be of galvanized steel and aluminum construction. The access platforms shall be four (4) feet wide and shall be located on each side of the enclosure with individual stairs to each platform. Suitable brackets shall be welded to the enclosure at the factory for field-bolting the access platforms or stairs onto the brackets on the enclosure. Stairs and handrails shall not prevent the enclosure doors from opening fully.

The service platforms or stairs shall be OSHA compliant and shall be provided by the engine-generator manufacturer.

The enclosure shall be rain proof type as defined by UL2200 and shall prevent the wetting of live parts when the unit is operating. If required to meet the rain penetration requirements, “rain resistant” louvers, vertical air turning plenums or a combination of the two shall be provided.

The enclosure walls shall be reinforced to support the plenums. Plenums shall utilize bracing as required to prevent vibration and damage from the specified

wind velocity in the Meteorological and Seismic Design Criteria section and shall be bolted to the enclosure walls to permit removal and reinstallation.

A minimum of four separate doors, two per side, shall be provided and located for easy maintenance access to the engine-generator, controls, and accessories. Doors shall be lockable with stainless hardware. Maximum width of each individual door shall not exceed three (3) feet.

The entire enclosure, except for the louvered opening, shall be provided with noise suppression insulation.

The enclosure shall be provided to meet the overall engine-generator unit noise emission requirements as specified in Section 2-4.13. Field sound level tests shall be performed on the unit as specified in Section 3-3.02.

The sub-base fuel storage tank fill connection locations shall be accessible through its own access door from the ground level located on the Northern side and radiator end of the enclosure as indicated on the Drawings.

If required, access door shall be provided in front of the auxiliary power terminal box, control panel, and panelboard to permit access and working space from outside the enclosure when the door is open.

Engine oil and coolant drains shall be piped to the outside of the enclosure with lockable shutoff valves and caps.

All enclosure penetrations shall be gasketed or sealed to prevent the entry of rodents.

The enclosure shall be cleaned and painted as specified herein.

2-4.07.02. Enclosure Ventilation. The enclosure shall be provided with intake and exhaust louvers with dampers to open on engine start. Louvers and dampers shall be sized for the cooling air requirements. Louvers shall be AC powered closed and spring open on unit start. The louvers shall be screened from the inside to prevent the entry of birds. The louvers shall be pre-wired to the panelboard specified in this section.

The enclosure shall be provided with vertical air turning plenums for cooling air intake. The air inlet turning plenum shall be located on the end of the enclosure opposite the radiator discharge.

The enclosure shall be provided with vertical air tuning plenums for radiator discharge air. The radiator discharge plenum shall direct the air and mechanical noise upwards away from the unit, and shall be supplied with a bottom sump area, with a one inch drain and shutoff valve to remove any moisture.

2-4.07.03 Electrical. The engine-generator enclosure shall be provided with interior AC/DC operated maintenance lights, controlled with a 1 hour, wind-up timer switch shall also be provided. A duplex receptacle rated 20 amp, 125 volts with a weatherproof enclosure shall be mounted inside and near the middle of the enclosure.

The enclosure shall be pre-wired, requiring only external connection to the panelboard.

2-4.08. Crankcase Vent Blow-By Absorber. Suitable crankcase breather system shall be provided by the engine-generator manufacturer to remove oil mist from the crankcase emission prior to induction into the air intake system. The system provided shall meet the applicable level mission requirements.

2-4.09. Control Panel. The engine-generator unit shall be provided with a unit mounted control panel that shall be accessible from outside the enclosure when the enclosure doors are open. The panel shall be provided with vibration isolators to prevent damage to the instruments from engine-generator vibration.

Adequate clearance shall be provided between the panel and engine to allow engine maintenance with removing the control panel.

The control panel shall be automatic and safety type and shall, at a minimum, include all items required by NFPA 110, Level 1, and in addition the following instrumentation and controls:

Tachometer.

Non-resettable hour meter.

AC voltmeter, AC ammeter, voltmeter/ammeter selector switch with “OFF” position.

Two normally open dry contacts which close when the engine is running and open when it is stopped.

Dry contact that closes for remote common alarm.

Dry contact that closes when the control selector switch is in “AUTO” mode.

Three-position selector switch with “RUN-OFF-AUTO”.

Indicating lights with common alarm for the following:

Sub-base tank low fuel level.

Sub-base tank leak detection.

Sub-base tank continuous reading level.

Dry contact for common alarm.

Contacts for a remote two position maintain contact emergency shutdown switch.

The control panel shall be provided with a three-position selector switch with the following positions: “RUN-OFF-AUTO”. In the “RUN” position, the engine starting sequence shall be initiated providing local control for maintenance, in the “AUTO” position, the engine-generator will be remotely started and stopped by a run contact from the remote statin located at the engine-generator switchgear. Isolated contacts for when the unit is in the “OFF” position shall be provided for remote indication.

2-4.09.01 Emergency Shutdown Control Station. A remotely located emergency shutdown control station shall be furnished under this section and connected to the engine-generator control panel. The control station when activated shall shutdown the engine-generator regardless of the position of the “RUN-OFF-AUTO” selector switch. The control station shall be located as indicated on the Drawings. Control wiring between the control station and the engine-generator control panel shall be furnished by the installing Supplier.

2-4.10. Panelboard. The engine-generator unit shall have an auxiliary panelboard center mounted inside the enclosure and isolated from engine-generator vibration. The power center panelboard shall be pre-wired to all engine-generator accessories as needed. The panelboard shall supply power including but not limited to the following:

Engine-generator starting system battery charger.

Enclosure lights and receptacles.

Fuel system.

Enclosure intake and exhaust louvers/dampers.

Engine jacket water heater.

Alternator winding heater.

Battery pad heater for starting batteries.

The panelboard shall have an integral surge protection device as specified in the Electrical section. All electrical equipment and materials shall meet the applicable requirements of the Electrical section.

2-4.11. Generator Line and Generator Component Overcurrent Protection. A generator line circuit breaker rated for the generator output voltage, having the trip rating indicated on the Drawings, shall be provided on the output terminals. The line circuit breaker shall be pre-wired to the generator output terminals, and shall be provided within the generator enclosure.

Overcurrent protection devices shall be provided as needed by the system design to protect generator rotor and excitation system components.

2-4.12. Limiting Dimensions. The engine-generator unit furnished shall be of a design that can be accommodated in the space available as specified herein.

2-4.13. Noise Emissions. The engine-generator unit, including the enclosure, louvered openings, and exhaust system, shall be designed to limit the noise emissions to not exceed the A-weighted sound pressure level of 75 dB(A) at 23 feet from any point of the engine-generator unit when operating at the specified capacity, and when measured in accordance with industry standards such as but not limited to ANSI S12.18, ASME PTC 36, ISO 8528-10.

2-5. SHOP PAINTING.

2-5.01. Engine-Generator. All steel and iron surfaces shall be protected by suitable coatings applied in the shop. Surfaces which will be inaccessible after assembly shall be protected for the life of the equipment. Coatings shall be suitable for the environment where the equipment is installed. Exposed surfaces shall be finished, thoroughly cleaned, and filled as necessary to provide a smooth, uniform base for painting. Electric motors, engine, alternator, enclosure, piping, and valves shall be shop primed and finish painted prior to shipment to the site.

Stainless steel, nonferrous, and nonmetallic surfaces shall not be painted.

2-5.02. Enclosure and Sub-Base Tank. The enclosure shall be thoroughly cleaned after assembly, etched, and shop painted, both interior and exterior surfaces. The enclosure and sub-base tank shall be painted according to the manufacturer's standard practices with the interior receiving at least one coat ANSI gray and the exterior powder coated with UV inhibitor. Paint colors shall be as selected by the Owner.

2-6. SHOP TESTS.

2-6.01. Engine-Generator Shop Test. The manufacturer shall shop test the engine-generator set with its control panel and unit mounted radiator to demonstrate that the equipment conforms to specified requirements for load capacity using a load bank at the specified frequency, voltage, phase, and power factor.

All items included on the control panel shall be assembled, wired, and tested in the manufacturer's shop.

At a minimum the tests shall consist of repeated starts and stops, operation under a load bank at specified capacity, frequency, voltage, phase, and power factor for a minimum of 1 continuous hour, and tests to demonstrate that each safety shutdown device is working properly.

Certified copies of the shop test results shall be submitted to the Design-Builder prior to shipping the unit.

2-6.02. Fuel Storage Tank Shop Test. The manufacturer shall shop test the fuel storage tank using the tank manufacturer's procedures.

2-7. OPERATION INSTRUCTION. Step-by-step instructions shall be furnished by the engine manufacturer for the unit. The instructions shall include, but not be limited to, the following procedures or information:

Startup of the unit.

Normal shutdown of the unit.

Emergency shutdown of the unit.

Normal operation of the unit, typical temperatures, pressures, speed, etc., for gauges and instruments which are displayed on the panel.

The operation instructions shall be submitted for review in accordance with the Submittals Procedures section. When the review is complete, the instruction sheets shall be printed on heavy paper or cardboard stock and laminated with clear plastic. Two copies of the laminated instructions shall be furnished with the unit. The instructions specified here are in addition to the operation and maintenance manuals required by the Submittals Procedures section.

2-8. PERMITS.

2-8.01. Air Emission Permit. Design-Builder shall be responsible for preparing and submitting air emissions permit application on behalf of the Owner to the local air quality authority for the engine-generator being supplied based on the maximum number of operating hours and the guaranteed emissions.

2-8.02. Fuel Storage Tank Permits. The Design-Builder shall be responsible for providing all plans, applications, and information needed for and applying and obtaining approval of the proposed construction and installation of the storage tank and fuel system as required by all local and state regulations.

PART 3 - EXECUTION

3-1. INSTALLATION. The engine-generator shall be installed in accordance with the Equipment Installation section and as specified herein.

The exposed finish shall be inspected after completing system installation, including pipe connections, fittings, valves, and specialties. Burrs, dirt, and construction debris shall be removed and any damaged finishes, including chips, scratches, and abrasions shall be repaired.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with the Commissioning section, and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of the Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the Contract Price.

3-3. FIELD TESTING. Manufacturer's field services shall be provided for field testing. All costs for these services shall be included in the Contract Price.

3-3.01. Engine-Generator Performance Test. The unit shall be mechanically checked for proper operation. Each alarm and safety shutdown shall be checked by artificially simulating an alarm condition. Defective equipment and controls disclosed by the tests shall be replaced or corrected, and the packages placed in satisfactory operating condition.

The engine-generator set shall be tested to demonstrate that the equipment conforms to specified requirements for load capacity, and starting duty.

The complete system (engine, generator, fuel system, exhaust system, starting system and control panel) shall be field tested together by the manufacturer as a complete system to assure compatibility.

The tests shall consist of repeated starts and stops, operation using a load bank at the specified power rating and power factor for the duration indicated below.

Before each of the following tests, the engine shall be brought to steady state conditions as determined by the instrument readings:

- Four (4) continuous hours at the specified power rating and power factor within normal operating conditions of the unit without any alarm conditions.
- Four (4) starts of the specified electrical loads in the order listed followed by 30 minutes of continuous operation per start all within normal operating conditions of the unit without any alarm conditions.
- Demonstration that each safety shutdown device is working properly.

Supplier shall furnish the lubricants, load bank, and the fuel for the tests.

At the option of the Design-Builder, an independent laboratory will be provided by others for the exhaust gas sampling and analysis during the 4 hour load test of the engine. The laboratory analysis will be used for verification the unit meets the guaranteed emissions.

Any retesting or modifications to the equipment to meet the above requirements and emission guarantees shall be approved by the Design-Builder. All costs of modifications and retesting, including the independent laboratory for air emission testing, shall be at no cost to the Owner.

The following items shall be measured, recorded at 15 minute intervals, and submitted in a field test report:

Outdoor ambient temperature.

kW output.

Engine speed, rpm.

Engine jacket water temperature.

Engine oil pressure.

Start time.

Completion time.

Test reports shall verify that the specified tests have been performed and shall state results. Test results shall be submitted as required in the Submittals Procedures section.

3-3.02. Engine-Generator Field Sound Level Test. At the option of the Design-Builder, the installed equipment shall be tested for noise during one of the 30 minute performance tests. The measured engine-generator sound levels shall not exceed the sound level specified herein.

Compliance with the noise emissions requirement shall be determined in accordance with industry standards including ASME PTC-36. Compliance shall be based on not exceeding the allowable sound level including background

sound level correction per section 4-2.6 ASME PTC-36 and excluding any correction for measurement uncertainties.

Any retesting or modifications to the equipment or enclosure to meet the above requirements shall be approved by the Design-Builder. All costs of modifications and retesting shall be at no cost.

Test reports shall verify that the specified tests have been performed and shall state results. Test results shall be submitted as required in the Submittals Procedures section.

3-3.03. Fuel Storage Tank Tightness Testing. After shipment to the Site, but prior to installation, the inner primary tank and secondary outer tank shall be pressure tested. While maintaining pressure required by the tank manufacturer for the primary and secondary tank, the inner primary tank and the outer secondary tank shall be checked for leaks using an air gauge. During testing, connections may be plugged but shall not be blocked or plugged on the inside. If there are leaks or indications of leaks, the tank shall be replaced with a new tank and tested after shipment to the jobsite.

Tightness testing at the site is not required if the tank is shipped from the factory with a vacuum drawn on the interstitial space and is maintained through completion of installation. This shall be documented throughout the fabrication, shipping and installation process and provided to the Design-Builder.

3-4. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer’s expense.

3-5. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-5.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-5.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

3-6. INITIAL TANK FILL. Upon satisfactory completion of all work, the Supplier shall fill the sub-base tank with the specified fuel.

End of Section

Section 26 36 26

BYPASS-ISOLATION AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

1-1. SCOPE. This section covers both indoor and outdoor automatic transfer switches, and bypass-isolation automatic transfer switches, which shall be furnished, and tested as specified and as indicated on the Drawings.

Automatic transfer switch equipment shall meet the design conditions and features.

Automatic transfer switch equipment shall be designated and located as follows:

Tag number(s).	As per Electrical One-line 80-E-701
Transfer switch designation(s).	As per Electrical One-line 80-E-701
Location of transfer switch(es).	As per electrical drawing

1-2. GENERAL. Equipment furnished and installed 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, unless exceptions are noted by Design Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment furnished under this section. If stipulations in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Dimensional Restrictions. Layout dimensions will vary between manufacturers and the layout area indicated on the Drawings is based on typical values. Supplier shall review the Drawings, the manufacturer's layout drawings and installation requirements, and make any modifications required for proper installation subject to acceptance by Design-Builder.

1-2.04. Workmanship and Materials. Equipment supplier shall guarantee all equipment against faulty or inadequate design, improper assembly or erection,

defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

1-2.05. Governing Standards. The equipment furnished under this section shall be designed, constructed, and tested in accordance with the following standards:

UL 1008;
NFPA 110;

The equipment shall also conform to all the applicable standards of ANSI, IEEE, NEMA, UL, and NFPA 70.

1-2.06. Nameplates. Nameplates with designation of each control or indicating device shall be mounted on the switch enclosure. Nameplates shall be black and white laminated phenolic material of suitable size, and shall be engraved with 3/4 inch [19 mm] high letters for section identity and 1/8 inch [3 mm] letters for other information. The engraving shall extend through the black exterior lamination to the white center.

Each control device and each control wire terminal block connection inside the units shall be identified with a permanent nameplate or painted legend to match the identification on the manufacturer's wiring diagram.

1-2.07. System Characteristics. The equipment will be connected to a power system with characteristics as specified below:

Voltage, phase	480, 3-phase V
Frequency	60 Hz
Number of conductors	4-wire

1-3. SUBMITTALS. Complete assembly, foundation, and installation drawings, together with complete engineering data covering the materials used, parts, devices, and accessories forming a part of the transfer switch, shall be submitted in accordance with the Submittal Procedures section. The drawings and data shall include, but shall not be limited to, the following:

Drawings showing front and side views, plan, and weight.
Rating and specifications.
Circuit breaker time-current characteristic curves, if applicable.
Single-line, control schematic, and wiring connection diagrams.
Operation and maintenance and manuals including a list of spare parts.
Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-4. OPERATION AND MAINTENANCE MANUALS. Operation and maintenance manuals shall be submitted in accordance with the Submittal Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-5. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and Storage shall be in accordance with the Product Storage and Handling Requirements section.

1-6. SPARE PARTS. Standard spare parts shall be provided.

1-7. Arc Flash Hazard Labels. Switchboards shall be provided with permanent labels warning the risk of arc flash and shock hazard. Labels shall be designed in accordance with ANSI Z535.4 and shall include the following:

WARNING
Arc Flash and Shock Hazard

Appropriate personal protection equipment (PPE) required. SEE NFPA 70E.
Equipment must be accessed by qualified personnel only.
Turn off all power sources prior to working on or inside equipment.

Additional information shall be provided on the labels as per the Arc Flash Hazard Analysis performed by the Supplier.

PART 2 - PRODUCTS

2-1. ACCEPTABLE MANUFACTURERS.

The automatic transfer switch shall be manufactured by Automatic Switch Co. (ASCO), GE Zenith Controls, or Russelectric Inc., without exception.

2-2. CONSTRUCTION FEATURES.

2-2.01. Enclosure. The enclosure for the transfer switch shall be as follows:

Type of mounting	Freestanding
Enclosure rating	Indoor NEMA Type 1

Adequate bracing shall be provided for seismic forces. The bracing shall be designed to meet the requirements of the Meteorological and Seismic Design Criteria section.

2-2.02. Rating. Automatic transfer switches shall be rated for continuous duty in both normal and emergency positions. The switches shall have the number of

poles as specified below, and shall be double-throw. Ampere ratings, and 3-cycle closing and withstand ratings shall be as specified below.

Number of poles	4-pole
Ampere rating and 3-cycle closing and withstand rating	As indicated on the Drawings

Switches shall be equipped with a solid neutral.

2-2.03. Space Heaters. Not used.

2-3. PERFORMANCE AND DESIGN REQUIREMENTS.

2-3.01. Equipment Description. The automatic transfer switches shall transfer electric loads from the normal source of electric power to an emergency source of power as indicated on the Drawings. The transfer switches shall automatically transfer the electrical load circuits upon an interruption or a decrease in the voltage of the normal source of power and shall transfer the loads back to the normal source when it becomes available. The transfer switches shall be furnished without integral overcurrent protection. The switches shall be electrically operated but mechanically held in both the normal and emergency positions. The operating mechanism shall be momentarily energized from the source to which the load is being transferred. All main and arcing contacts and control elements shall be removable from the front of the switches without removing the switch from the enclosure and without removing the power cables. The automatic transfer switches shall be so designed that the load circuits cannot be connected to more than one source of power at a time. The automatic transfer switches shall be magnetic contactor type.

2-3.01.01. Automatic Transfer Switch. The automatic transfer switch shall be an electrically operated double throw switch. Main contacts shall be silver composition. Main and arcing contacts shall be visible without major disassembly to facilitate inspection and maintenance. A manual handle shall be provided for maintenance.

Switches composed of molded case breakers, contactors, or similar components not specifically designed for automatic transfer switch applications will not be acceptable.

2-3.01.02. Bypass-Isolation Switch. A bypass-isolation transfer switch shall be provided to permit manual bypassing and isolation of the automatic transfer switch.

Bypassing the load to either the normal or emergency source shall completely isolate the transfer switch from both sources and the load and shall be possible regardless of the status of the switch. Bypassing to the load-carrying source

shall be possible without any interruption of power to the load (make-before-break). Load-break type bypassing will not be acceptable.

Provisions shall be made for testing the automatic transfer switch when operating in bypass. Testing in bypass shall not disturb power to the load.

2-3.02. Control System. The control system shall consist of all control devices necessary to operate the switch as described. The system shall incorporate a microprocessor control module connected to the power transfer components by a wire harness and keyed disconnect plugs. The control module shall be completely enclosed with a protective cover and shall be mounted separately from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on plug-in circuit boards. All interface relays shall be identical and shall be control grade, plug-in type, with dust covers.

All control components shall meet or exceed the voltage withstand capability in accordance with IEEE C37.90.1 and NEMA ICS 1.

2-3.02.01. Performance. The automatic transfer switch shall be designed to function in accordance with the following requirements:

a. The voltage of each phase of the normal source shall be monitored and the pickup voltage shall be adjustable from 85 percent to 100 percent of nominal, and the dropout voltage shall be adjustable from 75 percent to 98 percent of the pickup value. The transfer to emergency will be initiated upon reduction of the normal source to 85 percent of the normal voltage, and retransfer to normal shall occur when the normal source restores to 90 percent of the normal voltage.

b. A time delay to override momentary normal source outages to delay all transfer switch and engine starting signals shall be provided. The time delay shall be field adjustable from 0.5 to 6 seconds and shall be factory set at 1 second.

c. A time delay to retransfer to the normal source shall be provided. The time delay shall be automatically bypassed if the emergency source fails and the normal source is available. The time delay shall be field adjustable from 0 to 30 minutes and shall be factory set at 10 minutes.

d. An in-phase monitor shall be provided to control transfer so motor load inrush currents do not exceed normal starting currents. The monitor shall compare the phase relationship and frequency difference between the normal and emergency sources and shall permit transfer only at acceptable values of voltage, phase relationship, and frequency differential.

e. An unloaded running time delay for engine-generator cool-down shall be provided. The time delay shall be field adjustable from 0 to 60 minutes and shall be factory set at 5 minutes.

2-3.02.02. Indication. The automatic transfer switch shall include indication features in accordance with the following requirements:

a. A detailed step-by-step operating instruction plate shall be provided on the front of the switch.

b. Indicating lights or microprocessor control display indication shall be provided for, but shall not be limited to, the following:

Normal source available.
Emergency source available.
Bypass switch in normal position.
Bypass switch in emergency position.
Automatic transfer switch isolated.
Automatic transfer switch inhibit.
Automatic transfer switch in normal position.
Automatic transfer switch in emergency position.
Automatic transfer switch in test mode.

c. One auxiliary contact shall be provided that is closed when the automatic transfer switch is connected to the normal source and one contact that is closed when the automatic transfer switch is connected to the emergency source.

d. A contact, which will close when the normal source fails, shall be provided to initiate engine starting. The contact shall be rated 10 amperes, 32 VDC and shall be gold plated for low voltage service.

2-3.03. Shop Painting. All iron and steel surfaces, except machined surfaces and stainless steel, shall be shop painted with the manufacturer's standard coating. Finish color shall be ANSI 61. Field painting, other than touchup painting, shall not be required. A sufficient quantity of additional coating material and thinner shall be furnished to permit field touchup of damaged coatings.

2-3.04. Shop Tests. After the equipment has been completely assembled, it shall be shop tested for general operating condition, circuit continuity, high potential, and for compliance with the governing standards. Certified test results shall be submitted to Design Builder before the equipment is shipped.

PART 3 - EXECUTION

3-1. INSTALLATION. The transfer switch will be installed in accordance with Electrical Equipment Installation section.

3-2. TRAINING. The manufacturer's representative shall provide training of Owner's personnel as described in the Demonstration and Training specification. All costs for training services shall be included in the Contract Price.

End of Section

Section 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing the design of lightning protection systems and the furnishing and installation of lightning protection equipment for the following structures:

Operations Building

Lightning protection systems shall be designed, furnished, installed, and tested as specified. Lightning protection equipment shall meet the requirements specified herein.

Lightning protection systems shall consist of, but not be limited to, air terminals; main, bonding, and down conductors; ground terminals; and all required connectors and fittings required to complete the system.

The lightning protection system shall include the bonding of all roof-mounted mechanical equipment, roof drains, roof mounted ladders, chimneys, antennas, and other roof mounted metal objects.

1-2. GENERAL. Contractor shall furnish all installation drawings, tools, equipment, materials, and supplies and shall perform all labor and obtain all inspections to complete the work as specified, and in compliance with all codes, standards, and regulations.

Contractor shall provide coordination with other contractors and supervision of installation as needed during construction.

The design of the system shall include determination of the overall lightning hazard for the geographic location of the project and for the structures, the selection of Class I and/or Class II materials, the need of corrosion protection for the copper and/or aluminum components used, and consideration of other pertinent factors. The design shall produce a zone of protection from lightning to prevent personal injury, structural damage, and equipment downtime.

Equipment furnished and installed 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 UL unless exceptions are noted by Engineer.

The system shall be installed by an installer who has UL listing and subscribes to the UL Follow-Up Service.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment furnished under this section. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Governing Standards. All system components furnished under this section shall be designed in accordance with ANSI/UL 96 - Lightning Protection Components. All lightning protection systems furnished under this section shall be designed, constructed, and tested in accordance with UL 96A – Installation Requirements for Lightning Protection Systems and ANSI/NFPA 780 – Standard for the Installation of Lightning Protection Systems.

Lightning protection systems shall be bonded to grounding electrode systems in accordance with the National Electrical Code.

1-2.04. Workmanship and Materials. Contractor shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, unless required by tests.

1-3. SUBMITTALS. Complete certification of design calculations; assembly, and installation drawings; together with complete engineering data covering the materials used and the parts, devices, and accessories forming the system, shall be submitted in accordance with the Submittals Procedures section.

Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-4. QUALITY ASSURANCE. The lightning protection system shall be inspected and tested after installation by conducting continuity and ground resistance tests as well as a visual inspection. Inspection results and test data shall be submitted in accordance with the Submittals Procedures section. Upon completion of the installation, Contractor shall apply for and deliver the UL Master Label Certificate of Inspection for each structure/building.

PART 2 - PRODUCTS

2-1. ACCEPTABLE MANUFACTURERS. The system components shall be manufactured by a company that has been specializing in the design and manufacture of UL listed lightning protection equipment for at least 5 years.

2-2. MATERIALS. All manufactured and fabricated components shall conform to NFPA 780 Class I or Class II as needed for the structures on which they will be installed. The system components shall be fabricated from the following metals:

Conductors	Copper.
Air Terminals	Copper or bronze.
Grounding Electrodes	Copper clad steel.
Fasteners	Copper or bronze.
Bimetallic Fasteners	Bronze and aluminum.

Aluminum conductors and air terminals shall be mounted on aluminum surfaces only.

All materials furnished for the lightning protection system shall bear the inspection label of UL.

PART 3 - EXECUTION

3-1. INSTALLATION. The lightning protection system shall be installed in a neat and inconspicuous manner so all components will blend in with the appearance of the building. All conductors shall be concealed or semi-concealed during construction using methods recommended in NFPA 780 and UL 96A.

Air terminals shall have base supports designed for the surface on which they are used and shall be securely anchored. All exposed metal eave troughs, roof vents, guy wires, antennas, and air handling equipment shall be bonded to the lightning protection system in such a way that two paths to ground are provided.

The lightning protection system shall be bonded to structure/building electrical ground rings wherever they are available.

End of Section

Section 26 50 01

PERFORMANCE LIGHTING

PART 1 GENERAL

1-1. SCOPE. Scope of supply shall include designing, furnishing, and installing the plant lighting and convenience receptacle system as specified herein.

1-2. Items Furnished by Others and Interfaces – Not Used

1-3. PERFORMANCE AND DESIGN REQUIREMENTS
Performance and design requirements for the equipment and materials to be furnished under this section of these specifications are indicated herein.

1-3.01. Design Requirements. The lighting system shall be designed by the Electrical Installer to provide personnel with illumination for plant operations under normal conditions, essential lighting in selected process areas, electrical/control areas and means of egress under emergency conditions. The power supply for the normal lighting system shall be from Electrical Installer provided 120/208, 3-phase, 4 wire lighting transformer/panelboards. The power supply for convenience receptacles shall be from Electrical Installer provided 120/208 volt, 3-phase, 4 wire lighting transformer/panelboards. Emergency egress lighting shall be provided with normally "off," emergency "on" integral lead acid battery powered emergency lighting units with chargers rated for 1.5 hours minimum and in accordance with UL 924.

The lighting system shall be designed in accordance with the codes and standards noted in section 1-5 below. The illumination levels shall be as per the electrical drawings.

Panelboard breakers shall be used to switch light fixtures for large open interior and exterior spaces. Electric power to light fixtures in dedicated rooms shall be switched with wall mounted light switches or other devices as required by the local state Energy Code, and located at the entrance to all rooms on the latch side of the door. Light fixtures located outside above doors shall be provided with integral photoelectric controllers. Outdoor fixtures shall be controlled from lighting contactors with H-O-A switch on cover and coil operated by photocell.

The lighting shall have interface with the Plant Control System (PLC) so it can be turned on and off from the Plant Control System.

Convenience receptacles shall be grounding type and spaced to provide access to any equipment area with a 100 foot extension cord. A minimum of one receptacle shall be provided on each wall of every room. Weatherproof GFI receptacle shall be provided for exterior areas. Convenience receptacles shall be limited to six per circuit, with a branch circuit loading of 180 watts for each receptacle, unless specific conditions necessitate other requirements.

Lighting in process areas shall be designed with the equipment in the space in mind and to avoid physical interferences with tray, piping and HVAC ducts which are being designed by others, as well as shadows/light blockages from adjacent equipment.

For lighting system materials, the following requirements shall also apply in addition to the requirements of this section:

Section 26 05 11 - Electrical.

Section 26 05 83 - Electrical Equipment Installation.

1-3.02. Design Execution. The design process shall be fully tracked and managed from concept through execution.

1-4. SUBMITTALS All submittals shall be in accordance with Supplemental Procedure section. In addition to equipment submittals the Electrical Installer shall also submit the following information:

- A comprehensive/complete drawing list shall be provided at the start of the project and maintained through project completion. List shall include drawing names, drawing numbers, as well as expected/actual release dates for review and construction.
- Calculations verifying lighting levels and panelboard electrical loading.
- Lighting system drawings indicating all light fixtures, switches, receptacles, panelboards, sized circuiting, and quantities of materials including model numbers. Drawing backgrounds shall include equipment in the area. Elevations and plan locations shall be established for lighting materials to avoid interferences.
- Panelboard diagrams indication panel configurations, electrical load per breaker, breaker sizes, and description of load
- Energy calculations required by (Fill in State) Code.
- Native drawing files in CAD format (if required by EPC Contract)
- Electronic and hard-copy bills of quantity in MS Excel format for all equipment and devices

Lighting calculations shall be average maintained values determined from a working plane height of 30 inches above the floor for interior and at floor level for exterior. Light loss factors shall be determined as recommended by IESNA. Illumination point values shall be indicated on a background of the area being illuminated with equipment indicated on the background. The major equipment shall be modeled in the calculation. Panelboard load sheets shall be prepared with load per branch breaker and then overall panel loading. Voltage drop calculations shall be prepared for some of the longer branch runs to verify wire size used in design. Energy calculations or worksheets shall be prepared if

required by energy codes. Calculations shall be given unique file numbers as directed by the Purchaser and have cover sheets describing the calculation.

The drawings shall be prepared in the following format. Each drawing label shall indicate the drawing content and system type. Physical layout drawings shall include all floor plans drawn to a minimum scale of 3/16 inch equals one foot with the same north orientation. A legend shall be provided to describe the symbols used on the drawings. Drawings shall be corrected by the Subcontractor after system installation to show the as-built configuration of the systems. The drawings shall be stamped by a (Fill in State) registered professional electrical engineer.

The Electrical Installer shall design the lighting using 3D model software with the fixtures represented in 3D and shall obtain from the Design-Builder 3D files for the plant general arrangements, electrical cable tray, main piping and HVAC ductwork to input into their software. An interference check shall be performed between the lighting and other objects in the model by the Electrical Installer. The 3D lighting model shall be submitted to the Design-Builder to interface with the Design-Builder's modeling software files. The drawings noted above shall be extracted from the 3D model.

A fully configured and loaded model file shall be provided to the Design-Builder as needed on at least two scheduled dates to be determined after Contract award.

1-5. CODES AND STANDARDS Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply.

These references shall govern the work except where they conflict with the Design-Builder's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Work	In Accordance With
Lighting Design	Illumination Engineering Society (IES) Lighting Handbook 10th edition
Emergency and Exit Lighting	National Fire Protection Association (NFPA) 101, Life Safety Code. Exterior Structures will be classified as open structures in accordance with NFPA 101 and therefore will be exempt from emergency lighting requirements per Article 11.2.2.9
Luminaires	
Fluorescent	UL 542, 935, 1598
High intensity discharge	UL 496, 1029, 1598
Light emitting diode (LED)	UL 8750
Emergency and emergency power equipment	UL 924
Hazardous area	UL 844
Duplex and single receptacles	UL 498, 943, 1010, 1449, 1682, 1686
Switches, dimmers, contactor, and photocells	UL 20, 508, 773, 894, 1472
Device plates and outlet boxes (unfinished areas)	UL 514

1-6. MATERIALS The following materials shall be used:

Component	Material
Switches	
Housing and operating levers	Phenolic compound
Device plates	
Finished areas (metal)	Type 430 satin stainless steel
Unfinished areas	Formed sheet steel coated with zinc of cadmium
Weatherproof receptacle and switches	
Plates and lift cover	Cast aluminum

Component	Material
All other metal parts	Stainless steel or Monel metal

1-7. TEST REQUIREMENTS The testing of the lighting system shall be the responsibility of the Electrical Installer.

PART 2 PRODUCTS

2-1. LUMINAIRE DEVICES Luminaires shall be as specified in the specification section 26 05 11.

2-2. LUMINAIRE SUPPORTS All required luminaire supports, hangers, clamps, hardware, and fasteners shall be furnished and installed as required for a rigid support. Supports shall be from the building structure support steel, walls, or standalone light poles for exterior lighting. Chain supported luminaires are not acceptable. Supports shall be designed for the project seismic criteria.

2-3. LIGHTING AND CONVENIENCE RECEPTACLE RACEWAY The following raceway and raceway fittings (minimum size 1/2 inch) for use in lighting and convenience receptacle circuits shall be provided.

Raceway Type	Use
Electrical metallic tubing (EMT)	Installed in indoor nonhazardous areas
Rigid galvanized steel	Outdoors above grade and indoor hazardous areas
Flexible metallic tubing	Luminaire taps in finished areas

PART 3 EXECUTION

3-1. INSTALLATION. Installation shall be in accordance with the Electrical Equipment Installation section.

End of Section

Section 28 10 01

FACILITY SECURITY SYSTEM

PART 1 - GENERAL

1-1. SCOPE. This section covers the design, furnishing, installation, configuration, testing and commissioning of all security equipment, materials, cabling, conduits, and other accessories needed for a complete security system.

The facility security shall be implemented for the entire site. The security installation shall be UL certified.

Security System Supplier shall be responsible for the complete design including locating the devices and sizing and routing all the cables and conduits for complete security system specified herein.

All security equipment racks shall be located in the electrical room. A single power feed (120VAC, 30A) circuit will be provided for each equipment rack. The Supplier shall be responsible for providing all the necessary power transformer within the equipment rack for all the furnished security devices. Power supplies for all furnished security devices shall be fed from the furnished equipment rack at each location.

All low voltage signal and communication cables shall be routed in separate conduits from the 120VAC power cables.

1-2. GENERAL. Security apparatus on all equipment shall be installed complete and placed in readiness for proper operation.

Security materials furnished and installed 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, unless exceptions are noted by Design-Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment provided under this section. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Coordination. Security work shall conform to the construction schedule and the progress of other trades.

1-2.04. Anchor Bolts and Expansion Anchors. All anchor bolts, nuts, washers, and expansion anchors shall comply with Anchorage in Concrete and Masonry section, except smaller than 3/4 inch [19 mm] will be permitted to match NEMA standard size bolt holes on motors and electrical equipment.

1-2.05. Drawings. Supplementing this section, the Drawings indicate locations of equipment and enclosures and provide one-line and schematic diagrams regarding the connection and interaction with other equipment.

1-3. CODES AND PERMITS. All work shall be performed and materials shall be furnished in accordance with the NEC - National Electrical Code, the NESC - National Electrical Safety Code, and the following standards where applicable:

ANSI	American National Standards Institute.
AWG	American Wire Gauge.
ICEA	Insulated Cable Engineers Association.
IEEE	Institute of Electrical and Electronics Engineers.
NEIS	National Electrical Installation Standards
NEMA	National Electrical Manufacturers Association.
NFPA	National Fire Protection Association.
CEC	California Electrical Code

1-4. SEISMIC DESIGN REQUIREMENT.

1-4.01. Seismic Design Requirements. Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-5. IDENTIFICATION.

1-5.01. Security Equipment. Security equipment hall be provided with nameplates identifying the related equipment.

1-5.02. Circuit Breakers. Circuit breakers shall be provided with nameplates identifying related equipment. Nameplates shall be laminated black-over-white plastic, with 1/8 inch [3 mm] engraved letters, and shall be securely fastened to the circuit breakers.

1-6. SUBMITTALS. Complete assembly, foundation, and installation drawings, together with complete engineering data covering the materials used, parts, devices, and accessories forming a part of the work performed by the Contractor, shall be submitted in accordance with the Submittals Procedures section. The drawings and data shall include, but shall not be limited to, the following:

Overall System Diagram

Cable and Conduit lists

Design and Installation Drawings and data.

Operating manuals.

1-6.01. Submittal Identification. Information covering all materials and equipment shall be submitted for review in accordance with the Submittals Procedures section. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment as follows:

a. Equipment and materials descriptive literature and drawings shall show the specification paragraph for which the equipment applies.

b. Sheets or drawings covering more than the item being considered shall have all inapplicable information crossed out.

c. A suitable notation shall identify equipment and materials descriptive literature not readily cross-referenced with the Drawings or Specifications.

d. Schematics and connection diagrams for all security equipment shall be submitted for review. A manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted, unless it is clearly marked to show the intended connections.

e. Surge protective device submittals shall include drawings (including unit dimensions, weights, component and connection locations, mounting provisions, and wiring diagrams), equipment manuals that detail the installation, operation and maintenance instructions for the specified unit(s), and manufacturer's descriptive bulletins and product sheets.

1-7. PROTECTION AND STORAGE. During construction, the insulation on all equipment shall be protected against absorption of moisture, and metallic components shall be protected against corrosion by strip heaters, lamps, or other suitable means. This protection shall be provided immediately upon receipt of the equipment and shall be maintained continuously.

PART 2 - PRODUCTS

Each building listed below shall be equipped with the security devices specified herein.

1. Operations Building

2. RO Building

3. Maintenance Building

4. Electrical Building

The following security devices shall be provided.

1. An intelligent single door controller for each building entrance door.
2. A card reader for each building entrance door and for the site main entrance gate.
3. A badge making machine with 50 cards.
4. A magnetic door switch for each building entrance door.
5. An electric door lock for each building entrance door.
6. An outdoor rated, IP camera with weather proof and tampered housing for each building entrance door and for the site main entrance gate. The IP cameras shall have zoom and night vision capacity.
7. Motion detectors for the Operations Building and Maintenance Building
8. An Ethernet switch.
9. A 19" freestanding rack located in the Operations Building.
10. A rack mounted UPS with 2 hours battery time for each location.
11. A Networked Video Recorder (NVR) to record all CCTV's video. NVR shall provide at the minimum 30 days storage of video.
12. A security computer with security software for controlling all the security devices. The security software shall allow the operator to set security clearance for different staff, set security zone, monitor and alarm any security events, provide CCTV image, and provide remote access for the operator to the system.

PART 3 - EXECUTION

3-1. INSTALLATION, TESTING, AND COMMISSIONING. All material, equipment, components, cables, conduits, and necessary accessories for complete security system shall be installed, configured, tested, and commissioned for operation by the Supplier.

3-2. CABLE AND CONDUIT INSTALLATION.

3-2.01. General. Except as otherwise specified or indicated on the Drawings, cable and conduit shall be installed according to the Electrical section 16050 of this Contract.

3-3. WIRING DEVICES, BOXES, AND FITTINGS INSTALLATION.

3-3.01. General. Except as otherwise specified or indicated on the Drawings, all security accessories shall be installed according to the Electrical section 16050 of this Contract.

3-4. EQUIPMENT INSTALLATION. Except as otherwise specified or indicated on the Drawings, equipment shall be installed according to the Electrical section 260511.

3-5. TRAINING. The Supplier shall provide training of the system to the Owner.

End of Section

Section 28 31 16

FIRE DETECTION AND ALARM SYSTEM

PART 1 – GENERAL

1-1. SCOPE. This section covers the design and the furnishing and installation of a fire detection and alarm system. All associated equipment, devices, and controls necessary for proper operation shall be included.

The design of the system shall consist of, but shall not be limited to, a determination of the applicable fire and safety codes; an analysis of the various plant ambient temperatures, noise levels and environments (wet, dusty, oily, corrosive, hazardous, etc.); the number and type of detectors, alarm indicators, and manual stations required; and the proper wiring and mounting configurations.

Peripheral components as specified shall be located as indicated on the Drawings and provided in sufficient number and located as needed to meet all applicable codes.

The fire alarm system supplier shall coordinate with the fire suppression system supplier and other mechanical supplier for monitoring of sprinkler system flow switches and anti-tampering switches, backflow preventer flow switches and anti-tampering switches, and other associated devices.

1-2. GENERAL. Supplier shall furnish all installation drawings, tools, equipment, materials, and supplies and shall perform all labor to complete the work as specified, and in compliance with the codes, standards, and regulations listed below.

1-2.01. Contractor's Qualifications. The system design, equipment, installation, and installation supervision furnished under this section shall be provided by a single manufacturer or supplier who shall be UL certified for fire alarm installation.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment furnished under this section. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence.

1-2.03. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.04. Governing Standards.

a. California State Fire Marshal's Regulations for Safety to Life from

Fire and Emergencies in Buildings and Structures, and General Fire Protection.

b. National Fire Protection Association, NFPA 45, 71, 72, 90A, and 101.

c. California Fire Code

City of Morro Bay Fire Department Regulations

d. Morro Bay City Electrical Code.

e. National Electrical Code, Article 760.

All fire alarm equipment and materials, devices, and assemblies shall be listed and/or labeled by Underwriters' Laboratories, Factory Mutual, or another accepted testing laboratory for the intended purpose where acceptable to the authority having jurisdiction. The equipment shall not be altered, installed, or modified in any way that would void the label or listing.

All control equipment shall have transient voltage protection devices in compliance with UL 864.

The system controls shall be UL listed for Power Limited Applications according to NEC 760. All circuits shall be marked in accordance with NEC 760.10.

1-2.05. Nameplates. Major components of equipment shall be identified with a permanently affixed nameplate bearing the manufacturer's name and address, and type or style and catalog number of the item.

1-2.06. Tags. Keys and locks shall be furnished with tags bearing stamped identification numbers. Cable and conduit runs, wiring circuits, and all spare parts supplied to maintain the system shall be furnished with hard phenolic or stainless steel tags.

1-2.07. Power Requirements. Power supply to the fire alarm control panel (FACP) will be 120 volts, 60 Hz, single phase.

The alarm system shall include an automatically recharged backup power supply with sufficient battery capacity to operate the entire system in the normal supervisory mode for 24 hours and then sound all alarms for 5 minutes. In the event of power failure, the system shall automatically transfer to the standby batteries.

All external circuits requiring system-operating power shall be suitable for 24 volt dc service and shall be individually fused at the control panel.

1-2.08. Spare Parts. Spare parts as specified below shall be supplied with the fire detection and alarm system. Spare parts shall be suitably packaged for

shipment.

Spare Parts	Quantity
[Smoke detectors and heat detectors	One of each type used]
[Manual pulls stations	One of each type used]
[Audiovisual alarms	One of each type used]

1-3. SUBMITTALS. Complete electrical wiring diagrams; assembly and installation drawings; detailed specifications; and data covering the materials used and the parts, devices, and other accessories forming a part of the equipment furnished shall be submitted in accordance with the Submittal Procedures section.

In addition to the submittals to Design-Builder, Supplier shall submit complete plans and information to the local fire department for review. Supplier shall provide signed and sealed plans by a registered engineer in the state of where required by local or state requirements. The equipment submittals shall include the following:

A complete description of all system components, including certification of listing by the required testing laboratory.
Complete sequence of operation for all functions of the system.
Complete system wiring diagram for all components and interfaces to equipment supplied under other sections.
Location drawings for all controls, alarm actuating devices, and audiovisual alarm signaling devices.
A listing of the manufacturer's representatives responsible for installation and service.
Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.
Operation and maintenance manuals.

1-4. SYSTEM DESCRIPTION. The fire alarm system shall be operated and monitored by multiple fire alarm control panels (FACPs), located in the following locations:

1. Operations Building – Main Fire Alarm Control Panel, 95-FIRE-LCP-0001
2. Maintenance Building – 96-FIRE-LCP-0001
3. RO/UV Building – 50-FIRE-LCP-0001, and
4. Electrical Building – 80-FIRE-LCP-0001

The main FACP shall be located in the Operation Building lobby. The system shall automatically initiate fire alarm signals whenever any manual or automatic fire detection device is placed in an alarm mode. The system shall transmit a signal to the municipal alarm connection through telephone line, HVAC systems,

the plant control system, and other plant systems as indicated in the activation sequence herein. The FACP shall annunciate and sound local alarms for detection device alarm conditions, system trouble, or circuit failure. Alarm signals shall be consistent throughout the building or site. The operation of any alarm initiating device shall cause audible and visual alarms to sound and to be displayed throughout the building by applicable codes. A key-accessible reset function shall reset the alarm system after alarm initiating conditions have been cleared.

The system functions shall include area detection, manual stations, duct smoke detection, sprinkler system monitoring, backflow preventer monitoring, and other fire related systems as required by codes.

The system shall automatically activate smoke detected audiovisual annunciation equipment whenever an area smoke detector or duct smoke detector is in alarm mode. The system shall identify the device and the location. For duct smoke detection, the system shall simultaneously provide an isolated alarm contact indication to the temperature control system to deactivate the HVAC systems as indicated in the HVAC sequence of operations on the Drawings.

1-4.01. Fire Alarm System.

a. Initiating device, notification device, and signaling line circuits shall be NFPA 72, 3-4, Class A. The system shall monitor incoming power and standby power. In addition to the FACP, the system shall include heat detectors, smoke detectors, audiovisual alarm units, end-of-line devices, manual pull stations wiring connections to devices, outlet boxes, junction boxes, and all other necessary equipment for a complete operating system.

b. System trouble, including grounded or open supervised circuit, power failure, system battery low voltage, or system failure, shall cause the system to enter a trouble mode and display visual and audible alarms. The visual alarm shall be displayed until the initiating trouble has been cleared.

1-4.02. Activation Sequence. The alarm sequence initiated by the activation of any manual station, automatic detection device, duct smoke detector, sprinkler flow switch/tamper switch, or backflow preventer flow switch/tamper switch shall be as follows:

a. Selected audible alarm indicating devices shall sound a march time code until silenced by the alarm silence switch at the FACP.

b. Selected visual alarm indicating devices shall display a continuous strobe pattern until the system is reset.

c. A supervised signal shall notify the local fire department or the central processing unit.

d. For duct smoke detection, the system shall simultaneously provide an isolated alarm contact indication to the temperature control system to deactivate the HVAC systems as indicated in the HVAC sequence of operations on the Drawings.

PART 2 - PRODUCTS

2-1. ACCEPTABLE MANUFACTURERS. All panels and peripheral devices shall be the standard products of a single manufacturer, and the manufacturer's name shall be displayed on each component. The system shall be manufactured by Bosch Security Systems; Gamewell-FCI; Notifier; Siemens Building Technologies; or Simplex Grinnell.

2-2. REMOTE SENSORS.

2-2.01. Fire Alarm Pull Stations. Addressable pull stations shall communicate the station's status (alarm, normal) over two wires that also supply power to the pull station. The address shall be set on each station. The stations shall be manufactured from high-impact red Lexan. Lettering shall be raised and painted white. When activated, the stations shall mechanically latch and remain latched until they are manually reset using a key common to all locks.

The location "address" of the pull stations shall be capable of field programming from the FACP over the signaling line circuit.

2-2.02. Smoke Detectors. Analog addressable smoke detectors shall be of the photoelectric type and shall communicate actual smoke chamber values to the system control panel. The sensors shall be solid-state, containing no radioactive material, and shall be capable of detecting up to seven sensitivity levels between 0.5 and 3.7 percent.

The sensors shall be plug-in units mounted on a twist-lock base. Smoke detector bases shall be common with the heat detector bases and shall be compatible with other addressable detectors and addressable manual stations on the same circuit. The detectors shall be suitable for both ceiling and wall mounting and shall have a 30-mesh insect screen. Detector bases shall contain a light emitting diode that will flash each time it is scanned by the control panel. When the sensor detects smoke or fails, the diode shall illuminate to indicate the abnormal condition. When required, detector bases shall be provided with a relay driver output that may be controlled either automatically or manually from the control panel.

Each detector shall contain a magnetically actuated test switch for alarm testing

at the sensor location.

Smoke detectors for installation in ducts shall be as specified above and shall be provided with auxiliary dpdt relays, remote LED alarm indicators, and key-operated test stations.

2-2.03. Heat Detectors. Addressable heat detectors shall be ambient compensated combination rate-of-rise and fixed temperature types. The fixed temperature operation of the sensor shall be selectable for either 117 or 135°F [47 or 57°C]. Rate-of-rise operation shall be selectable for either 15 or 20°F [8 or 11°C] per minute and shall be self-restorable.

The thermal type sensor shall be a plug-in unit that mounts on a twist-lock base. Bases shall be as described for smoke detectors.

2-2.04. Audiovisual Alarm Units. Alarm units shall consist of a horn and a Xenon flashtube installed in a surface or semi-flush wall- or ceiling-mounted enclosure. The horn shall have polarized connections with separate leads for in/out wiring for each leg of the associated signal circuit. Sound level shall be 90 dB at 10 feet [3 m].

The visual unit shall operate on 24 volts dc and shall have a white translucent pyramidal lens with the word "FIRE" imprinted in red lettering. The flash rate shall be 1 to 1.5 times per second.

2-2.05. Auxiliary Relays. Auxiliary relays shall be supplied where required. The relays shall be of high quality and shall be fitted with dusttight plastic covers. The contacts shall be at least 1/8 inch in diameter, of gold-plated silver cadmium oxide, rated for 5 amperes at 115 volts ac.

Auxiliary relays shall be provided in the RO building fire alarm panel to provide the following 2 alarms to the plant control system.

1. Fire alarm (Any fire alarms from the entire fire alarm system.)
2. Trouble alarm (Any trouble alarms from the entire fire alarm system.)

2-2.06. Addressable Input Modules. Each external dry contact input from sprinkler system flow switches, tamper switches, backflow preventer flow switches, tamper switches, and other required auxiliary inputs shall be equipped with addressable input modules designed to provide circuit monitoring and point identification of dry contact inputs.

2-3. PANELS.

2-3.01. Fire Alarm Control Panel. The control panel shall be an analog/addressable type fire alarm control panel. The panel enclosure shall be

constructed from steel, in compliance with UL 864, with front access door, and shall be surface wall-mounted.

The control panel shall be of modular construction, with solid-state, microprocessor-based electronics, and shall display only the primary controls and functions essential to operation during a fire alarm condition. Keyboards or keypads shall not be required to operate the system during fire alarm conditions. A local audible device shall sound during alarm, trouble, or supervisory conditions. The sound that identifies each condition shall be readily distinguishable without having to view the panel. The audible device shall also sound during each key press to indicate that the key has been pressed. The panel shall be fully field programmable from the keypad and capable of downloadable programming from a Windows-based application program. The panel shall include self programming logic capable of automatically programming new addressable field initiating devices.

The following primary controls shall be visible through a front access panel:

Eighty-character liquid crystal display, backlit.

Red system alarm LED.

Yellow supervisory service LED.

Yellow trouble LED.

Green "power on" LED.

Alarm acknowledge key.

Supervisory acknowledge key.

Trouble acknowledge key.

Alarm system key.

System reset key.

Manual evacuation (drill).

The control panel shall include the following functions:

Setting of time and date.

LED testing.

Listing of alarm, trouble, and abnormal conditions.

Separate enabling and disabling of each monitor point.

Separate activation and deactivation of each control point.

Changing operator access levels.

Walk-test enable.

Running diagnostic functions.

Displaying software revision level.

Displaying historical logs.

Displaying card status.

Point listing.

The following lists from the points list menu shall be available for maintenance purposes:

All points by address.

Monitor points.

Auxiliary controls.

Feedback points.

Pseudo points.

LED/switch status.

Scrolling through menu options or lists shall proceed in a self-directing manner, guided by prompting messages. The controls for the points list menu shall be located behind an access door.

The control panel shall contain a back lighted 2 line by 40 character liquid crystal display. To conserve standby battery power in the event of an ac power failure, the display shall be lit only during keypad activity.

The display shall consist of both upper case and lower case letters. Lower case letters shall be used for soft key titles and for prompting the user. Upper case letters shall be used for system status information. A cursor shall be visible when information is being entered.

All wiring shall be brought to terminal strips for field connections.

2-3.01.01. Front Panel Operation and Capabilities. Under normal conditions, the front panel shall display a "SYSTEM IS NORMAL" message and the current time and date.

Should an abnormal condition be detected, the appropriate alarm, supervisory, or trouble LED shall flash. The audible signal shall pulse for alarm conditions and sound steady for trouble or supervisory conditions.

The LCD shall display the following information pertaining to the abnormal condition:

Location label (40 characters available).

Type of alarm device - smoke detector, pull station, and water flow sensor.

Point status - alarm, trouble.

Buttons shall be provided to acknowledge alarm conditions and to silence audible alarms in compliance with NFPA 72.

2-3.01.02. Alarm Silencing. When the "ALARM SILENCE" button is pressed, all alarm signals shall cease. Alarm signals shall not be silenced during "alarm silence inhibit" mode.

2-3.01.03. System Reset. Using the "SYSTEM RESET" button shall restore the system to its normal state after an alarm condition has been remedied.

The LCD display shall step the user through the resetting procedure with simple printed messages.

2-3.01.04. Device Status. Complete status of all addressable field devices shall be available through use of the operator keypad and front panel display.

2-3.01.05. History Logging. The system shall be capable of logging and storing 500 alarm, trouble, and operation events in a history log. These events shall be stored in a battery-protected random access memory. Each recorded event shall include the time and date of the occurrence.

2-3.01.06. Silent Walk Test with History Logging. The system shall be capable of being tested by one person. While in testing mode, the alarm activation of an initiating device circuit shall be silently logged as an alarm condition in the historical data file. After logging the alarm, the panel shall automatically reset.

The momentary disconnection of an initiating or indicating device circuit shall be silently logged in the historical data file as a trouble condition. After logging the trouble condition, the panel shall automatically reset.

Should the walk test feature be on for an inappropriate length of time, it shall automatically revert to the normal mode.

The control panel shall be capable of supporting up to eight separate testing groups, one of which may be in a testing mode while the other (nontesting) groups may be active and operating as normally programmed. After testing is completed, testing data may be retrieved from the system in chronological order to ensure device/circuit activation.

Should an alarm condition occur from an active point that is not in walk test mode; it shall initiate the normal alarm sequence.

2-3.01.07. LED Supervision. All LEDs shall be supervised for burnout or disarrangement. Should a problem occur, the LCD shall display the location numbers of the module and the LED to facilitate location of the affected LED.

2-3.01.08. System Trouble Reminder. In the event of a trouble condition within the system, with the audible signal silenced, the trouble signal shall resound at 24 hour intervals as a reminder that the fire alarm system is not 100 percent operational. Both the time interval and the trouble reminder signal shall be programmable to adapt to the application.

2-3.01.09. Operator Access Levels. Operator access to system functions shall be limited by a key switch and multiple levels of password protection.

The following functions shall be protected:

Alarm Silence.

System Reset.

Set Time/Date.

Manual Control.

On/Off/Auto Control.

Disable/Enable.

Clear Historical Alarm Log.

Clear Historical Trouble Log.

Walk Test.

Change Alarm Verification.

Acknowledge keys shall also require privileged access to acknowledge points. If the operator presses an acknowledge key with insufficient access, an error message will be displayed. The points shall scroll with acknowledge key presses to view the points on the list, but the points will not be acknowledged in the database.

2-3.01.10. Wiring. Intermodule wiring for common system functions shall be installed in a supervised cable bus. Disarrangement of the bus shall cause a distinctive "Cable Supervisory" LED to be illuminated in addition to activating the common trouble indicators.

Detector and signal circuits and wiring may be nonpower-limited type and shall comply with the applicable articles of the NEC.

2-3.02. Enclosures. A cabinet of sufficient size shall be provided to accommodate all equipment required. The door of the cabinet shall be equipped with locks and a continuous hinge, providing protection from tampering, yet

allowing full view of the various lights and controls. Indoor enclosures shall be of a NEMA type suitable for the area designation. Outdoor NEMA Type 4X enclosures shall be stainless steel.

2-4. CABLE AND RACEWAYS.

2-4.01. Cable. Cable used in the fire alarm system shall be multi-conductor cable, at least 18 AWG size, specifically designed for industrial fire alarm systems and UL listed for indoor/outdoor installations. All cable required for the system shall be furnished by the Supplier.

2-4.02. Raceways. All cable shall be installed in conduit furnished under this section. All conduit shall conform to the applicable paragraphs of the Electrical section.

PART 3 - EXECUTION

3-1. GENERAL. All work shall be installed as indicated on the Drawings, and in accordance with the manufacturer's diagrams and recommendations, except where otherwise indicated.

All junction boxes furnished hereunder shall be painted red and permanently labeled "FIRE ALARM". A consistent wiring color code shall be maintained throughout the installation.

Installation of equipment and devices that connect to equipment furnished under other sections, or furnished by the Owner, shall be closely coordinated with the suppliers of the equipment and with Owner.

After completion of the installation, Contractor shall clean the inside and the outside of the fire alarm equipment and shall remove all dirt and debris from the site.

3-1.01. Cable. Cable shall be installed as described in the cable installation paragraphs in the Electrical section. The system conductors shall be installed in conduits or junction boxes separate from conductors of other systems. Conduit fill shall meet applicable NEC requirements.

All wiring going to the fire alarm control panels except the power feed cable and the communication cables shall be furnished and installed by the Supplier.

The power feed cables, communication cables between the fire alarm control panels, the control cables between the RO building fire alarm panel and the plant PLC, and the telephone line for the main fire alarm control panel in Operations

Building will be by others.

3-1.02. Raceways. Conduit shall be installed as described in the conduit installation paragraphs in the Electrical section.

3-1.03. Testing. Supplier shall notify Design-Builder at least 30 days before the performance and acceptance tests are to be conducted. The tests shall be performed in the presence of Design-Builder and Local Fire Marshal. The Supplier shall furnish all instruments and personnel required for the tests. A complete test report and letter of completion shall be submitted to Design-Builder. The tests shall be performed by, or under the supervision of, a qualified representative of the fire alarm system manufacturer and shall include the following:

a. Verify that the system is free of grounds or open circuits. The FACP shall indicate when a ground or an open circuit exists.

b. Verify that all alarm signal devices, stations, transmitters, automatic detectors, and supervisory devices are functioning as specified.

c. Test each fire alarm device and circuit. Individually activate each manual initiating station and verify correct alarm operation and control panel response. Individually test each automatic initiating device and verify correct alarm operation, control panel response, and remote equipment operation.

d. Test battery backup systems for specified capacity.

e. Repeat test to verify correction of any defect found in the initial testing.

3-2. TRAINING. The manufacturer's representative shall provide training of Owner's personnel as described in the Demonstration and Training specification.

End of Section

Section 31 23 11

EXCAVATION AND FILL FOR STRUCTURES

PART 1 - GENERAL

1-1. SCOPE. This section covers earthwork and shall include the necessary clearing, grubbing, and preparation of the site; removal and disposal of all debris; excavation; handling, storage, transportation, and disposal of all excavated material; all necessary temporary earth retention and other protection work; preparation of subgrades; pumping and dewatering as necessary; protection of adjacent property; backfilling; construction of fills and embankments; grading; and other appurtenant work.

1-2. GENERAL. With reference to the terms and conditions of the construction standards for excavations set forth in OSHA "Safety and Health Regulations for Construction", Chapter XVII of Title 29, CFR, Part 1926, Design-Builder shall employ a competent person and, when necessary based on the regulations, a licensed professional engineer in the state where the earthwork is located, to act upon all pertinent matters of the work of this section.

1-3. SUBMITTALS. Drawings, specifications, and data covering the proposed materials shall be submitted in accordance with the Submittals Procedures section.

1-3.01. Temporary Excavation Design Certificate. Before starting construction on the temporary excavation and in accordance with OSHA requirements enumerated above, the Design-Builder shall ensure that the temporary excavation design engineer shall complete the Temporary Excavation Design Certificate , Figure 1-31 23 11 and shall use the temporary excavation design. If required by the OSHA requirements enumerated above or to protect existing facilities, the Design-Builder is responsible for ensuring that a separate certificate shall be submitted for each unique design. Refer to paragraph in this specification titled, “Temporary Excavations.”

1-3.02. Filter Fabric Data. Complete descriptive and engineering data for the fabric shall be submitted in accordance with the Submittals Procedures section. Data submitted shall include:

A 12 inch square sample of fabric.

Manufacturer's descriptive product data.

Installation instructions.

1-3.03 Test Results for Review of Materials. Complete test results for tests performed on fill and backfill, and other material specified herein, by an independent commercial laboratory retained by the Design-Builder, as described in the paragraph titled, “Review of Materials”.

1-3.04 CLSM Mix Design. Mix design by in independent commercial laboratory retained by the Design-Builder.

PART 2 - PRODUCTS

2-1. MATERIALS.

2-1.01. Filter Fabric. Filter fabric shall be provided in rolls wrapped with covering for protection from mud, dirt, dust, and debris.

2-1.01.01. Filter Fabric Type A. Filter fabric Type A shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter fabric Type A shall be a non-woven fabric consisting of only continuous chains of polypropylene filaments or yarns of polyester formed into a stable network by needle punching. The fabric shall be inert to commonly encountered chemicals; shall be resistant to mildew, rot, ultraviolet light, insects, and rodents; and shall have the indicated properties:

Property	Test Method	Unit	Min Roll Value*
Grab Strength	ASTM D4632	lbs	160
Grab Elongation	ASTM D4632	percent	50
CBR Puncture Strength	ASTM D6241	lbs	410
Trapezoidal Tear	ASTM D4533	lbs	60
UV Resistance at 500 hours	ASTM D4355	% Strength Retained	70

*Minimum average roll value in weakest principal direction.

The apparent opening size (diameter) for the filter fabric Type A shall be no larger than the U.S. Standard Sieve Size 70 per ASTM D4751.

2-1.01.02. Filter Fabric Type B. Filter fabric Type B shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter fabric Type B shall be a non-woven fabric consisting of only continuous chains of polypropylene filaments or yarns of polyester formed into a stable network by needle punching. The fabric shall be inert to commonly encountered chemicals; shall be resistant to mildew, rot, ultraviolet light, insects, and rodents, and shall have the indicated properties:

Property	Test Method	Unit	Min Roll Value*
Grab Strength	ASTM D4632	lbs	250
Grab Elongation	ASTM D4632	Percent	50

Property	Test Method	Unit	Min Roll Value*
CBR Puncture Strength	ASTM D6241	lbs	700
Trapezoidal Tear	ASTM D4533	lbs	100
UV Resistance at 500 hours	ASTM D4355	% Strength Retained	100

*Minimum average roll value in weakest principal direction.

The apparent opening size (diameter) for the filter fabric Type B shall be no larger than the U.S. Standard Sieve Size 70 per ASTM D4751.

2-1.01.03. Filter Fabric Type C.
Filter fabric Type C shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter fabric Type C shall be a woven fabric, TenCate Mirafi RS380*i*, or equal.

2-1.02. Polyethylene Film. Polyethylene film beneath concrete slabs or slab base course material shall comply with requirements of ASTM D4397, 6 mil minimum thickness.

2-1.03. Fill and Embankment Materials. To the maximum extent available, excess suitable material obtained from structure and trench excavation shall be used for the construction of site fills and embankments. Additional material shall be provided from Design-Builder's offsite source.
All material placed in fills and embankments shall be free from rocks or stones larger than 3 inches in their greatest dimension, brush, stumps, logs, roots, debris, and other organic or deleterious materials. No rocks or stones shall be placed in the upper 18 inches of any fill or embankment. Rocks or stones within the allowable size limit may be incorporated in the remainder of fills and embankments, provided they are distributed so that they do not interfere with proper compaction.

2-1.04. Granular Fill. Granular fill material shall be crushed rock or gravel suitable for use as a free draining subbase beneath slabs and foundations. Granular fill shall be free from dust, clay, and trash; hard, durable, non-friable; and shall be graded 3/4 inch to No. 4 as defined in ASTM C33 for No. 67 coarse aggregate. Granular fill shall meet the quality requirements for ASTM C33 coarse aggregate. The edges of granular fill shall be confined, either by placing against an excavation face or other fill.

2-1.05. Structure Backfill. Structure backfill shall be defined as the material placed around and outside of structures. For structures constructed in open excavations, structure backfill shall extend to the temporary excavation slope so that the entire excavation outside the structure shall be filled with structure

backfill. For structures constructed in supported excavations, the structure backfill shall completely fill the space between structure and temporary earth retention, or between structure and excavation face, if these specifications permit removal of the system. Structure backfill shall meet the requirements of the previous paragraph entitled "Fill and Embankment Materials", unless the Drawings indicate crushed rock or clean sand structure backfill is to be used.

2-1.05.01. Crushed Rock Structure Backfill. Crushed rock for structure backfill shall meet the following gradation requirements:

Size	Percent Passing
1/2 inch	100
3/8 inch	90 – 100
No. 4	30 – 60
No. 8	0 – 10
No. 200	0 - 5

2-1.05.02. Clean Sand Structure Backfill. Clean sand for structure backfill shall meet the following gradation requirements:

Size	Percent Passing
3/8 inch	100
No. 4	95 – 100
No. 8	75 – 90
No. 30	30 – 50
No. 100	2 – 10
No. 200	0 - 5

2-1.06. Select Fill. Select fill shall be defined as the material placed beneath the structure foundations and slabs below any granular material layer or lean concrete slab indicated on the Drawings. Select fill shall be used to replace any unsuitable material below the structure foundations and slabs and to raise the site grades below and within 5 feet horizontally(unless a different dimension is otherwise indicated on the Drawings or specified) of structural footprints and at locations indicated on the Drawings. Select fill shall meet the requirements of the previous paragraph entitled "Fill and Embankment Materials", unless the Drawings indicate crushed rock or clean sand select fill is to be used.

2-1.06.01. Crushed Rock Select Fill. Crushed rock for select fill shall meet the following gradation requirements:

Size	Percent Passing
1/2 inch	100

Size	Percent Passing
3/8 inch	90 – 100
No. 4	30 - 60
No. 8	0 - 10
No. 200	0 - 5

2-1.06.02. Clean Sand Select Fill. Clean sand for select fill shall meet the following gradation requirements:

Size	Percent Passing
3/8 inch	100
No. 4	95 – 100
No. 8	75 – 90
No. 30	30 – 50
No. 100	2 – 10
No. 200	0 - 5

2-1.07. Gravel Base Beneath Slabs. "Gravel Base Beneath Slabs" is defined as material to be placed directly beneath building floor slabs as shown on the Drawings. The material shall meet the quality requirements specified for ASTM C33 concrete coarse aggregate and shall be graded No. 7 coarse aggregate.

2-1.08. Controlled Low Strength Material (CLSM). CLSM shall consist of a mixture of Portland cement, fly ash, sand, and water and shall be placed at locations indicated on the Drawings or as directed by. The class of CLSM shall be as specified below.

The type of cement in CLSM shall be ASTM C150 Type I. The class of fly ash in CLSM shall be ASTM C618 Class C, except loss on ignition shall not exceed 4 percent. Fine aggregate in CLSM shall be clean natural sand, ASTM C33, except that clay particles shall not exceed one percent. Water in CLSM shall be potable.

Design-Builder shall design and test the CLSM. The mix design shall be such as to ensure that the CLSM hardens sufficiently to support the weight of an average person in one to four hours after placement and support equipment weight in 24 hours. The mixture shall be designed such that when tested in the field with the Kelly Ball apparatus per ASTM D6024, the maximum depression diameter shall be 3 inches. CLSM shall be self-leveling and shall have an average patty diameter from 8 to 12 inches when the flow is measured in accordance with ASTM D6103.

If a change in sources of materials is proposed, a new mix design shall be developed by Design-Builder before the new material is used. When unsatisfactory results or other conditions make it necessary, Design-Builder shall develop a new mix design to get the desired results.

2-1.08.01. Class A CLSM. The initial trial mixture for Class A CLSM shall consist of the following minimum proportions per cubic yard to provide minimum compressive strength listed below:

Cement	50 lbs
Fly Ash	250 lbs
Sand (SSD)	2860 lbs
Water	370 lbs
Air Entraining admixture	6 percent
Minimum compressive strength at 28 days	130 psi

2-1.08.02. Class B CLSM. The initial trial mixture for Class B CLSM shall consist of the following minimum proportions per cubic yard to provide minimum compressive strength listed below:

Cement	100 lbs
Fly Ash	100 lbs
Sand (SSD)	2760 lbs
Water	386 lbs
Air Entraining admixture	5 percent
Minimum compressive strength at 28 days	200 psi

2-1.08.03. Class C CLSM. The initial trial mixture for Class C CLSM shall consist of the following minimum proportions per cubic yard to provide minimum compressive strength listed below:

Cement	80 lbs
Fly Ash	275 lbs
Sand (SSD)	2795 lbs
Water	370 lbs
Air Entraining Agent	4 percent
Minimum compressive strength at 28 days	370 psi

2-1.09. Geocomposite Sheet Drains. The geocomposite sheet drains shall consist of a continuous plastic three dimensional drainage core wrapped on one side in a non-woven filter fabric permeable to water flow. The filter fabric shall be bonded to the individual dimples of the molded plastic core to minimize fabric intrusion into the flow channels caused by the backfill pressure. The fabric shall extend beyond the edges of the core to provide overlap for the adjacent panels. The geocomposite sheet drain shall be CCW-MIRADRAIN 6000XL as manufactured by CARLISLE, or SITEDRAIN Sheet 186 as manufactured by American Wick Drain Corporation, or equal.

2-2. MATERIAL TESTING.

2-2.01. Review of Materials. All tests required for preliminary review of materials and materials delivered to the Site shall be made by an acceptable independent testing laboratory. Tests performed by the aggregate supplier are not acceptable. Tests shall have been performed within 2 months of submittal and shall be representative of the material that will be delivered to the Site. Acquisition of samples for testing, both for preliminary review of materials and for testing of materials at the Site, shall be by the Design-Builder'sindependent testing laboratory. Samples acquired at the Site shall be obtained after placement and compaction of the material. Aggregate material shall be sampled in accordance with ASTM D75.

Two initial gradation tests shall be made for each type of general fill, select fill, structure backfill, granular fill, or other specified material, and one additional gradation test shall be made for each additional 500 tons of each material delivered (imported) to the jobsite or suitable onsite material incorporated in select fill or structure backfill. One additional gradation test shall be performed for each additional 2,000 tons of general fill material delivered to the jobsite or suitable onsite material incorporated in general fill. In addition, one set of initial Atterberg Limits test shall be made for each fill material containing more than 20 percent by weight pass the No. 200 sieve and for materials specified by Atterberg Limits. One additional Atterberg Limits test shall be made for each additional 500 tons of each material delivered to the job site or otherwise incorporated in select fill or structure backfill. One additional Atterberg Limits test shall be made for each additional 2,000 tons of general fill material delivered to the jobsite or suitable onsite material incorporated in general fill.

All material testing on CLSM shall be made by an independent testing laboratory at the expense of Design-Builder.

2-2.02. Field Testing Expense. All moisture-density (Proctor) tests and relative density tests on the materials, and all in-place field density tests, shall be made by an independent testing laboratory at the expense of Owner. Design-Builder shall provide access to the materials and work area and shall assist the laboratory as needed in obtaining representative samples.

2-2.03. Required Field Tests. For planning purposes, the Owner's testing laboratory will use the following general guidelines for frequency of field tests. Additional tests will be performed as necessary for job conditions and number of failed tests.

For area fills and embankments, an in-place field density and moisture test for each 1000 cubic yards of material placed.

One in-place field density and moisture test for every 100 to 200 cubic yards of structure backfill or select fill.

One in-place density and moisture test whenever there is a suspicion of a change in the quality of moisture control or effectiveness of compaction.

At least one test for every full shift of compaction operations on mass earthwork.

Testing of CLSM will be as follows.

Compressive Strength. For every 200 cubic yard of CLSM placed, prepare, cure, remove from molds, and test four 6 by 12 inch test cylinders in accordance with ASTM D4832. Cure cylinders in the molds in accordance with ASTM D4832 until time of testing, at least 14 days. Two cylinders will be tested at 7 days and the other two cylinders will be tested at 28 days.

Flow. Once each day, the CLSM material will be tested for flow in accordance with ASTM D6103.

Unit Weight, Yield, and Air Content. Once each day that flowable fill is placed, unit weight, yield and air content will be determined in accordance with ASTM D6023.

Penetration. Once a day that CLSM is placed, the resistance to penetration from ball-drop apparatus (Kelly Ball) will be measured in accordance with ASTM D6103. (Compliance will be based on maximum depression diameter of 3 inches.)

PART 3 - EXECUTION

3-1. SITE PREPARATION. All sites to be occupied by permanent construction or embankments shall be cleared of all logs, trees, roots, brush, tree trimmings, and other objectionable materials and debris. All stumps shall be grubbed. Subgrades for fills and embankments and sites to be occupied by permanent construction shall be cleaned and stripped of all surface vegetation, sod, and organic topsoil. All waste materials shall be removed from the site and disposed of by and at the expense of Design-Builder.

3-2. EXCAVATION.

3-2.01. General. Permanent excavations shall conform to the lines and grades indicated on the Drawings. Temporary excavations shall provide adequate working space and clearances for the work to be performed therein and for installation and removal of concrete forms. In no case shall excavation faces be undercut for extended footings.

Subgrade surfaces shall be clean and free of loose material of any kind when concrete is placed thereon.

3-2.02. Temporary Excavations. Except where excavation side slopes are cut to a stable slope, excavations for structures and trenches shall be supported as necessary to prevent caving or sliding. Temporary earth retention systems shall be furnished and installed as necessary to limit the extent of excavations for the deeper structures and necessary backfill under adjacent shallower structures, and to protect adjacent structures and facilities from damage due to excavation and subsequent construction.

Design of excavations by a professional engineer retained by Design-Builder is required when necessary to protect adjacent existing facilities, or when design by an engineer is required by the OSHA regulations cited herein. The Design-Builder's professional engineer shall be licensed in the state of the Project and is responsible for design of entire excavation (both the sloping and supported portions of the excavation). The design of temporary earth retention shall comply with the paragraph of this specification titled, "Temporary Earth Retention."

Before starting construction on a temporary excavation requiring design by a professional engineer in compliance with requirements of this specification (to protect existing structures, utilities, and other facilities), the Design-Builder shall ensure that the temporary excavation design engineer shall complete the Temporary Excavation Design Certificate (Figure 1 – 02200) and the Design-builder shall submit the certificate along with proof of professional liability insurance for the temporary excavation designer. The Design-builder shall use the temporary excavation design and shall submit a separate certificate for each unique design.

3-2.03. Classification of Excavated Materials. No classification of excavated materials will be made for payment purposes. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition, or condition thereof.

3-2.04. Preservation of Trees. No trees shall be removed outside excavated or filled areas, unless their removal is authorized by Owner. Trees left standing shall be adequately protected from damage by construction operations.

3-2.05. Unauthorized Excavation. Not applicable.

3-2.06. Blasting. Not used.

3-2.07. Dewatering. Dewatering equipment shall be provided to remove and dispose of all surface water and groundwater and all water, regardless of the source, entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the structure to be built, or the pipe to be installed therein, is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result.
All excavations for concrete structures or trenches which extend down to or below groundwater shall be dewatered by lowering and keeping the groundwater level to the minimum depth of 24 inches [600 mm] beneath such excavations. The specified dewatering depth shall be maintained below the prevailing bottom of excavation at all times.

Surface water shall be diverted or otherwise prevented from entering excavations or trenches to the greatest extent possible without causing damage to adjacent property.

Design-Builder shall be responsible for the condition of any pipe or conduit used for drainage purposes, and all such pipe or conduit shall be left clean and free of sediment.
3-2.08. Temporary Earth Retention. Temporary excavations shall be supported with temporary earth retention systems when excavation side slopes cannot be excavated to a stable slope.

If the soldier pile and lagging method is used for temporary earth retention, the soldier piles shall be installed by drilling. The lagging shall be seasoned hardwood, with maximum board width (vertical height) of 12 inches. The lagging boards shall be installed from the top down as the excavation advances.

The use of the following devices or systems are prohibited for use as temporary earth retention systems when the retention system is required to limit ground movement to protect structures, utilities, and other adjacent facilities.

1. soldier piles with plate lagging
2. slide rail systems
3. trench shields i.e. trench boxes (trench shields are considered worker protection only, not temporary earth retention systems)

The above prohibition does not prevent Design-builder from using soldier piles with plate lagging, slide rail systems, and trench shields to protect workers in an excavation.

Excavation support systems and sheeting and shoring shall be removed unless specifically otherwise permitted by Structural Engineer of Record.

Unless the excavation support is required to be left in place the design of the excavation support system shall be such as to permit complete removal while maintaining safety and stability in the excavation at all times. Excavation support systems to be left in place shall be designed and constructed of only steel. Excavation support elements left in place, shall be cut off 24 inches minimum below the finish grade indicated on the Drawings.3-2.09. Foundation Subgrade Preparation. Subgrades for foundations shall be prepared using the same procedure as required for fills and embankments. After preparation, foundation subgrades shall be firm, dense, and thoroughly compacted and consolidated; and shall be sufficiently stable to remain firm and intact under the feet of the workers. Reinforcing steel and concrete shall be placed as soon as possible after subgrade preparation. Subgrades that are disturbed due to weather or other conditions shall be repaired by removing the disturbed material and replacing with crushed rock select fill. Subgrade surfaces shall be clean and free of loose material of any kind when concrete is placed thereon.

3-2.10. Ring-wall Excavation. All surface vegetation, sod, and organic topsoil shall be removed beneath and within ring-wall foundations.

3-2.11. Roadway Excavation. Excavation for the roadways, drives, and parking areas shall conform to the lines, grades, cross sections, and dimensions indicated on the Drawings and shall include the excavation of all unsuitable material from the subgrade. After shaping to line, grade, and cross section, the subgrade shall be compacted to a depth of at least 6 inches and shall meet the following:

Test method to determine maximum density and moisture.	ASTM D698.
Relative compaction and moisture content relative to the optimum.	95%.
Moisture content relative to the optimum.	-2% to +2%.

This operation shall include any reshaping and wetting or drying required to obtain proper compaction. All soft or otherwise unsuitable material shall be removed and replaced with suitable material.

3-3. FILLS AND EMBANKMENTS. Fills and embankments shall be constructed to the lines and grades indicated on the Drawings. Fills and backfills placed beneath and around structures shall comply with the requirements of this specification for select fill and structure backfill, respectively. Construction of fills and embankments shall begin from the lowest elevation in each excavation or area and progress upward. Materials shall be deposited in approximately

horizontal layers not to exceed 8 inches in uncompacted thickness. Unless otherwise specified herein, the following governing standards apply:

Test method to determine maximum density and moisture.	ASTM D698.
Relative compaction.	95%.
Moisture content relative to the optimum.	-2% to +2%.

Where new fill is placed adjacent to an existing sloping surface steeper than 5 horizontal to 1 vertical, the existing slope shall be benched in advance of placement of new fill. The bench shall be of sufficient width to allow compaction of the junction between the new fill and existing earth surface.

Backfilling of excavations and construction of fills and embankments during freezing weather shall not be done. No backfill, fill, or embankment materials shall be installed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill, fill, or embankment.

3-3.01. Subgrade Preparation. After preparation of the fill or embankment site, the subgrade shall be scarified and moisture conditioned to a minimum depth of 6 inches, leveled and compacted to the same relative compaction and moisture content relative to optimum as specified for fill.

Unless otherwise directed by Design-Builder, the subgrade shall be proof-rolled by a rubber-tired roller, a loaded dump truck, or other suitable rubber-tired equipment acceptable to Design-Builder. A minimum of four passes of the proof-rolling equipment shall be provided such that the last two passes are made perpendicular to the first two passes.

All soft, yielding, or otherwise unsuitable material shall be removed and replaced with compacted fill.

3-3.02. Placement and Compaction. All fill and embankment materials shall be placed in approximately horizontal layers not to exceed 8 inches in un-compacted thickness. Material deposited in piles or windrows by excavating and hauling equipment shall be spread and leveled before compaction.

Each layer of material shall have the best practicable moisture content for satisfactory compaction. The material in each layer shall be wetted or dried to achieve the moisture content relative to optimum as specified above, and shall be thoroughly mixed to ensure uniform moisture content and adequate compaction. Each layer shall be thoroughly compacted to the required degree of compaction at the required moisture content. If the material fails to meet the density specified, compaction methods shall be altered. The changes in compaction methods shall include, but not be limited to, changes in compaction

equipment, reduction in uncompacted lift thickness, increase in number of passes, and better moisture control.

Wherever a pipe is to installed within a fill or embankment, the fill or embankment material shall be placed and compacted to an elevation not less than 12 inches above the top of pipe elevation before the trench for pipe installation is excavated.

3-3.03. Borrow Pits. Suitable material necessary to complete fills and embankments may be excavated from borrow pits indicated on the Drawings and hauled to the site of the work. The size, shape, depth, drainage, and surfacing of all borrow pits shall be acceptable to Design-Builder. Borrow pits shall be regular in shape, with graded and surfaced side and bottom slopes, when completed. Side slopes of borrow pits shall be not steeper than 3 horizontal to 1 vertical and shall be uniform for the entire length of any one side.

3-4. FILL AND BACKFILL FOR STRUCTURES. Earth and aggregate materials placed for structures include granular fill, structure backfill, select fill, gravel base beneath slabs, and controlled low strength material In addition to the specific requirements specified herein, all requirements for placement of fills and embankments shall apply to granular fill, structure backfill, select fill, and gravel base beneath slabs. These requirements include, but are not limited to subgrade preparation, lift thickness, and moisture conditioning requirements. All fills and backfills for structures shall be constructed to the lines and grades indicated on the Drawings. Backfilling and construction of fills during freezing weather shall not be done. No backfill, fill, or embankment materials shall be installed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill, fill, or embankment.

3-4.01. Granular Fill. Granular fills shall be provided where indicated on the Drawings. Granular fills shall be placed on suitably prepared sub-grades in uncompacted lift thickness of 6 inches or less and compacted by vibration. Granular fills shall be compacted to not less than 70 percent relative density as determined by ASTM D4253 and D4254. If the thickness of the granular fill is less than 6 inches, the compaction shall be by a minimum four passes (round trips) of a self-propelled or walk-behind type vibratory roller operating in full vibration mode in accordance with manufacturer's instructions.

Where granular fills are to be covered with concrete, the top surface shall be graded to the required sub-grade elevation. The completed fill shall be covered by polyethylene film.

3-4.02. Structure Backfill. Backfill materials shall be deposited in approximately horizontal layers not to exceed 8 inches in uncompacted thickness and shall meet the following requirements:

Test method to determine maximum density and moisture.	ASTM D698.

Relative compaction.	95%.
Moisture content relative to the optimum.	-2% to +2%.

Compaction of structure backfill shall be performed in such a manner that damage to the structure is prevented. The compaction equipment used within 8 feet of the walls and for the top 8 feet of backfill shall be the static type. Limit of equipment weight shall be 1 ton. Compaction of structure backfill by inundation with water will not be permitted.

No backfill shall be deposited or compacted in water.

Care shall be taken to compact structure backfill which will be beneath pipes, drives, roads, parking areas, walks, curbs, gutters, or other surface construction or structures. In addition, wherever a pipe is to be installed within structure backfill, the structure backfill shall be placed and compacted to an elevation not less than 12 inches above the top of pipe before the trench for pipe installation is excavated. Compacted areas, in each case, shall be adequate to support the item to be constructed or placed thereon.

3-4.03 Select Fill. Select fill shall be placed in approximately horizontal layers in uncompacted lift thickness of 8 inches or less and shall meet the following requirements:

Test method to determine maximum density and moisture.	ASTM D698.
Relative compaction.	95%.
Moisture content relative to the optimum.	-2% to +2%.

3-4.04. Gravel Base Beneath Slabs. The gravel base beneath building floor slabs shall be placed in uncompacted lift thickness of 6 inches or less and compacted with a minimum of four passes (round trips) of a self-propelled or walk-behind type vibrating roller. The roller shall be operated in the full vibrating mode and in accordance with the manufacturer's instructions.

3-4.05. Controlled Low Strength Material (CLSM) Fill. CLSM shall not be placed on frozen ground. Batching, mixing, and placing of CLSM may be started when weather conditions are favorable and when the temperature is at least 34°F and rising. At time of placement of CLSM the temperature shall be at least 40°F. Mixing and placing shall stop when the temperature is 38°F and falling. Each filling stage shall be as continuous an operation as is practicable.

CLSM shall be discharged from the mixer by an acceptable procedure into the area to be filled. CLSM shall be placed to limits indicated on the Drawings. Mixing CLSM with in-situ soil shall be avoided.

When CLSM is placed as backfill against structures, the fill shall be placed in lifts of 2 to 3 feet and the next lift shall not be placed until the previous lift can support the weight of workers without indenting the surface and at least 16 hours have elapsed from the end of placement. Lift thickness shall be reduced as necessary to prevent floatation of the structure.

When CLSM is placed over culverts or pipelines, they shall be anchored to prevent flotation during the placement of CLSM. Unless otherwise required, CLSM shall be placed to one foot below the finished grade elevation if the finished grade elevation is not more than 5 feet over the top of the culvert or pipe. If the finished grade is more than 5 feet over the top of the culvert or pipe, CLSM shall be placed to an elevation 2 feet over the top of the culvert or pipe, and the remainder shall be backfilled with the specified backfill or as indicated on the Drawings.

3-4.06. Ringwall Fill. Fill within ringwall foundations shall be granular fill and shall be placed and compacted as indicated on the Drawings and as specified herein. If no treated sand layer is required directly beneath the tank bottom, the fill shall be sloped or crowned up to the center of the tank or reservoir as indicated on the Drawings. If a treated sand layer is required, the fill shall be finished to true grade in preparation for the treated sand layer.

3-5. FILTER FABRIC INSTALLATION. Filter fabric shall be placed as specified herein and at the locations specified or otherwise indicated on the Drawings.

Filter fabric shall be protected from contamination by foreign material and damage. Any contaminated or damaged filter fabric shall be replaced with new filter fabric at no additional cost to the Owner. The fabric shall be covered within 7 calendar days after placement.

The subgrade for placement of filter fabric shall be smooth and free of irregularities and undulations. Filter fabric shall be laid smooth and free of tension, stress, folds, wrinkles, or creases. Type A and B filter fabric shall be overlapped a minimum of 2 feet between adjacent roll ends and adjacent strips.

The joints of Type C filter fabric shall be sewn unless otherwise recommended by the manufacturer for the specific application. All seams shall be formed by mating the edges of the filter fabric panels and sewing them together with continuous stitches located a minimum of three inches from the edges. The thread shall be ultraviolet light resistant and manufactured from the same material as the filter fabric. A two-thread, type 401 double-lock stitch shall be used for all sewn work. Sewing methods shall conform to the latest procedures recommended by the filter fabric manufacturer. The Design-Builder shall

demonstrate that the seam efficiency meets the requirements of the specified tabulated properties for the filter fabric as applicable.

All filter fabric placed shall be fixed to the subgrade to prevent filter fabric slippage or movement during placement of subsequent materials. Pins or staples shall not be used to fix the filter fabric to the subgrade when a geomembrane is to be placed on top of the filter fabric.

The Design-Builder shall exercise care during filter fabric installation to prevent damage to the prepared supporting subgrade surface. The shall exercise care to prevent the entrapment of rocks, clods of earth or other material which could damage the filter fabric, clog the filter fabric or hamper seaming. Filter fabric damaged or distressed by foreign objects shall be repaired or replaced.

No foot traffic will be allowed on the filter fabric except with approved smooth-sole shoes. The Design-Builder shall not use the filter fabric surface as a work area or storage area for tools and supplies.

Tracked or rubber tired construction equipment shall not be operated directly upon the filter fabric until a minimum thickness of 6 inches of the cover material is placed over the filter fabric. Turning of construction vehicles shall be minimized to avoid distorting or damaging the filter fabric.

3-6. GEOCOMPOSITE SHEET DRAINS INSTALLATION. The prefabricated geocomposite sheet drains shall be placed on buried structure walls as indicated on the Drawings. The fabric shall extend beyond the edges of the core to provide overlap for the adjacent panels. Before beginning the backfilling operations the geocomposite drains shall be permanently secured to the walls by means of an attachment system recommended by the sheet drain manufacturer. Adjacent sheet drain panels shall be joined as recommended by the manufacturer. Terminal edges of the sheet drain shall be covered by tucking the filter fabric flap behind the core. The bottom end of the sheet drain to be embedded in the granular drainage material shall have the plastic core exposed by peeling back the fabric a minimum of 3 inches but not so much as to expose the plastic core to intrusion and plugging by soil backfill. Backfill shall be placed and completed within 2 weeks of installation of the sheet drains.

3-7. FINAL GRADING AND PLACEMENT OF TOPSOIL. After other outside work has been finished, and backfilling and embankments completed and settled, all areas which are to be graded shall be brought to grade at the indicated elevations, slopes, and contours. All cuts, fills, embankments, and other areas which have been disturbed or damaged by construction operations shall be surfaced with topsoil to a depth of at least 4 inches. Topsoil shall be of a quality at least equal to the existing topsoil in adjacent areas, free from trash, stones, and debris, and well suited to support plant growth.

Use of graders or other power equipment will be permitted for final grading and dressing of slopes, provided the result is uniform and equivalent to manual methods. All surfaces shall be graded to secure effective drainage. Unless otherwise indicated, a slope of at least 1 percent shall be provided.

Final grades and surfaces shall be smooth, even, and free from clods and stones, weeds, brush, and other debris. Seeding and sod placement shall be in accordance with the Seeding and Sodding section.

3-8. DISPOSAL OF EXCAVATED MATERIALS. Suitable excavated materials may be used in fills and embankments as needed. Excess material shall be disposed of at the locations indicated on the Drawings; all such material shall be graded for drainage but need not be compacted.

All debris, stones, logs, stumps, roots, and other unsuitable materials shall be removed from the site and disposed of.

End of Section

Section 31 23 33

TRENCHING AND BACKFILLING

PART 1 - GENERAL

1-1. SCOPE. This section covers clearing, grubbing, and preparation of the site; removal and disposal of all debris; excavation and trenching; tunneled (trenchless construction) crossings; the handling, storage, transportation, and disposal of all excavated material; all necessary sheeting, shoring, and protection work; preparation of subgrades; pumping and dewatering as necessary; protection of adjacent property; backfilling; pipe embedment; surfacing and grading; and other appurtenant work.

1-2. GENERAL. With reference to the terms and conditions of the construction standards for excavations set forth in OSHA "Safety and Health Regulations for Construction", Chapter XVII of Title 29, CFR, Part 1926, Design-Builder shall employ a competent person and, when necessary based on the regulations, a licensed or registered professional engineer, to act upon all pertinent matters of the work of this section.

1-3. SUBMITTALS. Drawings, specifications, and data covering the proposed materials shall be submitted in accordance with the Submittals Procedures section.

At least 30 days before starting construction on the sheeting and shoring, and in accordance with the OSHA requirements identified above, the Design-Builder shall ensure that the sheeting and shoring design engineer shall complete the WTR-FM-EN-1001, Protective System Design Certificate -2 and shall use the sheeting and shoring design. If required by the CalOSHA requirements identified above or to protect existing facilities, the Design-Builder shall submit a separate certificate for each unique design. If required for protection of existing facilities or as required by the CalOSHA regulations identified above, the certificate(s) shall be signed and sealed by the registered professional engineer that designed the protection system.

1-3.01. Filter Fabric Data. Complete descriptive and engineering data for the fabric shall be submitted. Data submitted shall include:

A 12 inch square sample of fabric.

Manufacturer's descriptive product data.

Installation instructions.

1-3.02 Embedment and Backfill Materials. Complete test results covering tests performed by an independent commercial testing laboratory retained by the

Design-Builder for all materials described in the Materials Testing section shall be submitted.

PART 2 - PRODUCTS

2-1. MATERIALS.

2-1.01. Filter Fabric. The fabric shall be provided in rolls wrapped with covering for protection from mud, dirt, dust, and debris.

2-1.01.01. Filter Fabric Type A. Filter fabric Type A shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter Fabric Type A shall be a nonwoven fabric consisting of only continuous chains of polymeric filaments or yarns of polyester formed into a stable network by needle punching. The fabric shall be inert to commonly encountered chemicals; shall be resistant to mildew, rot, ultraviolet light, insects, and rodents; and shall have the indicated properties:

Property	Test Method	Unit	Minimum Average Roll Value *
Fabric Weight	ASTM D3776	oz/yd2	5.7
Grab Strength	ASTM D4632	lb	155
Grab Elongation	ASTM D4632	percent	50
Mullen Burst Strength	ASTM D3786	psi	190
Apparent Opening Size	CW-02215	U.S. Standard Sieve Size	70

* Minimum average roll value in weakest principal direction.

2-1.01.02. Filter Fabric Type B. Filter fabric Type B shall be provided for installation at locations indicated on the Drawings and as specified herein. Filter fabric Type B shall be a nonwoven fabric consisting of only continuous chains of polymeric filaments or yarns of polyester formed into a stable network by needle punching. The fabric shall be inert to commonly encountered chemicals; shall be resistant to mildew, rot, ultraviolet light, insects, and rodents; and shall have the indicated properties:

Property	Test Method	Unit	Minimum Average Roll Value *
Fabric Weight	ASTM D3776	oz/yd2	8.0
Grab Strength	ASTM D4632	lb	215

Grab Elongation	ASTM D4632	percent	50
Mullen Burst Strength	ASTM D3786	psi	375
Apparent Opening Size	CW-02215	U.S. Standard Sieve Size	70

* Minimum average roll value in weakest principal direction.

2-1.02. Polyethylene Film. Polyethylene film beneath concrete slabs or slab base course material shall be Product Standard PS17, 6 mil minimum thickness.

2-1.03. Tunnel Materials. Not used.

2-1.04. Backfill Materials.

2-1.04.01. Job Excavated Material. Job excavated material may be used for either uncompacted or compacted trench backfill when the job excavated material is finely divided and free from debris, organic material, cinders, corrosive material, and stones larger than 3 inches in greatest dimension. Masses of moist, stiff clay shall not be used.

2-1.04.02. Inundated Sand Fill. Sand fill shall be clean, with not more than 25 percent retained on a No. 4 [4.75 mm] sieve and not more than 7 percent passing a No. 200 [75 µm] sieve, and shall have an effective size between 0.10 and 0.30 mm.

2-1.04.03 Graded Gravel Fill. Graded gravel for compacted trench backfill shall conform to the following gradation:

Sieve Size	Percent Passing by Weight
1 inch	100
3/4 inch	85 – 100
3/8 inch	50 – 80
No. 4	35 – 60
No. 40	15 – 30
No. 200	5 – 10

The gravel mixture shall contain no clay lumps or organic matter. The fraction passing the No. 4 sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2-1.04.04. Granular Fill. Granular fill material shall be crushed rock or gravel. Granular fill shall be free from dust, clay, and trash; shall be hard, durable, and

non-friable; and shall be graded 3/4 inch to No. 4 [19 to 4.75 mm] as defined in ASTM C33 for No. 67 coarse aggregate. Granular fill shall meet the quality requirements for ASTM C33 coarse aggregate.

2-1.05. Controlled Low Strength Material (CLSM) Fill. CLSM shall consist of a mixture of Portland cement, fly ash, sand, and water and shall be placed at locations indicated on the Drawings or as directed by Engineer. The class of CLSM shall be as specified below.

The type of cement in CLSM shall be ASTM C150 Type I. The class of fly ash in CLSM shall be ASTM C618 Class C, except loss on ignition shall not exceed 4 percent. Fine aggregate in CLSM shall be clean natural sand, ASTM C33, except that clay particles shall not exceed one percent. Water in CLSM shall be potable.

Design-builder shall design and test the CLSM. Initial set time shall be 8 hours plus or minus one hour as determined by ASTM C403. CLSM shall have an efflux time of 10 to 26 seconds through a special flow cone with a 1/2 inch discharge tube.

The batch proportions shall apply only for materials from the same source and having the same characteristics as the materials used in the mix design. If a change in sources of materials is proposed, a new mix design shall be developed before the new material is used. When unsatisfactory results or other conditions make it necessary, Design-builder shall develop a new mix design to obtain the desired results.

2-1.05.01. Class A CLSM. The initial trial mixture for Class A CLSM shall consist of the following minimum proportions per cubic yard:

Cement	50 lb
Fly Ash	250 lb
Sand (SSD)	2860 lb
Water	370 lb
Air Entraining Agent	6 percent
Compressive strength range at 56 days	100-150 psi

2-1.05,02. Class B CLSM. The initial trial mixture for Class B CLSM shall consist of the following minimum proportions per cubic yard:

Cement	100 lb

Fly Ash	100 lb
Sand (SSD)	2760 lb
Water	386 lb
Air Entraining Agent	5 percent
Compressive strength Range at 56 days	125-250 psi

2-1.05.03. Class C CLSM. The initial trial mixture for Class C CLSM shall consist of the following minimum proportions per cubic yard:

Cement	80 lb
Fly Ash	275 lb
Sand (SSD)	2795 lb
Water	370 lb
Air Entraining Agent	4 percent
Minimum compressive strength at 56 days	370 psi

2-1.06. Pipe Embedment Material. Pipe embedment material shall be placed as indicated in Figure 1-31 23 33.

2-1.06.01. Granular Embedment. Granular embedment shall consist of crushed rock and crushed gravel, meeting the quality and gradation requirements of coarse aggregate size number 7 of ASTM C33.

2-1.06.02. Hand Placed Embedment. Hand placed embedment shall be finely divided job excavated or imported material, free from organic materials, debris, and stones.

2-1.06.03. Compacted Embedment. Compacted embedment shall be finely divided job excavated material free from debris, organic material, and stones. Graded gravel may be substituted for compacted embedment. Granular embedment may be substituted for all or part of the compacted embedment at the option of the Contractor.

2-2. MATERIALS TESTING.

2-2.01. Preliminary Review of Materials. All tests required for preliminary review of materials shall be made by an acceptable independent testing laboratory at the expense of Design-Builder. Two initial gradation tests shall be made for each type of embedment, fill, backfill, or other material, and one additional gradation test shall be made for each additional 500 tons of each material delivered to the site. In addition, one set of initial Atterberg Limits test shall be made for each fill

materials containing more than 20 percent by weight passing the No. 200 sieve. One additional Atterberg Limits test shall be made for each additional 500 tons of each material delivered to the site.

All material testing on CLSM shall be made by an independent testing laboratory.

2-2.02. Field Testing Expense. All moisture-density (Proctor) tests and relative density tests on the materials, and all in-place field density tests, shall be made by an independent testing laboratory at the expense of Owner. Design-builder shall provide access to the materials and work area and shall assist the laboratory as needed in obtaining representative samples.

2-2.03. Required Tests. For planning purposes, the following guidelines shall be used for frequency of field tests. Additional tests shall be performed as necessary for job conditions and number of failed tests. Test results shall be submitted as specified in the Submittals Procedures section.

a. Two moisture density (Proctor) tests in accordance with ASTM D698 (or, when required, ASTM D1557), or two relative density tests in accordance with ASTM D4253 and D4254 for each type of general fill, designated fill, backfill, or other material proposed.
b. In-place field density and moisture tests (ASTM D6938) at intervals of 1000 feet maximum along the trench.
c. One in-place field density and moisture test (ASTM D6938) for every 200 cubic yards of backfill.
d. One in-place density and moisture test (ASTM D6938) whenever there is a suspicion of a change in the quality of moisture control or effectiveness of compaction.
e. Additional gradation, Proctor, and relative density tests whenever the source or quality of material changes.
f. Testing of CLSM shall be as follows:
   Compressive Strength. For every 200 cubic yards of CLSM placed, fill four 6 by 12 inch plastic cylinder molds to overflowing and then tap sides lightly. Cure cylinders in the molds covered until time of testing, at least 14 days. Strip the cylinders carefully using a knife to cut away the plastic mold. Cap the cylinders with high strength gypsum plaster or other capping process that will not break these low strength materials. Test cylinders in accordance with ASTM C39. Two cylinders shall be tested at 7 days and the other two cylinders shall be tested at 56 days.
   Flow of Fill. Once each day that CLSM is placed, test the fill material in accordance with ASTM C939 for the efflux time. Wet screening may be required to remove coarse particles.
   Unit Weight and Yield. Once each day that CLSM is placed, determine unit weight and yield in accordance with ASTM C138.
   Air Content. Once each day that CLSM is placed, determine air

content in accordance with ASTM C231.
Penetration Resistance. Once each day that CLSM is placed, determine early bearing strength in accordance with ASTM C403 penetration procedure.

PART 3 - EXECUTION

3-1. CLEARING. All clearing shall be performed as necessary for access, stringing of pipeline materials, and construction of the pipeline and appurtenant structures.

3-2. EXCAVATION. Excavations shall provide adequate working space and clearances for the work to be performed therein and for installation and removal of concrete forms. In no case shall excavation faces be undercut for extended footings.

Subgrade surfaces shall be clean and free of loose material of any kind when concrete is placed thereon.

Except where exterior surfaces are specified to be damp-proofed, monolithic concrete manholes and other concrete structures or parts thereof, which do not have footings that extend beyond the outside face of exterior walls, may be placed directly against excavation faces without the use of outer forms, provided that such faces are stable and also provided that a layer of polyethylene film is placed between the earth and the concrete.

Excavations for manholes and similar structures constructed of masonry units shall have such horizontal dimensions that not less than 6 inches clearance is provided for outside plastering.

3-2.01. Classification of Excavated Materials. No classification of excavated materials will be made for payment purposes. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition, or condition thereof.

3-2.02. Preservation of Trees. No trees shall be removed outside excavated or filled areas, unless their removal is authorized by Owner. Trees left standing shall be adequately protected from permanent damage by construction operations.

3-2.03. Blasting. Not used.

3-2.04. Dewatering. Dewatering equipment shall be provided to remove and dispose of all surface water and groundwater entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the structure or tunnel to be built, or the pipe to be installed therein, is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result.

All excavations for concrete structures or trenches which extend down to or below groundwater shall be dewatered by lowering and keeping the groundwater level to the minimum depth of 24 inches [600 mm], beneath such excavations. The specified dewatering depth shall be maintained below the prevailing bottom of excavation at all times.

Surface water shall be diverted or otherwise prevented from entering excavations or trenches to the greatest extent possible without causing damage to adjacent property.

Design-Builder shall be responsible for the condition of any pipe or conduit which he may use for drainage purposes, and all such pipe or conduit shall be left clean and free of sediment.

Design-Builder shall obtain from the appropriate agencies and authorities, the dewatering and stormwater discharge permits required to remove and dispose of groundwater, surface water, and any other water used in Design-Builder's operations. The permits shall be obtained prior to start of construction.

3-2.05. Sheeting and Shoring. Except where banks are cut back on a stable slope, excavations for structures and trenches shall be supported with steel sheet piling and shoring as necessary to prevent caving or sliding.

Sheet piling or other excavation support systems shall be installed as necessary to limit the extent of excavations for deeper structures and to protect adjacent structures and facilities from damage due to excavation and subsequent construction. Design-Builder shall assume complete responsibility for, and shall install adequate protection systems for prevention of damage to existing facilities.

Sheeting, shoring and excavation support systems shall be designed by a professional engineer registered in the state where the project is located.

Trench sheeting may be removed if the pipe strength is sufficient to carry trench loads based on trench width to the back of sheeting. Trench sheeting shall not be pulled after backfilling. Where trench sheeting is left in place, it shall not be braced against the pipe, but shall be supported in a manner which will preclude concentrated loads or horizontal thrusts on the pipe. Cross braces installed above the pipe to support sheeting may be removed after pipe embedment has been completed. Trench sheeting shall be removed unless removal of the

sheeting will cause damage to the facility it is protecting or loss of necessary piping support from the piping embedment. If left in place, the sheeting shall cut off 12 inches below finished grade. The design of the support system shall be such as to permit complete removal while maintaining safety and stability at all times.

A movable trench support may be used, provided care is exercised in placing and moving the trench box or support bracing to prevent movement of the pipe and bedding and backfill material meets the required compaction without voids.

3-2.06. Stabilization. Sub-grades for concrete structures and trench bottoms shall be firm, dense, and thoroughly compacted and consolidated; shall be free from mud and muck; and shall be sufficiently stable to remain firm and intact under the feet of the workers.

Sub-grades for concrete structures or trench bottoms which are otherwise solid, but which become mucky on top due to construction operations, shall be reinforced with crushed rock or gravel as specified for granular fills. The stabilizing material shall be placed in a manner that no voids remain in the granular fill. All excess granular fill with unfilled void space shall be removed. The finished elevation of stabilized sub-grades shall not be above sub-grade elevations indicated on the Drawings.

3-3. TRENCH EXCAVATION. No more trench shall be opened in advance of pipe laying than is necessary to expedite the work. One block or 400 feet, whichever is the shorter, shall be the maximum length of open trench on any line under construction.

Except where tunneling is indicated on the Drawings, and is specified, all trench excavation shall be open cut from the surface.

Prior to excavation, Design-Builder shall contact local underground alert hotlines, “Dig Safe” and/or individual utility owners for marking underground utilities. Once utilities are marked, Design-Builder shall hand dig or pothole to expose the existing utilities. A survey shall be made of the utility size, material, location, and elevation prior to trench excavation and information shall be recorded on the record Drawings maintained by the Design-Builder.

3-3.01. Alignment, Grade, and Minimum Cover. The alignment and grade or elevation of each pipeline shall be fixed and determined from offset stakes. Vertical and horizontal alignment of pipes, and the maximum joint deflection used in connection therewith, shall be in conformity with requirements of the section covering installation of pipe.

Where pipe grades or elevations are not definitely fixed by the Drawings, trenches shall be excavated to a depth sufficient to provide a minimum depth of

backfill cover over the top of the pipe of 40 inches over pipes below paved and graded streets and, of 36 inches over pipes in other locations. Greater pipe cover depths may be necessary on vertical curves or to provide adequate clearance beneath existing pipes, conduits, drains, drainage structures, or other obstructions encountered at normal pipe grades. Measurement of pipe cover depth shall be made vertically from the outside top of pipe to finished ground or pavement surface elevation, except where future surface elevations are indicated on the Drawings.

3-3.02. Maximum Trench Widths. Not used.

3-3.03. Minimum Trench Widths. Except when maximum trench width is required for certain conduits, trenches shall be excavated to the minimum trench widths indicated in the following table. Trenches shall be excavated to a width which will provide adequate working space and sidewall clearances for proper pipe installation, jointing, and embedment.

Nominal Pipe Size	Minimum Trench Width	Clearance
Less than 27 in	Pipe OD plus 24 in	12 in
27 in through 60 in	Pipe OD plus nominal pipe size	ID/2
Greater than 60 in	Pipe OD plus 70 in	30 in

Clearance = Minimum sidewall clearance
OD = Outside diameter (or span) of conduit
ID = Inside diameter (or span) of conduit.

Specified minimum sidewall clearances are not minimum average clearances but are minimum clear distances which will be required to the trench excavation or the trench protective system.

Cutting trench banks on slopes to reduce earth load to prevent sliding and caving shall be used only in areas where the increased trench width will not interfere with surface features or encroach on right-of-way limits.

3-3.04. Mechanical Excavation. The use of mechanical equipment will not be permitted in locations where its operation would cause damage to trees, buildings, culverts, or other existing property, utilities, or structures above or below ground. In all such locations, hand excavating methods shall be used.

Mechanical equipment used for trench excavation shall be of a type, design, and construction, and shall be so operated, that the rough trench excavation bottom elevation can be controlled, and that trench alignment is such that pipe, when accurately laid to specified alignment, will be centered in the trench with adequate sidewall clearance. Undercutting the trench sidewall to obtain sidewall clearance will not be permitted.

In locations where maximum trench widths are required for designated rigid conduits, mechanical equipment shall be operated so that uniform trench widths and vertical sidewalls are obtained at least from an elevation 12 inches above the top of the installed pipe to the bottom of the trench.

3-3.05. Cutting Concrete Surface Construction. Not used.

3-3.06. Excavation Below Pipe Sub-grade. Except where otherwise required, pipe trenches shall be excavated below the underside of the pipe, as indicated on Figure 1-31 23 33, to provide for the installation of granular embedment.

Bell holes shall provide adequate clearance for tools and methods used for installing pipe. No part of any bell or coupling shall be in contact with the trench bottom, trench walls, or granular embedment when the pipe is jointed.

3-3.07. Artificial Foundations in Trenches. Whenever unsuitable or unstable soil conditions are encountered, Design-Builder shall notify Geotechnical and Structural Engineers of Record and with approval, trenches shall be excavated below grade and the trench bottom shall be brought to grade with suitable material.

3-3.08. Over-Excavation. Over-excavation carried below the grade shall be backfilled to the required grade and compacted.

3-4. PIPE EMBEDMENT. Embedment materials both below and above the bottom of the pipe, classes of embedment to be used, and placement and compaction of embedment materials shall conform to the requirements indicated on Figure 1-31 23 33 and to the following supplementary requirements.

Embedment material shall contain no cinders, clay lumps, or other material which may cause pipe corrosion.

3-4.01. Embedment Classes.

a. Class A Arch Encasement. When arch encasement is indicated on the Drawings, Class A arch encasement shall be used at all locations so indicated.
When arch encasement is not indicated on the Drawings, Class A arch encasement is not required unless improper trenching or unexpected trench conditions require its use.
Concrete and reinforcing steel for Class A arch encasement shall conform to the requirements of the Cast-in-Place Concrete and Concrete Reinforcement sections.

b. Class B Embedment. Class B bedding shall be used for all steel, ductile iron, bar-wrapped concrete, and vitrified clay pipelines, and

for all other pipelines not otherwise specified.

c. Class B Special Embedment. Class B special embedment shall be used for HDPE, PVC, ABS, FRP, GRP, steel or stainless steel pipe where the process fluid design maximum temperature is 140° F or higher such as for pressurized air service, and when recommended by the pipe manufacturer.

d. Class C Embedment. Class C embedment shall be used for all reinforced concrete and prestressed concrete pipelines.

3-4.02. Embedment for Ductile Iron, Steel, FRP, and PVC Pipelines. Granular embedment for polyethlene tube protected ductile iron, coal tar or tape coated steel, FRP, and PVC pipelines shall be crushed rock or crushed gravel with rounded or subrounded particles. Crushed rock or gravel with sharp edges which could cause significant scratching or abrasion of the pipe or damage to the coating or polyethylene tube protection shall not be used.

Inundated sand may be used for granular embedment in locations where the use of water will cause no damage to adjacent property and where it can be placed and properly compacted without damage to the pipe.

Inundated sand for granular embedment shall be deposited in, or placed simultaneously with the application of water so that the sand is inundated during compaction. During placement, the sand shall be compacted with a mechanical probe type vibrator. Water shall be allowed to escape or shall be removed during vibration, and no ponding shall be allowed to take place. Inundated sand shall be compacted to 70 percent relative density as determined by ASTM D4253 and D4254. If the required density cannot be achieved, placement and compaction methods shall be altered.

3-4.03. Placement and Compaction.

3-4.03.01. Granular Embedment. Granular embedment material shall be spread and the surface graded to provide a uniform and continuous support beneath the pipe at all points between bell holes or pipe joints. It will be permissible to slightly disturb the finished subgrade surface by withdrawal of pipe slings or other lifting tackle.

After each pipe has been graded, aligned, and placed in final position on the bedding material, and shoved home, sufficient pipe embedment material shall be deposited and compacted under and around each side of the pipe and back of the bell or end thereof by shovel slicing or other suitable methods to hold the pipe in proper position and alignment during subsequent pipe jointing and embedment operations.

Placing and compaction of embedment material shall not damage the pipe coating or polyethylene encasement. Embedment material shall not be dumped

directly on the pipe or polyethylene encasement unless a suitable temporary isolation layer such as a 60 mil HDPE sheeting, is used to cover the pipe and polyethylene encasement.

Embedment material shall be deposited and compacted uniformly and simultaneously on each side of the pipe to prevent lateral displacement. Granular embedment shall be placed in layers not more than 6 inches deep and compacted as specified.

Each lift of granular embedment material shall be vibrated with a mechanical probe type vibrator or shovel sliced during placement to ensure that all spaces beneath the pipe are filled. Granular embedment shall be placed in maximum lift thickness of 6 inches and compacted. Each lift of embedment material shall be compacted with three passes (round trip) of a platform type vibrating compactor and to at least 70 percent relative density as determined by ASTM D4253 and D4254.

Where indicated on the Drawings or where silt, fine sand, or soft clay soils are encountered below groundwater, migration of soil into the embedment material shall be prevented by installing filter fabric Type A, or by using graded gravel in place of granular embedment. Filter fabric shall be placed on the trench surfaces so that it completely surrounds the embedment material. Joints shall be lapped 12 inches.

3-4.03.02. Compacted Embedment. Not used.

3-4.03.03 Hand Placed Embedment. Hand placed embedment shall be placed by hand shovels or using methods that prevent dropping the material for more than 24 inches above the pipe. Hand placed embedment shall be lightly tamped using hand equipment. Care shall be taken so as to not damage the pipe or coating.

3-4.03.04. Compaction - Trench Box Support Systems. Where trench box support systems are used embedment compaction shall be performed outside the limits of the trench box so that relocating the trench box will not disturb the compacted embedment. Where necessary to protect workers, the compaction may be performed by compaction rollers or other compaction systems that are operated from above the trench and achieve the required compaction.

Trench boxes for earth trenches shall be positioned such that the bottom of the trench box is no lower than approximately two feet above the bottom of pipe invert elevation so that initial compaction of the haunch area of the pipe, from within the trench box, extends the full width of trench. Trenches shall be shaped to support the trench box above the bottom of trench.

When in rock and where it is not practicable to shape the trench to provide the trench box support above the bottom of the trench, initial compaction of the haunch area may be performed within the trench box.

Final compaction of the haunch area and all other compaction shall be performed outside the limits of the trench box after the trench box has advanced into the next section of trench..

3-4.04. Groundwater Barrier. Continuity of embedment material shall be interrupted by low permeability groundwater barriers to impede passage of water through the embedment. Groundwater barriers for sewer lines that contain manholes with cast-in-place bases shall be compacted soil around each manhole, extending through any granular material beneath the manhole, and meeting ASTM D2487 soil classification GC, SC, CL, or ML-CL and shall be compacted to at least 95 percent of maximum density with moisture content within 2 percent of the optimum moisture content (ASTM D698). Material may be finely divided, suitable job excavated material, free from stones, organic matter, and debris.

Groundwater barriers for sewer lines that contain manholes with precast (developed) bases and for all other pipelines shall be soil plugs of 3 feet in width, extending the full depth and width of granular material, and spaced not more than 400 feet apart. The soil plugs shall be constructed from soil meeting ASTM D2487 classification GC, SC, CL, or ML, and compacted to 95 percent of maximum density at near the optimum moisture content (ASTM D698).

3-5. TRENCH BACKFILL. All trench backfill above pipe embedment shall conform to the following requirements.

A layer of backfill material not more than 8 inches deep may be placed over concrete arch encasement or concrete thrust blocking after the concrete has reached its initial set, to aid curing. No additional backfill shall be placed over arch encasement or blocking until the concrete has been in place for at least 3 days.

3-5.01. Compacted Backfill. Compacted backfill will be required for the full depth of the trench above the embedment in the following locations:

Where beneath pavements, surfacings, driveways, curbs, gutters, walks, or other surface construction or structures.

Where in street, road, or highway shoulders.

In established lawn areas.

The top portion of backfill beneath established lawn areas shall be finished with at least 12 inches of topsoil corresponding to, or better than that which is underlying adjoining lawn areas.

Trench backfill material shall be suitable job excavated material and shall be as specified herein.

3-5.01.01. Job Excavated Material. Job excavated materials shall be placed in uniform layers not exceeding 8 inches in uncompacted thickness. Each layer of material shall have the best possible moisture content for satisfactory compaction. The material in each layer shall be wetted or dried as needed and thoroughly mixed to ensure uniform moisture content and adequate compaction. Increased layer thickness may be permitted for noncohesive material if the specified compacted density will be obtained. The method of compaction and the equipment used shall be appropriate for the material to be compacted and shall not transmit damaging shocks to the pipe. Job excavated material shall be compacted to 95 percent of maximum density at a moisture content within 2 percent of the optimum moisture content as determined by ASTM D698 when that test is appropriate, or to 70 percent relative density as determined by ASTM D4253 and D4254 when those tests are appropriate.

3-5.01.02. Inundated Sand. Sand shall be deposited in, or placed simultaneously with the application of, water so that the sand is inundated during compaction. During placement, the sand shall be compacted with a mechanical probe type vibrator. Water shall be allowed to escape or shall be removed during vibration and no ponding shall be allowed to take place. Inundated sand shall be compacted to 70 percent relative density as determined by ASTM D4253 and D4254. If the required relative density cannot be achieved, use of inundated sand shall be discontinued.

3-5.01.03. Graded Gravel. Gravel backfill shall be deposited in uniform layers not exceeding 12 inches in uncompacted thickness. The backfill shall be compacted with a suitable vibratory roller or platform vibrator to at least 70 percent relative density as determined by ASTM D4253 and D4254. Groundwater barriers specified under pipe embedment shall extend to the top of the graded gravel backfill.

3-5.02. Ordinary Backfill. Compaction of trench backfill above pipe embedment in locations other than those specified will not be required except to the extent necessary to prevent future settlement. Design-Builder shall be responsible for backfill settlement as specified.

Ordinary earth backfill material to be placed above embedments shall be free of brush, roots more than 2 inches in diameter, debris, cinders, and any corrosive material, but may contain rubble and detritus from rock excavation, stones, and boulders in certain portions of the trench depth.

Backfill material above embedments shall be placed by methods which will not impose excessive concentrated or unbalanced loads, shock, or impact on installed pipe, and which will not result in displacement of the pipe.

Compact masses of stiff clay or other consolidated material more than 1 cubic foot in volume shall not be permitted to fall more than 5 feet into the trench, unless cushioned by at least 2 feet of loose backfill above pipe embedment.

No trench backfill material containing rocks or rock excavation detritus shall be placed in the upper 18 inches of the trench, nor shall any stone larger than 8 inches in its greatest dimension be placed within 3 feet of the top of pipe. Large stones may be placed in the remainder of the trench backfill only if well separated and so arranged that no interference with backfill settlement will result.

3-5.03. Water-Settled Earth Backfill. Settlement or consolidation of trench backfill using water jetting or ponding shall not be performed.

3-5.04. Structure Backfill. Backfill around manholes and small concrete vaults shall meet the requirements specified for structure backfill specified in the Excavation and Fill for Structures section.

3-5.05. Controlled Low Strength Material (CLSM). CLSM shall not be placed on frozen ground. Batching, mixing, and placing of CLSM may be started when weather conditions are favorable and when the temperature is at least 34°F and rising. At time of placement, CLSM shall have a temperature of at least 40°F. Mixing and placing shall stop when the temperature is 38°F and falling. Each filling stage shall be as continuous an operation as is practicable.

CLSM shall be discharged from the mixer by an acceptable procedure into the area to be filled. CLSM shall be placed to limits indicated on the Drawings. Mixing CLSM with in-situ soil shall be avoided.

When CLSM is placed as backfill against structures, the fill shall be placed in lifts of 2 to 3 feet and the next lift shall not be placed until the previous lift has taken initial set and at least 16 hours have elapsed from the end of placement. Lift thickness shall be reduced as necessary to prevent floatation of the structure.

When CLSM is placed over culverts or pipelines, they shall be anchored to prevent flotation during the placement of CLSM. Unless otherwise required, CLSM shall be placed to one foot below subgrade elevation if the subgrade elevation is not more than 5 feet over the top of the culvert or pipe. If the subgrade is more than 5 feet over the top of the culvert or pipe, CLSM shall be placed to an elevation 2 feet over the top of the culvert or pipe, and the remainder shall be backfilled with soil designated by Design-Builder.

3-6. TUNNEL EXCAVATION. Not used.

3-6.03. Smooth Steel Pipe. The conduit shall be installed by jacking into place. Earth displaced by the conduit shall be removed through the interior of the conduit by hand, by auger, or by other acceptable means. Sections of the casing pipe shall be welded together to form a continuous conduit capable of resisting all stresses, including jacking stresses. The casing pipe conduit in its final position shall be straight and true in alignment and grade, as indicated on the Drawings. No space shall be left unfilled between the earth and the outside of the casing.

3-6.04. Wood Skids, Blocking and Casing Insulators. Wood skids shall be provided when indicated on the Drawings. Wood skids shall be securely strapped to the pipe with steel strapping material at least 3/4 inch wide. Steel straps shall be insulated from contact with carrier pipe.

Casing insulators shall be securely anchored to the carrier pipe.

3-6.05. Tunnel Backfill. Not used.

3-7. DRAINAGE MAINTENANCE. Trenches across roadways, driveways, walks, or other trafficways adjacent to drainage ditches or watercourses shall not be backfilled prior to completion of backfilling the trench on the upstream side of the trafficway, to prevent impounding water after the pipe has been laid. Bridges and other temporary structures required to maintain traffic across such unfilled trenches shall be constructed and maintained by Design-Builder. Backfilling shall be done so that water will not accumulate in unfilled or partially filled trenches. All material deposited in roadway ditches or other watercourses crossed by the line of trench shall be removed immediately after backfilling is completed, and the original section, grades, and contours of ditches or watercourses shall be restored. Surface drainage shall not be obstructed longer than necessary.

3-8. PROTECTION OF TRENCH BACKFILL IN DRAINAGE COURSES. Not used.

3-9. FINAL GRADING AND PLACEMENT OF TOPSOIL. After other outside work has been finished, and backfilling and embankments completed and settled, all areas which are to be graded shall be brought to grade at the indicated elevations, slopes, and contours. All cuts, fills, embankments, and other areas which have been disturbed or damaged by construction operations shall be surfaced with topsoil to a depth of at least 4 inches. Topsoil shall be of a quality at least equal to the existing topsoil in adjacent areas, free from trash, stones, and debris, and well suited to support plant growth. Topsoil required to provide the minimum thickness shall be imported and placed at no additional cost to the Owner.

Use of graders or other power equipment will be permitted for final grading and dressing of slopes, provided the result is uniform and equivalent to manual methods. All surfaces shall be graded to secure effective drainage. Unless otherwise indicated, a slope of at least 1 percent shall be provided.

Final grades and surfaces shall be smooth, even, and free from clods and stones, weeds, brush, and other debris.

3-10. DISPOSAL OF EXCESS EXCAVATED MATERIALS. Disposal of excess material from trench excavations on plant and major facility construction sites shall be accomplished as specified in the Excavation and Fill for Structures section of the Specifications for the major construction.

Disposal of excess material from trench excavation sites shall be as follows. Except as otherwise permitted, all excess excavated materials shall be disposed of away from the site.

Broken concrete and other debris resulting from pavement or sidewalk removal, excavated rock in excess of the amount permitted to be installed in trench backfill, debris encountered in excavation work, and other similar waste materials shall be disposed of away from the site.

Excess earth from excavations located in unimproved property may be distributed directly over the pipe trench and within the pipeline right-of-way to a maximum depth of 6 inches above the original ground surface elevation at and across the trench and sloping uniformly each way. Material thus wasted shall be carefully finished with a drag, blade machine, or other suitable tool to a smooth, uniform surface without obstructing drainage at any point. Wasting of excess excavated material in the above manner will not be permitted where the line of trench crosses or is within a railroad, public road, or highway right-of-way.

3-11. RESODDING. All established lawn areas cut by the line of trench or damaged during the work shall be re-sodded, after completion of construction, to the complete satisfaction of the property owner and Owner. All sod used shall be the same type as removed or damaged, shall be best quality, and, when placed, shall be live fresh growing grass with at least 1-1/2 inches of soil adhering to the roots.

All sod shall be procured from areas where soil is fertile and contains a high percentage of loamy topsoil and from areas that have been grazed or mowed sufficiently to form a dense turf.

Sod shall be transplanted within 24 hours from the time it is harvested, unless stacked at its destination in a suitable manner. All sod in stacks shall be kept moist and protected from exposure to the sun and from freezing. In no event shall more than 1 week elapse between cutting and planting.

Before placing sod, all shaping and dressing of the areas shall have been completed. After shaping and dressing, commercial fertilizer of a type acceptable to Owner shall be applied uniformly in the manner and amounts recommended by the manufacturer, and harrowed lightly. Sodding shall follow immediately.

All sodding shall be done during the period from March 15 to October 1, unless written permission is given by Owner to extend the planting season.

3-12. SETTLEMENT. Design-builder shall be responsible for all settlement of trench backfill which may occur within the correction period stipulated in the General Conditions.

End of Section

Section 33 05 14

MANHOLE AND VAULT COVERS AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the fabrication and erection of iron manhole and vault covers and accessories suitable for installation in manholes, vaults, slabs, electrical handholes, and other applications where a floor access hatch is not required. Manhole steps (suitable for both cast-in-place and epoxy grouted installations) are also included. For floor access hatches and doors see the specification section of the same name.

Fabricated items which are indicated on the Drawings but not mentioned specifically herein shall be fabricated in accordance with the applicable requirements of this section.

1-2. SUBMITTALS. Complete data, detailed drawings, and setting or erection drawings covering all materials shall be submitted in accordance with the Submittals Procedures section. Each separate piece shall be marked.

1-3. DELIVERY, STORAGE, AND HANDLING. Materials shall be handled, transported, and delivered in a manner which will prevent bends, dents, significant coating damage, or corrosion. Damaged materials shall be promptly replaced. Materials shall be stored on blocking and protected from the weather so that no metal touches the ground and water cannot collect thereon.

PART 2 - PRODUCTS

2-1. GENERAL. Materials work shall be fabricated in conformity with dimensions, arrangements, sizes, and weights or thicknesses as specified or as indicated on the Drawings.

All members and parts shall be free of warps, local deformations, and unauthorized bends. Holes and other provisions for field connections shall be accurately located and shop checked so that proper fit will result when the units are assembled in the field. All field connection materials shall be furnished.

2-2. DESIGN REQUIREMENTS. Manhole and electrical vault covers and frames shall be cast iron assemblies specifically intended as covers. Manufacturer, product number, and type shall be as specified.

All covers and frames shall be capable of carrying an AASHTO HS-20 street loading unless specifically indicated as light duty. An equivalent heavy duty cover and frame may be substituted for the indicated light duty cover and frame.

2-3. MATERIALS. Materials, appurtenances, and finishes used in the manufacturer of manhole and electrical handhole covers and frames shall be as indicated. Unless otherwise required, materials, appurtenances, and finishes shall be the manufacturer's standard for the type of each cover indicated.

Circular Covers and Frames	
Light Duty	Cast iron; Clay & Bailey "2020", Neenah "R-1737", or equal.
Heavy Duty (Subject to Vehicular Traffic)	Cast iron; Clay & Bailey "2008BV", Neenah "R-1736", or equal.
Rectangular Covers and Frames	
Light Duty	
Square	Cast iron; Neenah "R-6660", or equal.
Rectangular	Cast iron; Neenah "R-6661", or equal.
Heavy Duty (Subject to Vehicular Traffic)	
Square	Cast iron; Neenah "R-6662", or equal.
Rectangular	Cast iron; Neenah "R-6663", or equal.
Manhole Steps	Per City of Morro Bay standards.

PART 3 - EXECUTION

3-1. INSTALLATION. Prior to installation all loose rust shall be removed from castings and one coat of coal tar epoxy shall be applied to surfaces embedded in concrete. Materials shall be erected and installed in conformity with the dimensions and arrangements specified or indicated on the Drawings and as recommended by the manufacturer.

After erection covers and frames shall be cleaned. Product finishes damaged during erection, shall be repaired as recommended by the manufacturer.

End of Section

Section 33 31 33

SEWER PIPE INSTALLATION AND TESTING

PART 1 - GENERAL

1-1. SCOPE. This section covers the installation and testing of all sewer pipe furnished under the following specification sections:

Polyvinyl Chloride (PVC) Sewer Pipe

Pipe trenching, embedment, and backfill are covered in the Trenching and Backfilling section.

1-2. DELIVERY, STORAGE, AND HANDLING. See the general Terms and Conditions.

1-3. LAYING SCHEDULE. The Design-Builder shall produce a laying schedule which shall be updated as needed to provide at least one week notice on all pipeline installation.

PART 2 - PRODUCTS

2-1. MATERIALS. Sewer pipe materials are specified in the pipe sections.

PART 3 - EXECUTION

3-1. ALIGNMENT. Piping shall be laid to the lines and grades indicated on the Drawings. Laser beam equipment or surveying instruments shall be used to maintain alignment and grade. At least one elevation measurement shall be made on each length of pipe.

If laser beam equipment is used, periodic elevation measurements shall be made with surveying instruments to verify accuracy of grades. If such measurements indicate thermal deflection of the laser beam due to differences between the ground temperature and the air temperature within the pipe, precautions shall be taken to prevent or minimize further thermal deflections.

3-2. LAYING PIPE. Pipe shall be protected from lateral displacement by embedment material installed as specified in the Trenching and Backfilling section. Pipe shall not be laid in water or under unsuitable weather or trench conditions.

Pipe laying shall begin at the lowest elevation with bell ends facing the direction of laying, except when reverse laying is permitted by Design-Builder.

Foreign material shall be kept out of the pipe during installation. No debris, tools, clothing, or other foreign objects shall be placed in the pipe.

Whenever pipe laying is stopped, the open end of the pipe shall be closed with a tight-fitting end board to keep out soil. The end board shall have perforations to admit water and prevent flotation of the pipe in the event the trench becomes flooded.

Core holes and handling holes in concrete pipe shall be repaired by cementing a properly shaped concrete plug in place with epoxy cement or by other methods acceptable to Design-Builder. Plugs shall be provided by the pipe manufacturer and shall be sized and designed to match the pipe supplied.

3-3. JOINTING. All joint preparation and jointing procedures shall comply with the instructions and recommendations of the manufacturer.

3-3.01. Rubber Gasketed Joints. Rubber gaskets shall be positioned on the joint in accordance with the manufacturer's recommendations. Immediately before joints are pushed together, all joint surfaces shall be thoroughly cleaned and coated with the lubricant furnished with the pipe. The gasket shall be lubricated and positioned in the spigot groove so that the gasket is distributed uniformly around the pipe circumference. The position of the rubber gasket shall be checked with a feeler gauge after each joint is completed. If the gasket is not in the proper position, the joint shall be pulled apart, the gasket removed and discarded, and the joint re-assembled using a new, properly lubricated gasket.

Joint lubricant shall be stored in closed containers and shall be kept clean. When installing pipe in cold weather, the joint surfaces and gaskets shall be kept warm and the joint lubricant shall be protected from freezing.

For rubber and steel joints, each exterior joint recess shall be filled with joint grout. A diaper shall be used to prevent foreign material from entering the joint recess before grouting and to serve as a form for the grout. Each diaper shall be of sufficient length to encircle the pipe, leaving enough space between the ends to allow the grout to be poured. Joint grout shall be poured between the diaper and the pipe and shall be allowed to run down to the bottom of the pipe. The grout shall be rodded while being poured, using a stiff wire curved to the

approximate shape of the pipe. Each joint recess shall be completely filled with grout for the full circumference of the pipe.

Not less than two lengths of pipe shall be in final position in advance of exterior joint grouting. If placing of pipe embedment is resumed before the grout has attained initial set, care shall be taken to prevent damage to the grout while placing and compacting embedment material.

After trench backfilling has been completed, the interior joint recess of pipe with rubber and steel joints shall be filled with mortar following the recommendations of the pipe manufacturer. Joint surfaces shall be damp, but free from standing water, when the mortar is placed. Mortar shall be thoroughly compacted to completely fill the recess and shall be finished smooth. All excess mortar shall be removed from the pipe.

3-3.02. Flexible Sealant Joints. Joints made with flexible joint sealant shall be coated with adhesive as directed by the sealant manufacturer, and the joint sealant shall be positioned in accordance with the manufacturer's installation instructions. The pipe sections forming the joint shall be pulled together with sufficient force to uniformly fill and seal the annular space in the joint. Joints shall not be made when adverse weather conditions may prevent proper sealing, nor when the temperature of the pipe and sealing materials is too low to achieve proper sealing.

3-3.03. Mastic Joints. Surfaces of pipe to be joined with mastic joints shall be primed, if recommended by the mastic manufacturer. Immediately before joining the pipes, a uniform layer of mastic shall be applied to the joint surfaces. After the pipes are in final position, the mastic shall completely fill and seal the annular space in the joint. Joints shall not be made when weather conditions may interfere with obtaining a satisfactory seal.

3-3.04. Field Cut Joints or Connections Between Dissimilar Pipe Materials. Where indicated on the Drawings or required to facilitate installation of field cut joints in PVC or composite sewer pipe, or connections between PVC or composite sewer pipe and pipe of other materials, couplings may be used in accordance with the instructions of the coupling manufacturer and pipe manufacturer.

3-4. TEE BRANCHES. Tee branches shall be installed at locations indicated on the Drawings. Tee branch locations shall be marked in advance of the construction of sewers to any property to which sewer service will be extended and, if the locations have not been designated, sewer construction shall be stopped until the necessary tee branch locations have been established. Tee branches shall be installed with the lower lip not more than 2 inches below the

outside top of the pipe, and shall remain uncovered until their locations have been recorded.

Each tee branch shall be closed with a suitable plug and shall be marked with a wooden strip extending vertically from the tee to 12 inches above the ground surface. Markers shall be securely anchored and maintained upright until backfilling has been completed.

3-5. SERVICE CONNECTIONS. Service connections shall not be installed as vertical risers but shall be laid on a slope not to exceed 2 vertical to 1 horizontal. Each service connection pipe shall have a solid bearing on undisturbed earth.

3-6. CONCRETE ENCASEMENT. Concrete encasement shall be installed where indicated on the Drawings. A pipe joint shall be provided within 12 inches [300 mm] of each end of the concrete encasement. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section. All pipe which is to be encased shall be suitably supported and blocked in proper position and shall be anchored against flotation.

3-7. ACCEPTANCE TESTS. Each reach of sewer shall meet the requirements of the following acceptance tests.

3-7.01. Lamping. Unless otherwise indicated on the Drawings, each section of sewer line between manholes shall be straight and uniformly graded. Each section will be lamped by Engineer.

3-7.02. Exfiltration. An exfiltration test shall be conducted on each reach of sewer between manholes. The first line between manholes shall be tested before backfilling and before any additional sewer pipe is installed. Thereafter, exfiltration testing shall be done after backfilling, and individual or multiple reaches may be tested at the option of Design-Builder.

Exfiltration tests shall be conducted by blocking off all manhole openings except those connecting with the reach being tested, filling the line, and measuring the water required to maintain a constant level in the manholes. Each manhole shall be subjected to at least one exfiltration test.

During the exfiltration test, the water depth above the pipe invert at the lower end shall be at least to the elevation of the ground surface, unless otherwise specified. The maximum depth of the water at the lower end shall not exceed 25 feet, and the minimum depth of the water at the upper end shall be at least 5 feet above the crown of the pipe or 5 feet above groundwater elevation, whichever is higher.

The total exfiltration shall not exceed 100 gallons per inch of nominal diameter per mile of pipe per day for each reach tested. For purposes of determining maximum allowable leakage, nominal diameter and depth of manholes shall be included. The exfiltration tests shall be maintained on each reach for at least 2 hours and shall be longer if necessary, to locate all leaks.

Design-Builder shall provide, at his own expense, all necessary piping between the reach to be tested and the source of water supply, and all labor, equipment, and materials required for the tests. The methods used and the time of conducting exfiltration tests shall be acceptable to Design-Builder.

3-7.03. Low Pressure Air Testing. With prior approval by Design-Builder , low pressure air testing may be used in lieu of exfiltration testing for 24 inch diameter and smaller pipe. Air testing shall not be used for manholes, or for pipe larger than 24 inches in diameter.

Low pressure air testing shall comply with ASTM C828 for PVC, and composite pipe, and shall comply with ASTM C924 for concrete pipe.

The time elapsed for a 1 psi drop in air pressure shall be not less than, nor shall the air loss exceed, the limits set forth in the governing standard.

If the length of sewer to be tested is fully or partially submerged in groundwater, the test pressure shall be increased if necessary to overcome the actual static pressure exerted by the groundwater. If a test pressure greater than 8 psi results, air testing shall not be used, and exfiltration testing will be required.

Leaks shall be located by testing short sections of pipe. Leaks shall be repaired and the reach of sewer retested.

3-7.04. Infiltration. If, at any time prior to expiration of the correction period stipulated in the General Conditions, infiltration exceeds 100 gallons per inch of nominal diameter per mile of sewer per day, Design-Builder shall locate the leaks and make repairs as necessary to control the infiltration.

3-7.05. Deflection. After backfilling is completed, and before acceptance of the work, each reach of PVC and composite sewer pipe shall be checked for excessive deflection by pulling a mandrel through the pipe. Pipe with diametrical deflection exceeding 5 percent of the inside diameter shall be uncovered, and the bedding and backfill replaced to prevent excessive deflection. Repaired pipe shall be retested.

3-8. CLEANING. The interior of all pipe and fittings shall be thoroughly cleaned before installation and shall be kept clean until the work has been accepted. All joint contact surfaces shall be kept clean until the joint is completed.

End of Section

Section 40 05 05.11

MISCELLANEOUS PIPING AND ACCESSORIES INSTALLATION

PART 1 - GENERAL

1-1. SCOPE. This section covers the installation of piping and accessories as indicated on the Drawings for the following piping sections:

Section Title
Miscellaneous Piping and Accessories
Stainless Steel Pipe and Alloy Pipe, Tubing, and Accessories
Miscellaneous Steel Pipe, Tubing, and Accessories
Miscellaneous Plastic Pipe, Tubing, and Accessories
Copper Tubing and Accessories

Design-Builder or system supplier, whoever installs the equipment, shall furnish all necessary jointing materials, coatings, and accessories that are specified herein.

Pipe supports and anchors shall be furnished by Design-Builder, and are covered in the Pipe Supports section. Pipe trenching and backfilling are covered in the Trenching and Backfilling section.

1-2. GENERAL.

1-2.01. Coordination. Materials installed under this section shall be installed in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the manufacturer, unless exceptions are noted by Design-Builder.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Items requiring submittals shall include, but not be limited to, the following:

Watertight/dusttight pipe sleeves.

Materials as specified herein.

1-4. QUALITY ASSURANCE.

1-4.01. Welding and Brazing Qualifications. All welding and brazing procedures and operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of Section IX of the ASME Code. All procedure and operator qualifications shall be submitted to the Engineer for review.

1-4.02. Tolerances. These tolerances apply to in-line items and connections for other lines.

The general dimension, such as face-to-face, face or end-to-end, face- or end-to center, and center-to-center shall be 1/8 inch.

The inclination of flange face from true in any direction shall not exceed 3/64 inch per foot.

Rotation of flange bolt holes shall not exceed 1/16 inch.

1-5. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the General Terms and Conditions section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

Plastic pipe, tubing, and fittings shall be stored between 40°F and 90°F.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. Pipe, tubing, and fittings covered herein shall be installed in the services indicated in the various pipe sections.

2-2. MATERIALS.

Threaded Fittings

Anti-Seize Thread Lubricant	Jet-Lube "Nikal", John Crane "Thred Gard Nickel", Never-Seez "Pure Nickel Special", or Permatex "Nickel Anti-Seize".
Teflon Thread Sealer	Paste type; Hercules "Real-tuff", John Crane "JC-30", or Permatex "Thread Sealant with Teflon".
Teflon Thread Tape	Hercules "Tape Dope" or John Crane "Thread-Tape".

Solvent Welded Fittings	
Solvent cement for PVC Systems	ASTM D2564.
Solvent cement for CPVC Systems	ASTM F493.
Sodium Hypochlorite, Sodium Hydroxide, and Sodium Bisulfite Service	IPS Corporation "Weld-On 724"
Primer for PVC Systems	ASTM F656.
Solder or Brazed Fittings	
Solder	Solid wire, ASTM B32, ANSI/NSF 61 certified, Alloy Grade Sb5, (95-5).
Soldering Flux	Paste type, ASTM B813.
Brazing Filler Metal	AWS A5.8, BCuP-5; Engelhard "Silvaloy 15", Goldsmith "GB-15", or Handy & Harman "Sil-Fos".
Brazing Flux	Paste type, Fed Spec O-F-499, Type B.
Insulating Fittings	
Threaded	Dielectric steel pipe nipple, ASTM A53, Schedule 40, polypropylene lined, zinc plated; Perfection Corp. "Clearflow Fittings".
Flanged	Epco "Dielectric Flange Unions" or Central Plastics "Insulating Flange Unions". Shall be suitable for the temperature and service.
Pipe Insulation	See Mechanical Insulation section.
Watertight/Dusttight Pipe Sleeves	O-Z Electrical Manufacturing "Thruwall" and "Floor Seals", or Thunderline "Link-Seals"; with modular rubber sealing elements, nonmetallic pressure plates, and galvanized bolts.
Pipe Sleeve Sealant	Polysulfide or urethane, as specified in the Caulking section or as indicated on the Drawings.
Protective Coatings	

Tape Wrap	ANSI/AWWA C209, except single ply tape thickness shall not be less than 30 mils; Protecto Wrap "200" or Tapecoat "CT".
Primer	As recommended by the tape manufacturer.
Coal Tar Epoxy	High-build coal tar epoxy; PPG Amercoat "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Chlorine Tank Car Unloading Connection	Special flanged hose assembly conforming to materials and details on Drawing No. 135, The Chlorine Institute, Inc.

PART 3 - EXECUTION

3-1. INSPECTION. All piping components shall be inspected for damage and cleanliness before being installed. Any material damaged or contaminated in handling on the job shall not be used unless it is repaired and recleaned to the original requirements by Design-Builder or system supplier, whoever installs the equipment. Such material shall be segregated from the clean material and shall be inspected and approved by Owner or his representative before its use.

3-2. PREPARATION.

3-2.01. Field Measurement. Pipe shall be cut to measurements taken at the site, not from the Drawings. All necessary provisions shall be made in laying out piping to allow for expansion and contraction. Piping shall not obstruct openings or passageways. Pipes shall be held free of contact with building construction to avoid transmission of noise resulting from expansion.

3-3. INSTALLATION.

3-3.01. General. All instruments and specialty items shall be installed according to the manufacturer’s instructions and with sufficient clearance and access for ease of operation and maintenance.

Flat faced wrenches and vises shall be used for copper tubing systems. Pipe wrenches and vises with toothed jaws will damage copper materials and shall not be used. Bends in soft temper tubing shall be shaped with bending tools.

3-3.02. Pipe Sleeves. Piping passing through concrete or masonry shall be installed through sleeves that have been installed before the concrete is placed or when masonry is laid. Pipe sleeves installed through floors with a special finish, such as ceramic or vinyl composition tile, shall be flush with the finished floor surface and shall be provided with nickel or chromium plated floor plates. Unless otherwise indicated on the Drawings, in all other locations where pipes pass through floors, pipe sleeves shall project not less than 1 inch [25 mm] nor more than 2 inches [50 mm] above the floor surface, with the projections uniform within each area. In the case of insulated pipes, the insulation shall extend through pipe sleeves. Where the Drawings indicate future installation of pipe, sleeves fitted with suitable plastic caps or plugs shall be provided.

Holes drilled with a suitable rotary drill will be considered instead of sleeves for piping which passes through interior walls and through floors with a special finish.

Unless otherwise indicated on the Drawings, all pipes passing through walls or slabs which have one side in contact with earth or exposed to the weather shall be sealed watertight with special rubber-gasketed sleeve and joint assemblies, or with sleeves and modular rubber sealing elements.

3-3.03. Pipe Joints. Pipe joints shall be carefully and neatly made in accordance with the indicated requirements.

3-3.03.01. Threaded. Pipe threads shall conform to ANSI/ASME B1.20.1, NPT, and shall be fully and cleanly cut with sharp dies. Not more than three threads at each pipe connection shall remain exposed after installation. Ends of pipe shall be reamed after threading and before assembly to remove all burrs. Unless otherwise indicated, threaded joints shall be made up with teflon thread tape, thread sealer, or a suitable joint compound.

Threaded joints in plastic piping shall be made up with teflon thread tape applied to all male threads. Threaded joints in stainless steel piping shall be made up with teflon thread sealer and teflon thread tape applied to all male threads. Threaded joints in steel piping for chlorine service shall be made up with teflon thread tape or litharge and glycerine paste applied to all male threads.

3-3.03.02. Compression. Ends of tubing shall be cut square and all burrs shall be removed. The tubing end shall be fully inserted into the compression fitting and the nut shall be tightened not less than 1-1/4 turns and not more than 1-1/2 turns past fingertight, or as recommended by the fitting manufacturer, to produce a leaktight, torque-free connection.

3-3.03.03. Flared. Ends of annealed copper tubing shall be cut square, and all burrs shall be removed prior to flaring. Ends shall be uniformly flared without scratches or grooves. Fittings shall be tightened as needed to produce leaktight connections.

3-3.03.04. Soldered and Brazed. Where solder fittings are specified for lines smaller than 2 inches, joints may be soldered or brazed at the option of Design-Builder or system supplier, whoever installs the equipment. Brazing alloy shall contain no tin.

Surfaces to be joined shall be thoroughly cleaned with flint paper and coated with a thin film of flux. At each joint, tubing shall enter to the full depth of the fitting socket.

Care shall be taken to avoid overheating the metal or flux. Each joint shall be uniformly heated to the extent that filler metal will melt on contact. While the joint is still hot, surplus filler metal and flux shall be removed with a rag or brush.

3-3.03.05. Solvent Welded. Solvent welded connections shall only be used for PVC or CPVC pipe. All joint preparation, cutting, and jointing procedures shall comply with the pipe manufacturer's recommendations and ASTM D2855. Pipe ends shall be beveled or chamfered to the dimensions recommended by the manufacturer. Newly assembled joints shall be suitably blocked or restrained to prevent movement during the setting time recommended by the manufacturer. Pressure testing of solvent welded piping systems shall not be performed until the applicable curing time, as set forth in Table X2.1 of ASTM D2855, has elapsed. Solvent welding shall be performed by bonding operators who have met the requirements of ASME B31.3 and A328.

3-3.03.06. Epoxy and Adhesive Bonded. Not Used.

3-3.03.07. Heat Fusion Bonded. Heat fusion bonded joints shall be used for polyethylene pipe with socket and butt fusion fittings. All joint preparation, cutting, jointing equipment, and jointing procedures shall comply with the pipe manufacturer's recommendations. The heating time, temperature, pressure applied to the joint during bonding, and cooling time shall consistently produce leaktight joints as strong as the pipe being joined.

3-3.03.08. Flanged. Flange bolts shall be tightened sufficiently to slightly compress the gasket and effect a seal, but shall not be torqued less than the minimum value required by the gasket manufacturer. Flange bolts shall not be so tight as to fracture or distort the flanges. A plain washer shall be installed under the head and nut of bolts connecting plastic pipe flanges. Anti-seize thread lubricant shall be applied to the threaded portion of all stainless steel bolts during assembly.

Flange bolt holes shall be oriented as follows, unless otherwise indicated on the spool drawings:

Vertical flange face: Bolt holes to straddle the vertical centerlines.

Horizontal flange face: Bolt holes shall be aligned with connecting pipe.

Pipe sealants, thread compounds, or other coatings shall not be applied to flange gaskets unless recommended by the gasket manufacturer for the specified service and approved by Design-Builder.

Welds at orifice flanges shall have internal surfaces ground smooth to the pipe wall.

Slip-on flanges shall be welded inside and outside. There shall be a distance of approximately 1/16 to 1/8 inch [1.5 to 3 mm] between the edge of the fillet weld and the face of the flange. The seal weld shall be applied so that the flange face shall be free of weld spatter and does not require refacing.

Flat-faced flanges shall be used when mating to Class 125 flanges. Full-face gaskets shall be used with flat-faced flanges and ring gaskets shall be used with raised faced flanges.

Weld neck flanges shall be used with butt-weld fittings. The bore of weld neck flanges shall match the pipe wall thickness.

Insulating joints connecting submerged (buried) piping to exposed piping shall be installed above the maximum water surface elevation and before the first pipe support not having coated anchor bolts or adhesive-bonded concrete anchors. All submerged (buried) metallic piping shall be isolated from the concrete reinforcement. Insulating flanges shall be tested for electrical isolation after installation and bolt-up but prior to introduction of conducting fluid.

3-3.03.09. Welded. Welding shall conform to the specifications and recommendations contained in the "Code for Pressure Piping", ANSI B31.1.

Weld cross-sections shall be equal to or greater than the pipe wall thickness. Welds shall be smooth and continuous and shall have interior projections no greater than 1/16 inch [1.5 mm]. Backing strips or rings shall not be used except with specific prior review by Design-Builder as to use, material, and design. Root gap inserts that are completely melted and consumed in the weld bead are acceptable only when reviewed in advance by Design-Builder.

Stainless steel welding shall be inert gas tungsten arc (TIG) or the direct current, straight polarity, inert gas metal arc process (MIG). Refer to the stainless steel piping section for additional information on stainless steel welding.

Carbon steel welding shall be made by the shielded metal arc process.

For socket weld joints, fully engage the two pipe ends, then separate them by 1/16 inch prior to welding to all space for shrinkage.

3-3.03.10. Grooved Couplings. Grooves for grooved couplings shall be cut with a specially designed grooving tool. Grooves cut in steel pipe shall conform to flexible grooving dimensions, as set forth in AWWA C606, and shall be clean and sharp without burrs or check marks.

3-3.03.11. Push-on. Gasket installation and other jointing procedures shall be in accordance with the recommendations of the manufacturer. Each spigot end shall be suitably beveled to facilitate assembly. All joint surfaces shall be lubricated with a heavy vegetable soap solution immediately before the joint is completed. Lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean.

3-3.03.12. Rubber-Gasketed. Not Used.

3-3.03.13. Other Pipe Joints. Coupled joints in tempered glass pipe, plastic joints in vitrified clay pipe, and other proprietary type joints shall be made in accordance with the manufacturer's recommendations.

3-3.04. Pipe. Pipe shall be installed as specified, as indicated on the Drawings.

Piping shall be installed without springing or forcing the pipe in a manner which would induce stresses in the pipe, valves, or connecting equipment.

Piping shall be supported in conformance with the Pipe Supports section.

Piping shall be connected to equipment by flanges or unions as specified in the various piping sections. Piping connecting to equipment shall be supported by a pipe support and not by the equipment.

Water, gas, and air supply piping shall be provided with a shutoff valve and union at each fixture or unit of equipment, whether or not indicated on the Drawings, to permit isolation and disconnection of each item without disturbing the remainder of the system. Air supply piping shall be provided with sectionalizing valves and valved air inlet connections as needed for isolation of portions of the system for periodic testing. Gas supply lines to buildings shall be provided with a shutoff valve and union located above grade immediately outside the building. A capped drip leg shall be provided at the bottom of the vertical riser of gas supply piping adjacent to gas-fired appliances.

A union shall be provided within 2 feet [600 mm] of each threaded-end valve unless there are other connections which will permit easy removal of the valve. Unions shall also be provided in piping adjacent to devices or equipment which may require removal in the future and where required by the Drawings or the Specifications.

All air piping shall be graded to points of drainage collection where drip legs and drain valves shall be provided. Air piping shall be sized for the service conditions, with the indicated minimum sizes:

Service	Minimum Size
Air signal	1/4 inch OD
Power air	1/2 inch OD
Air supply	1/2 inch OD
Bubbler drop pipes	3/4 inch
Buried piping	3/4 inch

Water supply piping within structures shall be arranged, and facilities provided, for complete drainage. All piping serving metering equipment shall be uniformly graded so that air traps are eliminated and complete venting is provided.

Stuffing box leakage from water sealed pumps shall be piped to the nearest point of drainage collection.

Taps for pressure gauge connections on the suction and discharge of pumping units shall be provided with a nipple and a ball type shutoff valve.

Drilling and tapping of pipe walls for installation of pressure gauges or switches will not be permitted.

In all piping, insulating fittings shall be provided to prevent contact of dissimilar metals, including but not limited to, contact of copper, brass, or bronze pipe, tubing, fittings, valves, or appurtenances, or stainless steel pipe, tubing, fittings, valves, or appurtenances with iron or steel pipe, fittings, valves, or appurtenances. Insulating fittings shall also be provided to prevent contact of copper, brass, or bronze pipe, tubing, fittings, valves or appurtenances with stainless steel pipe, tubing, fittings, valves, or appurtenances.

Branch connections in horizontal runs of steam, air, and gas piping shall be made from the top of the pipe.

Buried PVC piping shall be "snaked" in the trench and shall be kept as cool as possible during installation. PVC pipe shall be kept shaded and shall be covered with backfill immediately after installation.

All chemical piping shall be installed so that lines are readily accessible for cleaning. Tees shall be provided at regular intervals in all chemical piping except chlorine piping, with extra openings plugged, to facilitate cleaning. Teflon thread tape or teflon thread sealer shall be applied to the threads of the plugs so that

they can be easily removed. At each point where hose or reinforced plastic tubing is connected to rigid piping, a quick-disconnect coupling shall be provided.

Double-contained chemical feed piping shall be installed according to the manufacturer's recommendations. Joints shall be solvent cemented. Splitting and rewelding of fittings will not be acceptable. Suitable drains and vents shall be provided to permit complete drainage of both the primary and secondary containment piping. Interstitial supporting devices shall be designed to allow continuous drainage in the annular space to the drain ports. Drain fittings shall be designed to allow a valve attachment to be made so that the secondary containment compartment can be readily drained and manually inspected for leaks.

Polyethylene piping shall be installed in accordance with the manufacturer's recommendations. A continuous 12 AWG THHN insulated copper tracer wire shall be placed 6 inches [150 mm] above all portions of the buried pipe, but no more than 18 inches [450 mm] below the ground surface. Where the pipe extends above grade, a 2 foot [0.6 m] length of wire shall be coiled and attached to the pipe.

Piping adjacent to flow sensors shall be installed in accordance with the requirements of the manufacturer of the flow sensor and commonly accepted design practices of the appropriate straight pipe runs both upstream and downstream.

Drains required for operation are shown on the Drawings. However, vents at all high points and drains at all low points in the piping that are required for complete draining for pressure test may not be shown on these Drawings. Design-Builder or system supplier, whoever installs the equipment, shall add such items as found to be necessary during detail piping design and/or piping installation.

3-3.05. Reducers. Eccentric reducers shall be installed flat on the bottom for steam, condensate return and digester gas services.

3-3.06. Valves. Isolation valves provided with equipment and instruments shall be located in a manner which will allow ease of access and removal of the items to be isolated. Prior to soldering or brazing valves, teflon and elastomer seats and seals shall be removed to prevent damage.

3-4. PIPING ASSEMBLY.

3-4.01. General. Design-Builder or system supplier, whoever installs the equipment, shall only use labor that has been qualified by training and experience to capably perform the specified activities required to accomplish the work in a satisfactory manner

3-4.02. Buttwelded Piping. The specification and qualification of weld joints and welders for buttwelded piping shall be in accordance with ASME Boiler Pressure Vessel Code, Section IX, Welding and Brazing.

Nondestructive examination (NDE) shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section V, Nondestructive Examination. The minimum level of NDE shall be as follows:

(1) 100 percent visual examination of welds by a qualified examiner (per ASME B31.1), and

(2) Radiographic testing (RT) of 10 percent random sampling of welds.

Welding shall not begin until weld joint and welder qualification submittals have been reviewed and approved. NDE shall be performed before the pressure and leakage testing of the piping. Weld acceptance standards shall be in accordance with ASME B31.1, Chapter VI. If a weld fails the NDE, it shall be repaired and the test repeated at no additional cost to the Owner.

3-5. PROTECTIVE COATING. Standard weight steel pipe in buried locations will have exterior surfaces protected with a shop applied plastic coating.

Where specified in the Miscellaneous Steel Pipe, Tubing, and Accessories section, extra strong steel pipe in buried locations will have exterior surfaces protected with a shop applied plastic coating or a shop applied tape wrap. Where not specified to be shop coated or wrapped in the Miscellaneous Steel Pipe, Tubing and Accessories section, a tape wrap shall be field applied. The exterior surfaces of all fittings, couplings, specials, and other portions of buried piping not protected with plastic coating shall be tape-wrapped in the field.

All surfaces to be tape-wrapped shall be thoroughly cleaned and primed in accordance with the tape manufacturer's recommendations immediately before wrapping. The tape shall be applied by two-ply (half-lap) wrapping or as needed to provide a total installed tape thickness of at least 60 mils [1.5 mm]. Joints in plastic-coated pipe shall be cleaned, primed, and tape-wrapped after installation.

Joints in galvanized steel piping in underground locations shall be field painted with two coats of coal tar epoxy coating.

3-5.01. Inspection. All shop-applied plastic coatings and tape wrap on pipe or fittings shall be inspected for holidays and other defects after receipt of the pipe or fitting on the job and immediately before installation. All field-applied tape wrap on pipe, joints, fittings, and valves shall be inspected for holidays and other defects following completion of wrapping. Inspection of plastic coatings after installation of the pipe or fitting in the trench shall be made where the coating may have been damaged during installation. Holidays and defects disclosed by

inspection shall be repaired in accordance with the recommendations of the coating or tape wrap manufacturer, as applicable.

The inspection shall be made using an electrical holiday detector. The detector and inspection procedures shall conform to the requirements of Section 4.4 of ANSI/AWWA C209.

3-6. PRESSURE AND LEAKAGE TESTING. All specified tests shall be made by and at the expense of Design-Builder or system supplier, whoever installs the equipment. Each piping system shall be tested for at least 1 hour with no loss of pressure. The Design-Builder shall coordinate this section with the Pipeline Pressure and Leakage Testing section. Piping shall be tested at the indicated pressures:

Service	Test Pressure	Test Medium
Water supply	1-1/2 times working pressure but not less than 120 psi [828 kPa]	Water
Gas supply	1-1/2 times working pressure but not less than 60 psi [414 kPa]	Compressed air
Air supply and signal (See paragraph 3-6.01)	1-1/2 times working pressure but not less than 50 psi [345 kPa]	Compressed air with 100 percent of all oil 0.025 micron and larger removed
Other piping	1-1/2 times working pressure but not less than 50 psi [345 kPa]	Suitable fluid or gas; for distilled water piping, distilled water or filtered oil-free compressed air may be used

Compressed air or pressurized gas shall not be used for testing plastic piping unless specifically recommended by the pipe manufacturer.

Leakage may be determined by loss-of-pressure, soap solution, chemical indicator, or other positive and accurate method. All fixtures, devices, or accessories which are to be connected to the lines and which would be damaged if subjected to the specified test pressure shall be disconnected and the ends of the branch lines plugged or capped as needed during the testing.

After completion of the specified pressure tests, all anhydrous ammonia, chlorine and sulfur dioxide gas piping shall be tested for leakage using the appropriate gas chemical at operating pressures. Piping shall be thoroughly cleaned and dried before admitting gas chemical into the system. Gas chemical shall be slowly admitted to the piping system.

For chlorine gas piping, leakage shall be checked by waving a swab soaked in aqua ammonia solution near each fitting. Ammonia solution shall not be applied directly to the fittings. Formation of white fumes will indicate the presence of leaks. All chlorine gas shall be purged from the line before leaks are repaired.

Unless otherwise required by the applicable codes, drainage and venting systems shall be water tested. For water testing, the drainage and venting system shall be filled with water to the level of the highest vent stack. For air testing, the system shall be charged with air to a minimum pressure of 5 psig [35 kPa]. Openings shall be plugged as necessary for either type of test. To be considered free of leaks, the system shall hold the water or air for 30 minutes without any drop in the water level or air pressure.

All necessary testing equipment and materials, including tools, appliances and devices, shall be furnished and all tests shall be made by and at the expense of Design-Builder or system supplier, whoever installs the equipment.
All joints in piping shall be tight and free of leaks. All joints which are found to leak, by observation or during any specified test, shall be repaired, and the tests repeated.

3-6.01. Air Pressure Tests. Pressure tests shall be performed on all air piping systems as specified herein to conform to ASME B31.1.

The test pressure shall be as specified herein and shall not exceed the maximum allowable test pressure of any non-isolated component, such as vessels, compressors, blowers, or valves, in the system. The pressure in the system shall gradually be increased to not more than one-half of the test pressure, after which the pressure shall be increased in steps of approximately one-tenth of the test pressure until the required test pressure has been reached. The pressure shall be continuously maintained for a minimum duration of 10 min. It shall then be reduced to the blower rated discharge pressure held for such time as may be necessary to conduct the examination for leakage.

Examination for leakage detected by soap bubble or equivalent method shall be made at all joints and connections. The piping system, exclusive of possible localized instances at the compressor, blower, or valve packing, shall show no evidence of leaking.

Design-Builder or system supplier, whoever installs the equipment shall be responsible for ensuring that all air piping is free of leaks. All joints which are found to be leaking shall be repaired and the test repeated.

3-7. CLEANING. The interior of all pipe, valves, and fittings shall be smooth, clean, and free of blisters, loose mill scale, sand, dirt, and other foreign matter

when installed. Before being placed in service, the interior of all lines shall be thoroughly cleaned.

Metal anhydrous ammonia, chlorine and sulfur dioxide piping shall be cleaned as recommended by the gas chemical feed system supplier. All surfaces which may come into contact with gas chemical shall be thoroughly dry and free of oil or grease before being placed in service. The recommended cleaning procedures shall be submitted for review in accordance with the Submittals section.

Tin-lined copper tubing for distribution of distilled water shall be flushed and cleaned with distilled water in accordance with the tubing manufacturer's recommendations.

3-8. ACCEPTANCE. Owner reserves the right to have any section of the piping system which he suspects may be faulty cut out of the system by Design-Builder or system supplier, whoever installs the equipment, for inspection and testing. Should the joint prove to be sound, Owner will reimburse Design-Builder or system supplier, whoever installs the equipment, on a time-and-material basis as specified in the Contract. Should the joint prove to be faulty, the destructive test will continue joint by joint in all directions until sound joints are found. Costs for replacement of faulty work and/or materials shall be the responsibility of Design-Builder or system supplier, whoever installs the equipment.

End of Section

Section 40 05 17

COPPER TUBING AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of copper tubing and accessories. Copper tubing shall be furnished complete with all fittings, flanges, unions, and other accessories specified herein.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

shall obtain and submit a written statement from the gasket material manufacturer certifying that the gasket materials are compatible with the joints specified herein and are recommended for the specified field test pressures and service conditions.

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping, handling and storage shall be in accordance with the general Terms and Conditions section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

PART 2 - PRODUCTS

2-1. MATERIALS. Copper tubing materials and service shall be as specified herein.

2-1.01. Material Classification CU-1.

CU-1 – Water Tubing with Flared Fittings	Tubing	Soft annealed copper tubing, ASTM B88, Type K.

Buried water supply, 2 inch and smaller. Differential pressure lines from flow elements to transmitters. All instrument tubing not otherwise specified.	Fittings	Flared, material to match tubing. Fittings shall conform to ANSI/ASME B16.26.

2-1.02. Material Classification CU-2.

CU-2 – Water Tubing with Brazed Joints Buried water supply, 2-1/2 and 3 inch.	Tubing Fittings	Hard drawn copper tubing, ASTM B88, Type K. Brazed joint, material to match tubing. Fittings shall conform to ANSI B16.18 or ANSI/ASME B16.22.

2-1.03. Material Classification CU-3.

CU-3 – Water Tubing with Solder and Brazed Joints Potable, non-potable, and plant effluent water supply, 3 inch and smaller. Hot water supply. Heating water. Differential pressure lines for flow transmitters. Chilled water. Compressed air, in-plant and exposed. Laboratory vacuum.	Tubing Fittings Flanges	Hard drawn copper tubing, ASTM B88, Type L. Solder joint (smaller than 2 inch except compressed air piping), Brazed joint (2 inch and larger for piping other than compressed air and all sizes for compressed air piping), material to match tubing. Fittings shall conform to ANSI B16.18, or ANSI/ASME B16.22. Where required for connection to equipment, valves, and accessories, ANSI B16.24, class 150, cast bronze, brazed joint.

2-1.04. Material Classification CU-4.

CU-4 – Air Tubing with Solder and Brazed Joints Buried or submerged compressed air supply piping.	Tubing Fittings	Soft annealed copper tubing, ASTM B88, Type K. Solder joint (smaller than 2 inch except liquid oxygen), Brazed joint (any size), material to match tubing. Fittings shall conform to ANSI B16.18, or ANSI/ASME B16.22.

2-1.05. Material Classification CU-5.

CU-5 – Chemical Feed Tubing with Union Fittings Chlorine container flexible connection. Sulfur dioxide container flexible connection.	Tubing Fittings	Soft annealed copper tubing, ASTM B88, Type K, cadmium plated for chlorine services. Union type with nonmetallic gasket or chemical lead alloy gasket containing 2 to 4 percent antimony. Fittings shall be brazed to tubing.

2-1.06. Material Classification CU-6.

CU-6 – Instrument Tubing with Compression Fittings Panel mounted compressed air piping, 3/4 inch and smaller. Instrument air piping 3/4 inch and smaller.	Tubing Fittings	Soft annealed copper tubing, ASTM B280. Dimensions shall be in accordance with ASTM B280. Compression type, brass, Crawford "Swagelok" or Parker Hannifin "CPI".

2-1.07. Material Classification CU-7.

CU-7 – ARC Tubing with Brazed Fittings Refrigerant piping.	Tubing Fittings	Hard drawn ACR copper tubing, ASTM B280. Dimensions shall be in accordance with ASTM B280. Brazed.

2-1.08. Material Classification CU-8.

CU-8 – Hydraulic Tubing with Compression Fittings As shown on Drawings.	Tubing Fittings	ASTM B75, seamless, soft annealed, wall thickness as required. Tubing size: As shown on Drawings. Required wall thickness: As required. Compression type, brass, Crawford "Swagelok" or Parker Hannifin "CPI".

2-1.09. Accessory Materials. Accessory materials for the copper tubing systems shall be as indicated.

Flange Bolts and Nuts	ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.
Flange Gaskets	ASTM D1330, Grade I, red rubber, ring type, 1/8 inch thick.
Expansion Joints	Tempflex "Model HB Expansion Compensators" with copper tube ends.
Insulating Fittings	
Threaded	Dielectric steel pipe nipple, ASTM A53, Schedule 40, poly-propylene lined, zinc plated; Perfection Corp. "Clearflow Fittings".
Flanged	Epco "Dielectric Flange Unions" or Central Plastics "Insulating Flange Unions".

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 19

DUCTILE IRON PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of ductile iron pipe. Ductile iron pipe shall be furnished complete with all fittings, specials, adapters, closure pieces, blowoffs, outlets, caps and plugs, temporary bulkheads, access manholes, jointing materials, pipe hangers and supports, anchors, blocking, encasement, appurtenances, and accessories specified and indicated on the Drawings, and as required for proper installation and functioning of the piping.

The size, service, and locations of ductile iron pipelines are covered in the Pipeline Schedule section and on the Drawings.

Piping furnished hereunder shall be complete with all joint gaskets, bolts, nuts and other jointing materials required for installation of any valves and equipment furnished by the equipment supplier, Design-Builder or others for installation under this Contract.

Pipe hangers and supports, pressure and leakage testing, cathodic protection, and cleaning and disinfection are covered in other sections. Pipe trenching, embedment, and backfill are covered in the Trenching and Backfilling section.

1-2. GOVERNING STANDARDS. Except as modified or supplemented herein, all ductile iron pipe, fittings, and specials shall conform to the applicable requirements of the following standards and other standards named in this section:

ANSI/AWWA Standards	Title
C151	Ductile-Iron Pipe, Centrifugally Cast, For Water
C600	Installation of Ductile Iron Water Mains and Their Appurtenances
M41	Ductile Iron Pipe and Fittings - Manual of Water Supply Practices
C104	Cement Mortar Lining for Ductile Iron Pipe and Fittings
C105	Polyethylene Encasement for Ductile Iron Pipe Systems
C110	Ductile-Iron and Gray-Iron Fittings

C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
C115	Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
C153	Ductile-Iron Compact Fittings

1-3. PIPE MANUFACTURER AND FIELD SERVICES. The pipe manufacturer responsibilities, which shall include, at a minimum; coordinating and furnishing all pipe materials, gaskets, bolts, and other jointing materials, and pipe appurtenances (except for furnished coupled joints and other similar products by a specified manufacturer) for a complete piping system that meets the specified test pressures and service conditions; ensuring and certifying that all pipe, fittings, specials, and other pipe materials, pipe gaskets and bolts specified herein, are being manufactured in full accordance with the Contract Documents; preparing and submitting all submittal information and shop drawings; and making any corrections that may be required to submittal information and shop drawings.

All ductile iron pipe shall be installed in accordance with the pipe manufacturer's recommendations.

1-4. SUBMITTALS. Drawings, details, specifications, and installation schedules covering all ductile iron pipe and accessories shall be submitted in accordance with the Submittals Procedures section. The drawings and data shall include, but shall not be limited to, the following:

Certification by manufacturer (affidavit of compliance) for each item furnished in accordance with the ANSI/AWWA Standards.

Restrained joints details.

Certification of gaskets by pipe manufacturer, certifying that gasket material is suitable for test pressures and services intended.

Certification that all materials in contact with treated or potable water are ANSI/NSF 61 approved.

Certification of joint lubricant.

Certification of proof-of-design tests for joints, including restrained joints.

Certification of proof-of-design tests for welded-on outlets and experience documentation. Air test documentation for the welded-on outlets used for this project.

Two samples of the polyethylene encasement, each sample clearly identified as required by the Governing Standards and test results from an independent third party laboratory of the requirements specified in ANSI/AWWA C105/A21.5.

Submittal data shall clearly indicate the country of origin of pipe, fittings, flanges, restraining devices, and accessories. When requested by Design-Builder, certified copies of physical and chemical test results as outlined in ANSI/AWWA C151/A21.51 shall be submitted for the materials to be provided.

1-5. SPARE MATERIALS. Not Used.

1-6. SHIPPING, HANDLING, AND STORAGE. Shipping shall be in accordance with the general Terms and Conditions . Handling and storage on-site shall be in accordance with the Product Storage and Handling Requirements section, and as specified herein.

Pipe, fittings, and accessories shall be handled in a manner that will ensure installation in sound, undamaged condition. Equipment, tools, and methods used in handling and installing pipe and fittings shall not damage the pipe and fittings. Hooks inserted in ends of pipe shall have broad, well-padded contact surfaces. Unpadded hooks, wire brushes or other abrasive tools shall not be permitted to come into contact with polyethylene lining if such lining is specified.

PART 2 - PRODUCTS

2-1. PIPE CLASS. The class of ductile iron pipe shall be as indicated in the following table for those services indicated in the Pipeline Schedule section. The specified class includes service allowance and casting allowance.

2-2. MATERIALS.

Pipe	Ductile iron, ANSI/AWWA C151/A21.51
Gaskets – All Joint Types	Synthetic rubber unless otherwise specified; natural rubber will not be acceptable. All gaskets shall be furnished by the pipe manufacturer

	unless another manufacturer's product is indicated. Pipe manufacturer shall submit certificates of gasket suitability certifying that the gasket materials are compatible with the joints specified, are recommended for the specified field test pressure and service conditions. Gaskets for treated or potable water service shall be certified for chlorinated and chloraminated potable water. Gas and oil-resistant gaskets shall be made of Nitrile (NBR [Acrylonitrile Butadiene]) rubber. The name of the material shall be permanently marked or molded on the gasket. Gaskets shall also be certified as suitable where soils may be contaminated with gas and oil products.
Joint Lubricant	Vegetable-based lubricant recommended by the pipe manufacturer. Petroleum or animal-based lubricants will not be acceptable. Lubricants that will be in contact with treated or potable water shall be certified as being in compliance with ANSI/NSF 61.
Fittings	ANSI/AWWA C110/A21.10 (except shorter laying lengths will be acceptable for U.S. Pipe), or ANSI/AWWA C153/A21.53, minimum working pressure rating as follows, unless indicated otherwise on the Drawings.

Fitting Size in.	Material	Type	Min. Working Pressure Rating, psi
4 to 24	DI	Mechanical and Push-on joints	350
4 to 24	DI	Flanged joints	250
30 to 48	DI	All joints	250

54 to 64 DI All joints 150

All fittings shall be ductile iron and suitable for the rated working pressure plus a surge or test pressure allowance of 100 psi or 1.5 times rated working pressure, whichever is less, without leakage or damage.

Push-on Joints ANSI/AWWA C111/A21.11.

	Restrained Push-on Joints, gaskets with stainless steel gripping segments, (4 inch through 12 inch), working pressure rating 350 psi.	American “Fast Grip”. U.S. Pipe "Field Lok 350 Gasket", or McWane Sure Stop 350 Gasket.
	Restrained Push-on Joints, locking wedge type, (4 inch through 24 inch), working pressure rating 350 psi for 4 through 16 inch and at least 250 psi for 18 through 24 inch.	EBAA Iron "Megalug" Series 1700; U.S. Pipe “TR Flex Gripper Ring”; Star Pipe Products “StarGrip 3100P”; or American “Field Flex Ring”, or accepted equal.
	Restrained Push-on Joints, positive locking segments and/or rings, (4 inch through 24 inch), working pressure rating 350 psi.	American "Flex-Ring,"; U.S. Pipe or McWane "TR Flex"
	Restrained Push-on Joints, positive locking segments and/or rings, (30 inch through 48 inch), working pressure rating at least 250 psi.	American "Flex-Ring," or "Lok-Ring"; U.S. Pipe or McWane "TR Flex"; U.S. Pipe HP LOK..
	Restrained Push-on Joints, positive locking segments and/or rings, (54 inch thru 64 inch), working pressure rating at least 250 psi.	American "Lok Ring"; or U.S,Pipe “H.P. LOK”.
Restrained push-on joints shall be suitable for a test or working pressure plus surge pressure of the rated working pressure plus 100 psi (680 kPa)		
Flanged Joints		ANSI/AWWA C115/A21.15.
	Flanges	
	Class 250 (Where identified on the Drawings)	Ductile iron, flat faced, with ANSI/ASME B16.1, Class 250 diameter and drilling.

	All Others	Ductile iron, Class 125, ANSI/AWWA C115/A21.15.
Flanges		All flanges shall be suitable for test pressure of 1.5 times rated pressure without leakage or damage.
Bolts		ASTM A307, chamfered or rounded ends projecting 1/4 to 1/2 inch beyond outer face of nut.
Nuts		ASTM A563, hexagonal, ANSI/ASME B18.2.2, heavy semifinished pattern.
Gaskets		ASTM D1330, Grade I rubber, full face type, 1/8 inch thick unless otherwise required by pipe manufacturer and accepted by Design-Builder. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets - All Joint Types.
Insulated Flanges		
Flanges		As specified herein, except bolt holes shall be enlarged as needed to accept bolt insulating sleeves.
Insulation Kits		As manufactured by Advanced Products or Pipeline Seal and Insulator, Inc.
	Insulating Gaskets	Type E, G-10, 1/8 inch thick, with Nitrile or EPDM sealing element for water and air service and Viton sealing elements for wastewater service unless otherwise required by pipe manufacturer and accepted by Design-Builder. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets - All Joint Types.
	Bolt Insulating Sleeves	G-10, 1/32 inch thick.
	Insulating Washers	G-10, 1/8 inch thick, two for each flange bolt.
	Backing Washers	Steel, 1/8 inch thick, two for each flange bolt.
Mechanical Joints		ANSI/AWWA C111/A21.11., with ductile iron glands.

	Restrained Mechanical Joints (factory prepared spigot), (4 inch through 48 inch), working pressure rating at least 250 psi.		American "MJ coupled Joints", or Griffin "Mech-Lok".
	Restrained Mechanical Joints, (field cut spigot), (4 inch through 24 inch), working pressure rating 350 psi for 4 through 16 inch and at least 250 psi for 18 through 24 inch.		EBAA Iron "Megalug" Series 1100, Sigma “One Lok” SLDE series, or Star Pipe Products “StarGrip 3000” or accepted equal.
Restrained mechanical joints shall be suitable for a test or working pressure plus surge pressure of the rated working pressure plus 100 psi			
	Wall Pipes or Castings		Mechanical joint with water stop and tapped holes; single casting or fabricated ductile iron pipe; holes sized in accordance with the details on the Drawings and provided with removable plugs.
	Mechanical Joints with Tie Rods		As indicated on the Drawings.
		Tie Rods	ASTM A307.
		Steel Pipe	ASTM A53, Schedule 40 or 80 as indicated on the Drawings.
		Washers	ANSI/ASME B18.22.1, plain steel.
Threaded Connections			ANSI/ASME B1.20.1, NPT; with boss or tapping saddle wherever wall thickness minus the foundry tolerance at the tapped connection is less than that required for 4-thread engagement as set forth in Table A.1, Appendix A, of ANSI/AWWA C151/A21.51.
Mechanical Couplings			
	Couplings		Dresser "Style 38"; Smith-Blair "411 Steel Coupling"; or Romac “Style 400” or "Style 501"; without pipe stop.

	Gaskets	Oil-resistant synthetic rubber gaskets shall be as recommended by the coupling manufacturer. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets - All Joint Types.
Restrained Mechanical Couplings		American Pipe “Restrained Coupling Gland Joint” coordinated with mechanical couplings furnished.
Grooved-End Joints		AWWA C606.
	Pipe Ends (rigid joints)	Grooved, with dimensions conforming to AWWA C606, Table 3.
	Pipe Ends (flexible joints)	Shouldered, with dimensions conforming to AWWA C606, Table 4.
	Couplings (non-shouldered pipe)	Tyco/Grinnell "Figure 772," or Victaulic "Style 31."
	Couplings (shouldered pipe)	Victaulic "Style 41" or "Style 44".
Flanged Coupling Adapters		
	Restrained (4 inch through 12 inch). Unless otherwise indicated on the Drawings, flanged coupling adapters shall be restrained.	Smith-Blair "Type 912", Romac "Style FCA501", or equal, with anchor studs of sufficient size and number to withstand test pressures.
	Unrestrained (14 inch and larger)	Smith-Blair "Type 913", Romac "Style FC400", or equal.
Dismantling Joints		
	Restrained (3 inch and larger) Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.	Romac "DJ400"; Dresser "Style 131 Dismantling Joint", Viking Johnson, or equal. For use in potable water systems, coating to be in accordance with NSF-61.
Tapping Saddles		Ductile iron, with stainless steel straps and synthetic rubber sealing gasket, 250 psi pressure rating.
Watertight/Dusttight Pipe Sleeves		GPT " Link-Seal", insulating type with modular rubber sealing elements, nonmetallic pressure plates, and stainless steel bolts and nuts.
Shop Coating and Lining		

	Cement Mortar Lining with Seal Coat	ANSI/AWWA C104/A21.4.
	Protective Fusion-Bonded	ANSI/AWWA C116/A21.16.
	Ceramic Epoxy Lining	Induron "Protecto 401 Ceramic Epoxy".
	Glass Lining	Two-coat system applied over blast-cleaned surface; ground and finish coats separately fired; finished lining thickness at least 10 mils, Mohs' Hardness 5 to 6 density as determined by ASTM D792; Fast Fabricators, Inc. "MEH 32" or "SG-14".
	Universal Primer	Manufacturer's standard. If in contact with treated or potable water, certify as being in compliance with ANSI/NSF 61.
	Asphaltic Coating	Manufacturer's standard.
	Zinc Coating	ISO 8179
	Coal Tar Epoxy	Manufacturer's standard.
	Liquid Epoxy	ANSI/AWWA C210, non-coal tar modified, or when in contact with treated or potable water, certify as being in compliance with ANSI/NSF 61.
Anti-Seize Thread Lubricant		Jet-Lube "Nikal", John Crane "Thred Gard Nickel", Bostik/Never-Seez "Pure Nickel Special" or Permatex "Nickel Anti-Seize".
Corrosion Protection		
	Polyethylene Encasement	Seamless, ANSI/AWWA C105/A21.5; LLDPE - 8 mil or HDCLPE - 4 mil.
	Heat-shrinkable Coating and Primer (Shrink Sleeve)	ANIS/AWWA C216, cross-linked polyethylene sheeting precoated with adhesive; minimum 80 mils; type and recovery as recommended by Shrink Sleeve manufacturer; Canusa-CPS or Berry Plastics Water Wrap.
	Wax Tape and Primer	ANSI/AWWA C217, cold-applied petroleum wax primer and cold-applied petroleum wax tape; Trenton Wax-Tape and Primer.

	Medium Consistency Coal Tar	Carboline "Bitumastic 50" or Tnemec "46-465 H.B. Tnemecol."

2-3. OUTLETS. Where a 12 inch or smaller branch outlet is indicated and the diameter of the parent pipe is at least twice the diameter of the branch, a tee, a factory welded-on boss, or a tapping saddle will be acceptable.

Where a 4 inch [100 mm] or larger branch outlet is indicated on the Drawings and the diameter of the branch pipe for a given diameter of parent pipe is less than or equal to the maximum diameter listed herein, a factory welded-on outlet fabricated from centrifugally cast ductile iron pipe will be acceptable.

Parent Pipe Diameter Versus Maximum Branch Pipe Diameter for Welded-On Outlets

Parent Pipe Dia inches	Max Branch Pipe Dia inches	Parent Pipe Dia inches	Max Branch Pipe Dia inches
8	4	30	20
10	6	36	24
12	8	42	30
14	8	48	30
16	10	54	36
18	12	60	36
20	14	64	36
24	16		

All 30 inch and smaller branch pipe diameter welded-on outlets shall be rated for a working pressure of 250 psi, 36 inch branch diameter welded-on outlets shall be rated for a working pressure of 200 psi, and all outlets shall have a minimum factor of safety of 2.0. The pipe manufacturer shall provide test data and certification of proof of design. It is not necessary that these tests be performed on pipe manufactured specifically for this project. Certified reports covering tests made on other pipe of the same size and design as specified herein and manufactured from materials of equivalent type and quality may be accepted as adequate proof of design.

Welded-on outlets may be provided as a radial (tee) outlet, a tangential outlet, or a lateral outlet fabricated at a specific angle to the parent pipe (in 15 degrees [0.262 rad] increments between 45 degrees and 90 degrees [0.785 to 1.570 rad]

from the axis of the parent pipe), as indicated on the Drawings. The fillet weld dimensions for welded-on outlets shall be as specified herein. Parent pipe and branch pipe shall meet hydrostatic test requirements in accordance with ANSI/AWWA C151/A21.51 prior to fabrication.

Welded-on Outlet Fillet Weld Dimensions for Specified Outlet Configurations

Radial and Lateral Outlets			Tangential Outlets		
Parent Pipe Dia inches	Branch Pipe Dia inches	Weld Fillet Size inches	Parent Pipe Dia inches	Branch Pipe Dia inches	Weld Fillet Size inches
24 and smaller	24 and smaller	1 x 1	8-30	24 and smaller	1-1/4 x 1-1/4
30-48	24 and smaller	1-1/4 x 1-1/4	36-54	24 and smaller	1-1/2 x 1-1/2
54-64	24 and smaller	2-1/4 x 2-1/2	60-64	24 and smaller	2-1/2 x 2-1/2
42-64	30	2-1/2 x 2-1/2	42-54	30	2-1/2 x 2-1/2

All joints on welded-on branch outlets shall be made in accordance with the latest revision of ANSI/AWWA C111/A21.11 and/or ANSI/AWWA C115/A21.15, as applicable. All outlets shall be fabricated from centrifugally cast ductile iron pipe designed in accordance with ANSI/AWWA C150/A21.50 and manufactured and tested in accordance with ANSI/AWWA C151/A21.51. Ni-Rod FC 55® electrodes manufactured by International Nickel Corporation (or an electrode with equivalent properties) shall be used in the manufacture of the fillet welds. Carbon steel electrodes will not be acceptable. Special Thickness Class 53 pipe shall be used for all branch pipe and parent pipe in 4 to 54 inch sizes. Pressure Class 350 pipe shall be used for 60 inch and 64 inch parent pipe. After welding, each fabricated outlet shall be subjected to a 15 psi air test. A soap and water solution shall be applied during the testing procedure to inspect the weld for leakage. Any welds that show air seepage shall be refabricated and retested.

Welded-on outlets shall be fabricated by the pipe manufacturer at its production facilities. Manufacturers of welded-on outlets shall have at least 5 years of satisfactory experience in the manufacture and performance of these products. The manufacturer shall have a documented welding quality assurance system and shall maintain resident quality assurance records based on ANSI/AWS D11.2, the Guide for Welding Iron Castings. The manufacturer shall also maintain appropriate welding procedure specifications (WPS) and procedure qualification (PQR), and welder performance qualification (WPQR) records.

The type of pipe end for the branch outlet shall be as specified or indicated on the Drawings. The maximum size and laying length of the welded-on branch outlet shall be as recommended by the pipe manufacturer and shall be acceptable to Design-Builder for the field conditions and the connecting pipe or valve.

At locations acceptable to Design-Builder, drilling and tapping of the pipe wall for 2 inch and smaller pipe connections will also be acceptable, provided that the wall thickness, minus the casting allowance, at the point of connection equals or exceeds the wall thickness required for 4-thread engagement in accordance with Table A.1, Appendix A of ANSI/AWWA C151/A21.51.

2-4. JOINTS. Joints in buried and tunnel locations shall be mechanical or push-on type unless otherwise indicated on the Drawings or where required to connect to existing piping or to valves. Bells on wall castings and wall sleeves shall be mechanical joint type, with tapped holes for tie rods or stud bolts. All other joints shall be flanged unless otherwise indicated on the Drawings.

Certification of joint design shall be provided in accordance with ANSI/AWWA C111/A21.11, Performance Requirements, as modified herein. The joint test pressure shall be not less than 2 times the working pressure rating of the joint. The same certification and testing shall also be provided for restrained joints. For restrained joints, the piping shall not be blocked to prevent separation and the joint shall not leak or show evidence of failure. It is not necessary that such tests be made on pipe manufactured specifically for this project. Certified reports covering tests made on other pipe of the same size and design as specified herein and manufactured from materials of equivalent type and quality may be accepted as adequate proof of design. Any new proof-of-design testing to meet the requirements for this project shall be independently verified and the Owner shall be given the opportunity to witness the testing.

Unless otherwise indicated on the drawings or acceptable to the Design-Builder, field closure pieces shall be located away from the bends or dead ends beyond the length over which joints are to be restrained.

The length of pipe having restrained joints shall be as indicated on the drawings or specified. All vertical bends and eccentric reducers shall have restrained joints.

2-4.01 Flanged Joints. Pipe shall extend completely through screwed-on flanges. The pipe end and flange face shall be finish machined in a single operation. Flange faces shall be flat and perpendicular to the pipe centerline.

2-4.02. Flanged Coupling Adaptors. Flanged coupling adapters shall be provided for restrained couplings 12 inch and smaller where indicated on the Drawings and as specified herein. Unless indicated otherwise on the Drawings,

all flange coupling adapters 12 inch and smaller shall be restrained. Flange coupling adapters 14 inch and larger may only be used in unrestrained pipe applications.

The inner and outer surfaces of couplings, except flange mating surfaces, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall then be shop coated with liquid epoxy in accordance with ANSI/AWWA C210. The flange mating surfaces shall be cleaned and shop primed with universal primer.

2-4.03. Dismantling Joints. Dismantling joints shall be provided for restrained couplings 6 inch and larger piping where indicated on the Drawings and as specified herein. Dismantling joints shall comply with AWWA C219 and shall be restrained flange by flange couplings manufactured as a single unit. Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.

The inner and outer surfaces of dismantling joints, except flange mating surfaces, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall then be shop coated with liquid epoxy in accordance with ANSI/AWWA C210. The flange mating surfaces shall be cleaned and shop primed with universal primer.

2-4.04. Mechanical Couplings. The piping layout for mechanical couplings shall provide a space of at least 1/4 inch , but not more than 1 inch , between the pipe ends.

All surfaces, including the interior surfaces of the middle rings, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall be shop coated with 16 mils liquid epoxy in accordance with ANSI/AWWA C210.

A ductile iron pipe factory spacer shall be provided for the piping where indicated on the drawings. The spacer shall be shop lined and coated with 16 mils of liquid epoxy. Piping surfaces within the coupling shall be shop coated with 16 mils of liquid epoxy.

Tie bolts shall be provided to restrain mechanical coupling connections where indicated on the Drawings. The connecting pipe shall be furnished with welded retainer rings as recommended by pipe manufacturer. The pipe manufacturer shall also coordinate the restrained connection with the pressure rating, length, and diameter dimensions of the mechanical coupling being furnished to assure proper clearance is provided for completing the restrained coupling installation.

2-4.05. Grooved-End Couplings. Grooved-end couplings shall not be used in the following applications: chemical service, except lime slurry piping, flammable liquid or flammable gas piping, compressed air or compressed gas piping operating at pressures above 25 psig , toxic gas piping, hot liquid with operating temperatures above 120°F, or steam piping.

2-5. REDUCERS. Reducers shall be eccentric or concentric as indicated on the Drawings. Reducers of eccentric pattern shall be installed with the straight side on top, so that no air traps are formed.

2-6. BLOWOFFS. Each blowoff shall be located and arranged as indicated on the Drawings.

2-7. ACCESS OPENINGS. Access openings shall be installed at the locations indicated on the Drawings. Access openings shall be 36 inch diameter outlets for 36 inch and larger diameter pipe and the same size as the pipe for 24 and 30 inch diameter pipe. Access openings shall be provided with either flanged outlets with blind flange cover or mechanical joint outlets with restrained mechanical joint plugs. Unless otherwise indicated on the, covers shall be designed for the same external loads and internal pressures as the adjacent pipe. Covers shall be fabricated from steel plate and shall have two handles fabricated from 1 inch diameter rod or shall be manufacturer's standard blind flange with integrally cast lifting devices, either one in the center or two or more symmetrically located around the perimeter of the cover. At the option of the Design-Builder, reinforced or dished covers of lighter weight and equal strength may be provided.

2-8. WALL AND FLOOR PIPES. Wall and floor pipes shall be installed where ductile iron pipes pass through concrete walls or floors, unless otherwise indicated on the Drawings.

Where a flange and mechanical joint pipe piece is to connect to a mechanical joint wall pipe or casting, the bolt holes in the bell of the wall pipe or casting shall straddle the top centerline of the horizontal pipe or casting and shall align with the bolt holes in the flange and mechanical joint piece. The top centerline shall be marked on the wall pipe or casting at the foundry or fabrication shop.

In vertical piping, the bolt holes of flanged and mechanical joint floor pipes or castings shall be aligned with the bolt holes of the flange or mechanical joint connecting piece. The required centerline alignment and orientation of the floor pipe or casting shall be marked on the floor pipe or casting at the foundry or fabrication shop.

2-9. WALL AND FLOOR SLEEVES. Wall and floor sleeves shall be installed where indicated on the Drawings and shall be installed where ductile iron pipe passes through concrete walls and floors or masonry walls, unless otherwise noted. To minimize sleeve size, piping on either side of the sleeve shall be

provided with a screw-on flange, grooved coupling, or mechanical coupling with anchor studs to allow the pipe to pass through the sleeve. Where required, sleeves in masonry walls may be enlarged enough for flange or other joint restraint to pass through the sleeve.

Where specified or indicated on the Drawings, one or two sets of modular casing seals shall be installed at the face of walls to seal against soil or provide a dust or water tight seal. Design-Builder shall coordinate the diameter of wall or floor sleeves with the modular casing seal manufacturer. When soil may be present at wall sleeves, two sets of modular casing seals shall be installed, one at each face of the wall. Unless otherwise indicated on the Drawings, modular casing seals shall not be used in submerged conditions unless the hydrostatic pressure is less than 20 feet and piping is less than 24 inch size.

2-10. SHOP COATING AND LINING. The interior of all pipe and fittings, unless noted otherwise, shall be cement mortar lined.

Lining for pipe and fittings for gravity sewers and wastewater facilities services shall be as specified below:

Service	Lining
Gravity sewers	Cement mortar.
Grit piping	Glass or system supplier standard
Scum piping	Glass or system supplier standard
All sludge piping except piping conveying activated sludge from final settling basins	Glass or system supplier standard
Sludge holding tank overflow and supernatant drawoff piping	Glass or system supplier standard
All other wastewater piping	Cement mortar.

Glass-lined pipe buried or embedded in concrete shall be ductile iron with mechanical or push-on joints; glass-lined pipe installed in interior locations may be flanged ductile iron with flanged cast or ductile iron fittings. Where drilling or tapping of glass-lined pipe for 2-inch and smaller pipe connections is required, pre-manufactured welded on, threaded bosses shall be provided. Alternatively, the pipe manufacturer may pre-drill the pipe prior to installing glass lining and provide a tapping saddle.

The exterior surfaces of all pipe and fittings which will be exposed in both interior and exterior locations shall be shop primed. For System Supplier packages, piping shall be coated in the shop with the final coating as indicated in the

various System Supplied packages. Field painting of exposed exterior surfaces is covered in the Protective Coatings section for Design-Builder installed piping. Flange faces shall be coated with a suitable rust-preventive compound. Exterior surfaces of all other pipe and fittings shall be coated with asphaltic coating.

2-11. OWNER'S SHOP INSPECTION AND TESTING. Not Used.

PART 3 – EXECUTION

3-1. INSPECTION. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation; pipe ends shall be examined with particular care. All defective pipe and fittings shall be removed from the site.

3-2. PROTECTION AND CLEANING. The interior of all pipe and fittings shall be thoroughly cleaned of all foreign material prior to installation and shall be kept clean until the work is completed. Before jointing, all joint contact surfaces shall be wire brushed if necessary and wiped clean.

Precautions shall be taken to prevent foreign material from entering the pipe during installation. Debris, tools, clothing, or other objects shall not be placed in or allowed to enter the pipe.

Whenever pipe laying is stopped, the open end of the pipe shall be closed to prevent entry of dirt, mud, rodents, and other material. All water in the trench shall be removed prior to removing the closure.

3-3. CUTTING PIPE. Cutting shall be done in a neat manner, without damage to the pipe or the lining. Cuts shall be smooth, straight, and at right angles to the pipe axis. After cutting, the ends of the pipe shall be dressed with a file or a power grinder to remove all roughness and sharp edges. The cut ends of push-on joint pipe shall be suitably beveled.

All field cutting of existing gray cast iron pipe shall be done with mechanical pipe cutters, except where the use of mechanical cutters would be difficult or impracticable.

Ends of ductile iron pipe shall be cut with a portable guillotine saw, abrasive wheel, saw, milling cutter, or oxyacetylene torch. The use of hydraulic squeeze type cutters will not be acceptable. Field-cut holes for saddles shall be cut with mechanical cutters; oxyacetylene cutting will not be acceptable.

Design-Builder shall use factory prepared pipe ends unless a field cut is required for connections.

3-4. ALIGNMENT AND GRADE. Buried piping shall be laid to the lines and grades indicated on the Drawings and as specified. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line or grade shall not exceed the values stipulated for full-length push-on joint pipe for full-length mechanical joint pipe of AWWA C600, unless specially designed bells and spigots are provided. Design-Builder shall submit his proposed methods to measure deflection of deflected joints in accordance with the Submittal section.

Whenever deflections would exceed the values stipulated in AWWA C600, either shorter pipe sections or fittings shall be installed where needed to conform to the alignment or grade indicated on the Drawings.

Unless otherwise specified or acceptable to Design-Builder, laser beam equipment, surveying instruments, or other suitable means shall be used to maintain alignment and grade. At least one elevation reading shall be taken on each length of pipe. If laser beam equipment is used, periodic elevation measurements shall be made with surveying instruments to verify accuracy of grades. If such measurements indicate thermal deflection of the laser beam due to differences between the ground temperature and the air temperature within the pipe, precautions shall be taken to prevent or minimize further thermal deflections.

Additional requirements for alignment and grade are covered in the Project Requirements and Trenching and Backfilling sections and on the Drawings.

3-4.01. Tolerances. Each section of pipe shall be laid to the alignment and grade indicated on the Drawings and pipe laying schedule with pipe ends within the following tolerances;

+/- 0.10 foot in grade at any point
+/- 0.20 foot in alignment at any point

In addition, piping shall be visually straight or on a smooth curve between the points of defection or curvature indicated on the Drawings. Stricter tolerances than specified above shall be used as necessary to maintain minimum cover, to maintain required clearances, to make connections to existing pipe, to maintain the correct slope to avoid high or low points along the pipeline other than at locations indicated on the Drawings, or to meet other restrictions as required or directed by the Design-Builder.

3-5. LAYING PIPE. Buried pipe shall be protected from lateral displacement by placing the specified pipe embedment material installed as specified in the Trenching and Backfilling section. Under no circumstances shall pipe be laid in water, and no pipe shall be laid under unsuitable weather or trench conditions.

Pipe embedment material and trench backfill shall be placed and compacted under and around each side of outlets and fittings to hold the pipe in proper position and alignment during the subsequent pipe jointing, embedment, and backfilling.

Pipe shall be laid with the bell ends facing the direction of laying, except where reverse laying is specifically acceptable to Design-Builder.

3-6. JOINTS.

Each joint, including restrained joints, shall be checked by Design-Builder as recommended by the pipe manufacturer to verify that the joint and the restraints are installed properly. Restrained joints shall be extended after they are assembled to minimize further take-up.

3-7. MECHANICAL JOINTS. Mechanical joints shall be carefully assembled in accordance with the pipe manufacturer's recommendations. If effective sealing is not obtained, the joint shall be disassembled, thoroughly cleaned, and reassembled. Bolts shall be uniformly tightened to the torque values listed in Appendix A of ANSI/AWWA C111/A21.11. Over tightening of bolts to compensate for poor installation practice will not be acceptable.
The holes in mechanical joints with tie rods shall be carefully aligned to permit installation of the tie rods. In flange and mechanical joint pieces, holes in the mechanical joint bells and the flanges shall straddle the top centerline for horizontal piping.

3-8. PUSH-ON JOINTS. The pipe manufacturer's instructions and recommendations for proper jointing procedures shall be followed. All joint surfaces shall be lubricated with a soap solution provided by the pipe manufacturer immediately before the joint is completed. Lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean. Each spigot end shall be suitably beveled to facilitate assembly.

Pipe ends for restrained joint pipe shall be prepared in accordance with the pipe manufacturer's recommendations.

3-9. FLANGED JOINTS. When bolting flanged joints, care shall be taken to avoid restraint on the opposite end of the pipe or fitting which would prevent uniform gasket compression or would cause unnecessary stress in the flanges. One flange shall be free to move in any direction while the flange bolts are being tightened. Bolts shall be tightened gradually in a crisscross pattern and at a uniform rate, to ensure uniform compression of the gasket around the entire flange. All flange joint bolting procedures shall be in accordance with the pipe manufacturer's recommendations.

Special care shall be taken when connecting piping to any pumping equipment to ensure that piping stresses are not transmitted to the pump flanges. All connecting piping shall be permanently supported to obtain accurate matching of bolt holes and uniform contact over the entire surface of flanges before any bolts are installed in the flanges.

Pump connection piping shall be free to move parallel to its longitudinal centerline while the bolts are being tightened. Each pump shall be leveled, aligned, and wedged into position which will fit the connecting piping, but shall not be grouted until the initial fitting and alignment of the pipe, so that the pump may be shifted on its foundation if necessary to properly install the connecting piping. Each pump shall, however, be grouted before final bolting of the connecting piping.

After final alignment and bolting, the pump connections shall be tested for applied piping stresses by loosening the flange bolts which, if the piping is properly installed, should result in no movement of the piping relative to the pump or opening of the pump connection joints. If any movement is observed, the piping shall be loosened and re-aligned as needed and then the flanges bolted back together. The flange bolts shall then be loosened and the process repeated until no movement is observed.

3-9.01. Insulated Flanged Joints. Insulated flanged joints shall be installed where indicated on the Drawings. In addition to one full-faced insulated gasket, each flange insulating assembly shall consist of one full-length sleeve, two insulating washers, and two backing washers for each flange bolt. The insulating gasket ID shall be 1/8 inch [3 mm] less than the ID of the flange in which it is installed. The insulated flanged joint accessories shall be installed in accordance with the instructions and recommendations of the insulating kit manufacturer.

3-10. FLANGED COUPLING ADAPTERS. Flange coupling adapters shall be installed in accordance with the coupling manufacturer's recommendations. After the pipe is in place and bolted tight, the locations of holes for the anchor studs shall be determined and the pipe shall be field-drilled. Holes for anchor studs shall be drilled completely through the pipe wall. Hole diameter shall be not more than 1/8 inch [3 mm] larger than the diameter of the stud projection. Unless indicated on the Drawings, all flange coupling adapters shall be restrained.

3-11. DISMANTLING JOINTS. Dismantling joints shall be installed in accordance with the coupling manufacturer's recommendations.

3-12. MECHANICAL COUPLINGS. Mechanical couplings shall be installed in accordance with the coupling manufacturer's recommendations. A space of at least 1/4 inch [6 mm], but not more than 1 inch [25 mm], shall be left between the

pipe ends. Pipe and coupling surfaces in contact with gaskets shall be clean and free from dirt and other foreign matter during assembly. All assembly bolts shall be uniformly tightened so that the coupling is free from leaks, and all parts of the coupling are square and symmetrical with the pipe. Following installation of the coupling, damaged areas of shop coatings on the pipe and coupling shall be repaired to the satisfaction of Design-Builder.

3-13. GROOVED-END JOINTS. Grooved-end joints with rigid type grooving shall be installed in accordance with the coupling manufacturer's recommendations. Completed joints shall be rigid and shall allow no angular deflection or longitudinal movement. Except for closure pieces, field grooving of pipe will not be acceptable.

3-14. GAS AND OIL-RESISTANT GASKETS. Not used.

3-15. CORROSION PROTECTION.

3-15.01. Polyethylene Encasement. All buried pipe including all straight pipe, bends, tees, adapters, closure pieces, and other fittings or specials, shall be provided with at least one wrap of polyethylene encasement. Other locations where ductile iron pipe and accessories shall be double wrapped with polyethylene encasement shall be as specified herein. Where ductile iron pipe is also encased in concrete, including in locations beneath structures, the polyethylene encasement shall be installed around the pipe for 5 feet extending into each end of the concrete encasement. Where the ductile iron pipe is embedded within a concrete structure wall, floor or footing, the polyethylene encasement for the pipe shall end at the outside faces of the structure. Ductile iron pipe embedded within concrete structures shall not be wrapped with polyethylene encasement.

All buried flanged valves, mechanical joint couplings with tie rods, mechanical couplings, restrained mechanical couplings and other pipe harness assemblies at valves or structure walls shall be provided with two wraps of polyethylene encasement in addition to other corrosion protection coatings as specified herein.

Polyethylene tube protection shall be installed in accordance with ANSI/AWWA C105/A21.5, Method A. Preparation of the pipe shall include, but shall not be limited to, removal of lumps of clay, mud, cinders, etc., prior to installation.

The terms "polyethylene tube protection" and "polyethylene encasement" are interchangeable and shall have the same meaning in these Contract Documents.

3-15.01.01. Inspection and Testing. Tests for preliminary acceptance of polyethylene encasement materials as required in the submittal paragraph shall be made at the expense of the Design-Builder.

At the Owner's expense, the Owner may obtain samples from the material supplied in the field and have test conducted of the requirements specified in ANSI/AWWA C105/A21.5 by an independent third-party laboratory.

3-15.02. Mechanical Joint Couplings with Tie Rods. The mechanical joint tie rods, bolt studs, pipe spacers and washers of buried mechanical joint couplings as detailed on the Drawings shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Following application of the wax tape protection, the entire mechanical joint coupling assembly shall be wrapped with two layers of polyethylene encasement as specified herein. The two wraps of polyethylene encasement shall be lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the coupling assembly.

3-15.03. Flanged Joints. The flange bolts and nuts on buried flanges, including valve flanges, shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Following application of the wax tape protection, the entire flanged joint shall be wrapped with two layers of polyethylene encasement as specified herein. The two wraps of polyethylene encasement shall be lapped a minimum of 12 inches with the polyethylene encasement on each side of the joint.

3-15.04. Valves. Buried portions of the valve and the actuator to the wrench nut shall be wrapped with two layers of polyethylene encasement as specified herein. The two wraps of polyethylene encasement shall be lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the valve.

3-15.05. Mechanical Couplings. The tie bolts and nuts on all buried mechanical couplings shall be coated with two coats of medium consistency coal tar.

After the protective coating has been applied to the tie bolts, the entire mechanical coupling shall be encapsulated with a shrink sleeve as indicated on the Drawings. The shrink sleeve shall extend a minimum of 6 inches on to the pipe on each side of the coupling. A primer shall be applied to the piping on each side of the coupling prior to installing the shrink sleeve. The application of the shrink sleeve shall be in accordance with ANSI/AWWA C216 and as recommended by the shrink sleeve manufacturer. There shall be no bare or unprotected ferrous metal surfaces. Following installation of the shrink sleeve,

the entire assembly shall be encapsulated with two wraps of polyethylene encasement lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the assembly as specified herein.

3-15.06. Restrained Mechanical Couplings. The corrosion protection for the mechanical coupling and its tie bolts and nuts of all buried restrained mechanical coupling assemblies shall be protected with two coats of medium consistency coal tar and shrink sleeve as specified herein for buried mechanical couplings.

The tie rods and bolts of the coupling assembly shall be protected by wrapping them with wax tap in accordance with ANSI/AWWA C217 and as detailed on the Drawings. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Following the application of the wax tape, the entire restrained mechanical coupling assembly shall be encapsulated with two wraps of polyethylene encasement lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the assembly as specified herein.

3-15.07. Other Assemblies. All ferrous metal clamps, tie rods, bolts, and other components of buried joint harnesses, tapping saddles, or pipe reaction anchorages in contact with earth or other fill material and not encased in concrete, shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Following the application of the wax tape, the entire assembly shall be encapsulated with two wraps of polyethylene encasement lapped a minimum of 12 inches with the polyethylene encasement of the piping on each side of the assembly as specified herein.

3-15.08. Surfaces Exposed in Manholes and Vaults. Unless otherwise specified, all uncoated surfaces exposed in manholes and vaults shall be cleaned and coated with two coats of medium consistency coal tar. The first coat shall be dry and hard before the second coat is applied. There shall be no unprotected, bare, or uncoated ferrous metal surfaces.

3-16. PROVISIONS FOR CATHODIC PROTECTION SYSTEMS. If required, a corrosion protection system shall be provided for buried piping as specified in the Corrosion Protection for Pipelines section.

3-16.01. Electrical Bond Across Rubber-Gasketed Joints. Two electrical bonding cables shall be provided across each mechanical coupling and each

rubber-gasketed bell-and-spigot joint. Before applying the field joint coating to mechanical couplings, two small areas of the metal surface shall be exposed on each side of the coupling, on the middle ring, and on each follower ring. Each exposed area shall be thoroughly cleaned, and two cathodic protection cables shall be connected to the top of the pipe at least 12 inches apart, one end of each on either side of the joint, and to the middle ring and follower rings of mechanically coupled joints, using the thermite process. The completed connections and exposed metal surfaces shall be coated as specified for field repair of coatings.

Joint bond cables shall contain at least 6 inches of slack wire to compensate for pipe movement and backfill settlement.

3-16.02. Electrical Bond Across Valves and Flanges. Two electrical bonding cables shall be provided across valves and flanged connections other than insulating flanges in the same manner as specified for rubber-gasketed joints.

3-16.03. Bonding Cables. Bonding cable and test lead wires shall be at least 8 AWG, Type CP copper cathodic protection cable, with low density, high molecular weight polyethylene insulation.

3-17. CONNECTIONS WITH EXISTING PIPING. Connections between new work and existing piping shall be made using fittings suitable for the conditions encountered. Each connection with an existing pipe shall be made at a time and under conditions which will least interfere with service to customers, and as authorized by Owner. Facilities shall be provided for proper dewatering and for disposal of all water removed from dewatered lines and excavations without damage to adjacent property.

Special care shall be taken to prevent contamination when dewatering, cutting into, and making connections with existing potable water piping. Trench water, mud, or other contaminating substances shall not be permitted to enter the lines. The interior of all pipe, fittings, and valves installed in such connections shall be thoroughly cleaned and then swabbed with, or dipped in, a 500 mg/L chlorine solution.

3-18. CONCRETE ENCASEMENT. Concrete encasement shall be installed where indicated on the Drawings. A pipe joint shall be provided within 12 inches of each end of the concrete encasement. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section. All pipe to be encased shall be suitably supported and blocked in proper position, and shall be anchored to prevent flotation.

3-19. REACTION ANCHORAGE AND BLOCKING. Concrete blocking shall be installed where indicated on the Drawings. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section.

The blocking size shall be of the dimensions indicated on the Drawings, shall extend from the fitting to solid, undisturbed earth, and shall be installed so that all joints are accessible for repair. If adequate support against undisturbed ground cannot be obtained, restrained joints shall be installed to provide the necessary support. If the lack of suitable solid vertical excavation face is due to improper trench excavation, restrained joints shall be furnished and installed by and at the expense of Design-Builder.

Reaction blocking, anchorages, or other supports for fittings installed in fills or other unstable ground, installed above grade, or exposed within structures, shall be provided as indicated on the Drawings.

All ferrous metal clamps, rods, bolts, and other components of tapping saddles, reaction anchorages, or joint harness, subject to submergence or in contact with earth or other fill material and not encased in concrete, shall be protected from corrosion as specified in the Corrosion Protection paragraph of this section.

3-20. PRESSURE AND LEAKAGE TESTS. After installation, pipe and fittings shall be subjected to a pressure test and a leakage test in accordance with the Pipeline Pressure and Leakage Testing section.

After installation, pipe and fittings shall be subjected to a pressure test and a leakage test. The Design-Builder shall provide all necessary pumping equipment; piping connections between the piping and the nearest available source of test water; pressure gauges; and other equipment, materials, and facilities necessary for the tests.

All pipe, fittings, valves, pipe joints, and other materials which are found to be defective shall be removed and replaced with new and acceptable materials, and the affected portion of the piping shall be retested by and at the expense of Design-Builder.

All joints shall be watertight and free from visible leaks. Any visible leak which is discovered within the correction period stipulated in the Terms and Conditions shall be repaired by and at the expense of Design-Builder .

End of Section

Section 40 05 23

STAINLESS STEEL PIPE AND ALLOY PIPE, TUBING, AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of stainless steel pipe and alloy pipe, tubing and accessories through 24" diameter for the services as indicated herein. Pipe and tubing shall be furnished complete with all fittings, flanges, unions, and other accessories specified herein.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

Gasket materials shall be compatible with the joints specified herein and shall be recommended by the manufacturer for the specified field test pressures and service conditions.
All welding and brazing procedures and operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of Section IX of the ASME Code. All procedure and operator qualifications shall be in written form and submitted to the Design Builder for review.

Pipe for liquid chemical service shall comply with ASME B31.3. Pipe for all other services shall comply with ASME B31.1.

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage after delivery onsite shall be in accordance with the Product Storage and Handling Requirements section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

PART 2 - PRODUCTS

2-1. MATERIALS. Stainless steel pipe and alloy pipe materials shall be as specified herein.

2-1.01. Material Classification SS-1. Not used.

2-1.02. Material Classification SS-2.

SS-2 – Schedule 10S with Beveled Ends. Aeration air piping. Air scour piping. Indirect potable reuse piping. Microfiltration filtrate piping. Overflow piping. Reverse osmosis concentrate piping. 2-1/2 inch and larger.	Pipe Fittings	ASTM A312 or ASTM A778 with longitudinal seams only, TP304L, Buttwelded, ASTM A403 WP-W or A774, wrought stainless steel, grade equivalent to pipe. Fittings shall conform to ANSI/ASME B16.9, Schedule 10S with beveled ends.

2-1.03. Material Classification SS-3. Not used.

2-1.04. Material Classification SS-4.

SS-4 – Schedule 40S with Beveled Ends. Microfiltration filtrate piping Reverse osmosis feed and forward flushing piping 2-1/2 inch and larger	Pipe Fittings	ASTM A312, Grade TP304L,. Buttwelded, ASTM A403, WP304L, Fittings shall conform to ANSI/ASME B16.9, Schedule 40S with beveled ends.

2-1.05. Material Classification SS-5.

SS-5 – Schedule 40S with Beveled Ends Reverse Osmosis piping. 2-1/2 inch and larger.	Pipe Fittings	ASTM A312, Grade TP316L. Buttwelded, ASTM A403, WP316L. Fittings shall conform to ANSI/ASME B16.9, Schedule 40S with beveled ends.

2-1.06. Material Classification SS-6.

SS-6 – Schedule 40S with Threaded Ends. Carbon slurry. Bubbler dip tube. Parshall flume to floatwell piping. Gauge piping in stainless steel piping systems (to match pipe). 2 inch and smaller.	Pipe Fittings	ASTM A312, TP316. Threaded, material to match pipe. Fittings shall conform to ANSI/ASME B16.3, Class 150.

2-1.07. Material Classification SS-7.

SS-7 – Schedule 40S with Plain Ends. Gauge piping in stainless steel piping systems. 2 inch and smaller with socket welded ends.	Pipe Fittings	ASTM A312, Grade TP304L, Socket welded, ASTM A182, F304L. Fittings shall conform to ANSI/ASME B16.11, Class 3000.

2-1.08. Material Classification SS-8.

SS-8 – Schedule 40S with Plain Ends. 2 inch and smaller.	Pipe Fittings	ASTM A312, Grade TP316L. Socket welded, ASTM A182, F316L. Fittings shall conform to ANSI/ASME B16.11, Class 3000.

2-1.09. Material Classification SS-9.

SS-9 – SS Tubing with Compression Fittings	Tubing	ASTM A269, seamless, TP316, annealed, max hardness Rockwell B80; with the following min wall thicknesses:

Lubrication water to grit removal equipment.		Tube OD inches 1/4 to 3/8 1/2 to 7/8 1 to 2	Wall Thickness inches 0.065 0.083 0.109
	Fittings	Compression type, AISI Type 316 stainless steel; Crawford "Swagelok", or Parker Hannifin "CPI" or "Ferulok".	

2-1.10. Material Classification SS-10. Not used.

2-1.11. Material Classification SS-11.

SS-11 – Schedule 10S with Beveled Ends. Aeration air piping. Filter air scour piping. Above grade in dry, noncorrosive atmospheres. 2-1/2 inch and larger.	Pipe Fittings	ASTM A312 or ASTM A778 with longitudinal seams only, TP304L or TP316L, Buttwelded, ASTM A403 WP-W or A774, wrought stainless steel, grade equivalent to pipe. Fittings shall conform to ANSI/ASME B16.9, Schedule 10S with beveled ends.

2-1.12. Material Classification CRP-1.

CRP-1 – Carpenter 20-Cb3 Pipe with Socket Weld Fittings Sulfuric acid piping, except where indicated otherwise.	Welded Seamless Fittings	ASTM B464 - UNS NO8020, Schedule 40. ASTM B729 - UNS NO8020, Schedule 40. Forged Fittings, ASTM B462; Socket weld, Class 3000, ASTM B462 - UNS NO8020. The use of flanged fittings shall be limited to equipment connections.

2-1.13. Material Classification HST-1.

-1 – Hastelloy C276 - Pipe with Socket Weld Fittings Sodium hypochlorite piping, except where indicated otherwise	Pipe Seamless Fittings	ASTM B622; Hastelloy C276 ASTM B622 - UNS N10276, Schedule 40 Forged Fittings ASTM B366; Welded Fittings ASTM B366; Hastelloy C276. The use of flanged fittings shall be limited to equipment connections.

2-1.14. Material Classification SS-12.

SS-12 – Alloy 2205 Duplex stainless Schedule 10S. Reverse Osmosis Piping with high chlorides	Pipe Fittings	ASTM A790 S31803 SMLS Buttwelded A815 S31803 or Socketwelded A182 F51 Fittings shall conform to ANSI/ASME B16.9 Schedule 10S with beveled ends or B16.11.

2-1.15. Accessory Materials. Accessory materials for the stainless steel pipe systems shall be as indicated. Flanges shall be flat faced for water service and shall be raised face for air or gas service except when connecting to flat face equipment or valve flanges.

Flanges

SS-1, SS-2 and SS-3 Pipe Backing Flanges	Stainless steel plate, AISI Type 304 or 316 to match fittings. Provide stub ends or angle face rings with material and thickness to match fittings. The angle or radius between the angle face ring or stub end and the pipe shall match the angle or radius of the backing flange for proper seating. Flanges shall conform with ANSI/ASME B16.5, Class 150 diameter and drilling; with the following thicknesses:

Nominal Pipe Size inches	Flange Thickness inches
1/2-8	1/2
10-16	5/8
18-20	3/4
24-30	1
36	1-1/4

SS-4 and SS-5 Pipe Flanges	ANSI/ASME B16.5, Class 150, AISI Type 304, 304L, 316, or 316L, to match piping.

SS-10 Pipe Flanges

Except where otherwise permitted or required, ANSI/AWWA C207, Class D, slip-on constructed of stainless steel plate or ANSI/ASME B16.5, Class 150, AISI Type 304, 304L, 316, or 316L, to match piping.

SS-11 Pipe Backing Flanges

Epoxy coated carbon steel to match fittings. Provide stub ends or angle face rings with material and thickness to match fittings. The angle or radius between the angle face ring or stub end and the pipe shall match the angle or radius of the backing flange for proper seating. Flanges shall conform with ANSI/ASME B16.5, Class 150 diameter and drilling; with the following thicknesses:

Nominal Pipe Size inches	Flange Thickness inches
1/2-8	1/2
10-16	5/8
18-20	3/4
24-30	1
36	1-1/4

Flange Bolts

ASTM A193 Class 2, AISI Type 304, ANSI B18.2.1, heavy hex head, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.

Flange Nuts

ASTM A194, AISI Type 304, ANSI/ASME B18.2.2, heavy hex pattern. Washers shall be installed under the nuts.

Flange Gaskets

Process air

Raised Face Flanges

Non-asbestos inorganic fiber with EPDM binder; dimensions to suit flange contact face, 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces, rated for 275°F service; Garlock "IFG 5507".

Flat Faced Flanges

Premium Grade, EPDM, full face type, 1/8 inch thick, rated for 275°F service; Garlock "8314".

Chemical services.

Gaskets in chemical service shall be compatible with chemical.

All other services.	Flexitalic "Style CG", spiral wound, AISI Type 304 stainless steel, non-asbestos filler, 3/16 inch nominal thickness, with compression ring 1/8 inch thick to match required flange dimensions.
Elbows	Except for elbows in chemical service lines 4 inches [100 mm] and smaller, elbows shall be long radius type for which the laying length is 1.5 times the pipe diameter.
Protective Coatings – High Temperature Buried Service	
Epoxy for buried aeration and process air piping	Shop or field applied high solids epoxy; suitable for protection at continuous pipe wall temperatures up to 300 F. Coating shall be abrasion resistant. The finished coating shall have a minimum total film thickness of 10 mils. The surface shall be prepared in accordance with SSPC-SP7 as a minimum unless otherwise recommended by the coating manufacturer. The coating shall be Carboline “Thermaline 450”, PPG Amercoat “Amerlock 400”, or equal.
Expansion Joints	
Process air	Expansion joints shall be the elastomeric, arched type and shall be Mercer “Type 450” with “Type 500” retaining rings and Kevlar reinforcement, or equal. The number of arches shall be as indicated on the Drawings. The connection shall be suitable for a maximum pressure of 15 psig [105 kPa gauge] and maximum temperature of 275 F [122 C]. Expansion joints shall have the following minimum ratings: Number of Arches: 1 Spring rate: 1,846 lbs/inch Movement: 1.25 inch Number of Arches: 2 Spring rate: TBD lbs/inch

	Movement:	TBD inch
	Number of Arches:	3
	Spring rate:	5,412 lbs/inch
	Movement:	0.75 inch
Anti-Seize Thread Lubricant		
Insulating Fittings		
Threaded	Dielectric steel pipe nipple, ASTM A53, Schedule 40, polypropylene lined, zinc plated; Perfection Corp. "Clearflow Fittings".	
Flanged	Epco "Dielectric Flange Unions" or Central Plastics "Insulating Flange Unions". Shall be suitable for temperature and service.	

2-1.15.01. Branch Connections. Branch connections 2-1/2 inches and smaller shall be made with welding fittings. Welded or Threaded outlets shall be used. Where the exact outlet size desired is in doubt, but is known to be less than 1 inch, a 1 inch outlet shall be provided and reducing bushings used as needed.

Branch connections sized 3 and larger shall be made with pipe nipples or with welding fittings with welded outlets. Pipe nipples and welding fittings shall be welded to the pipe shell and reinforced as needed to meet design and testing requirements. The pressure rating of branch and branch connections shall equal or exceed the pressure rating of the main pipe it is connected to.

Small branch connections shall be so located that they will not interfere with joints, supports, or other details, and shall be provided with caps or plugs to protect the threads during shipping and handling.

2-2. WELDING OF STAINLESS STEEL AND ALLOYS. Filler metal for welding austenitic stainless steel and alloys, P-number 8 base materials shall be in accordance with the following:

Material Type/Grade 304 shall use Type 308 filler metal.

Material Type/Grade 304L shall use Type 308L filler metal.

Material Type/Grade 316, shall use Type 316 filler metal.

Material Type/Grade 316L shall use Type 316L filler metal.

Material Type/Carpenter 20 shall use Carpenter 20 filler metal.

Material Type/Hastelloy C276 shall use Hastelloy C276 filler metal.

The following requirements shall apply when fabricating austenitic stainless steel and alloy components.

Grinding shall be by aluminum oxide, zirconium oxide, or silicon carbide grinding wheels that shall not have been used on carbon or low alloy steels. Hand or power wire brushing shall be by stainless steel brushes that shall not have been used on carbon or low alloy steels for stainless steel pipe. Hand or power wire brushing shall be by Carpenter 20 brushes that shall not have been used on carbon or low alloy steels for Carpenter 20 pipe. Hand or power wire brushing shall be by Hastelloy C276 brushes that shall not have been used on carbon or low alloy steels for Hastelloy C276 pipe. All tools used in fabrication shall be protected to minimize contact with steel alloys or free iron. Grinding wheels and brushes shall be identified and controlled for their use on these materials only to ensure that contamination of these materials does not occur.

Antispatter compounds, marking fluids, marking pens, tape, temperature indicating crayons, and other tools shall have a total halogen content of less than 200 parts per million.

Heat input control for welding shall be specified in the applicable WPS and shall not exceed 55,000 joules per inch (22,000 joules per cm) as determined by the following formula:

$$\text{Heat Input (J/in.)} = \frac{\text{Voltage x Amperage x 60}}{\text{Travel Speed (in./min.)}}$$

Complete penetration pressure retaining welds shall be made using the Gas Tungsten Arc Welding (GTAW) process for the root and second layer as a minimum.

Austenitic stainless steel instrument tubing shall be welded using only the GTAW process.

Socket welds or butt welds in all austenitic stainless steel instrument tubing lines shall require an inert gas backing (purge) using argon during welding to avoid oxidation.

The application of heat to correct weld distortion and dimensional deviation without prior written approval from the Design-Builder is prohibited.

Unless otherwise approved in writing, the GTAW process shall require the addition of filler metal.

The maximum preheat and interpass temperature for austenitic stainless steel shall be 350° F (176° C). The minimum preheat temperature shall be 50° F (10° C).

Complete joint penetration welds welded from one side without backing, weld repairs welded from one side without backing, or weld repairs in which the base metal remaining after excavation is less than 0.1875 inch (5 mm) from being through wall, which are fabricated from austenitic stainless steel ASME P-number 8 base metal or unassigned metals with similar chemical compositions, shall have the root side of the weld purged with an argon backing gas prior to welding. Backing gas (purge) shall only be argon. The argon backing gas shall be classified as welding grade argon or shall meet Specification SFA-5.32, AWS Classification SG-A. The backing gas (purge) shall be maintained until a minimum of two layers of weld metal have been deposited.

2-3. SHOP CLEANING AND PICKLING OF STAINLESS STEEL PIPING AND WELDS. All stainless steel piping shall be thoroughly cleaned and pickled at the mill in accordance with ASTM A380.

Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. After fabrication, pickled surfaces shall be subjected to a 24 hour water test or a ferroxyl test to detect the presence of residual embedded iron. All pickled surfaces damaged during fabrication including welded areas shall either be mechanically cleaned or repickled or passivated in accordance with ASTM A380. Materials that have been contaminated with steel alloys or free iron shall not be used until all contamination is removed. When cleaning to remove steel or iron contamination is required, it shall be performed in accordance with ASTM A380, Code D requirements. All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces. Particulate matter shall be removed from piping and welds. Labels shall be affixed to the piping sections to indicate shop cleaning has been performed. Welds shall be either mechanically cleaned or pickled or passivated on the exterior of the pipe.

For buried piping, at least the exterior of all welds shall be passivated.

2-4. HIGH TEMPERATURE EPOXY COATING. Not used.

2-5. INSULATING FITTINGS. In all piping, insulating fittings shall be provided to prevent contact of dissimilar metals, including but not limited to, contact of copper, brass, or bronze pipe, tubing, fittings, valves, or appurtenances, or stainless steel pipe, tubing, fittings, valves, or appurtenances with iron or steel pipe, fittings, valves, or appurtenances. Insulating fittings shall also be provided to prevent contact of copper, brass, or bronze pipe, tubing, fittings, valves or appurtenances with stainless steel pipe, tubing, fittings, valves, or appurtenances.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 24

STEEL PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of steel pipe 6 inches in diameter and larger. Steel pipe shall be furnished and installed complete with all fittings, specials, adapters, closure pieces, blowoffs, outlets, caps and plugs, temporary bulkheads, access manholes, jointing materials, pipe hangers and supports, anchors, blocking, encasements, cathodic protection, appurtenances, and accessories specified and indicated on the Drawings, and as required for proper installation and functioning of the piping.

Steel pipe smaller than 6 inches in diameter, light wall steel pipe, miscellaneous small piping, pipe hangers and supports, cathodic protection, pressure and leakage tests, and cleaning and disinfection are covered in other sections. Pipe trenching, embedment, and backfill are covered in the Trenching and Backfilling section.

The size, service, and location of steel pipelines are covered in the Pipeline Schedule section.

Piping furnished hereunder shall be complete with all joint gaskets, bolts, nuts and other jointing materials required for installation of any valves and equipment, including any valves and equipment furnished by Design-Builder or others for installation under this Contract.

1-2. GOVERNING STANDARDS. Except as modified or supplemented herein, all steel pipe, fittings, and specials shall conform to the applicable requirements of the following standards:

ANSI/AWWA Standards	Title
C200	Steel Water Pipe - 6 In. [150 mm] and Larger
C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied
C206	Field Welding of Steel Water Pipe

C207	Steel Pipe Flanges for Waterworks Service – Sizes 4 In. through 144 In. [100 mm through 3,600 mm]
C208	Dimensions for Fabricated Steel Water Pipe Fittings.
C209	Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
C210	Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
C216	Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
C217	Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines
C602	Cement Mortar Lining of Water Pipelines in Place – 4 In. [100 mm] and Larger
C604	Installation of Steel Water Pipe – 4 In. (100 mm) and Larger
C606	Grooved and Shouldered Joints
M11	Steel Pipe – A Guide for Design and Installation

ANSI/ASME Standards

B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
B16.47	Large Diameter Steel Flanges NPS 26 through NPS 60
B18.2.1	Square and Hex Bolts and Screws (Inch Series)
B18.2.2	Square and Hex Nuts (Inch Series)

B36.10 Welded and Seamless Wrought Steel Pipe

1-3. QUALIFICATIONS. Pipe manufacturer shall be ISO-9001 or SPFA certified with 5 years' experience in the manufacture of steel pipe, fittings, coatings, and linings specified.

1-4. SUBMITTALS. Drawings, details, specifications, installation schedules, welding procedures and welder qualifications, and other data showing complete details of the fabrication, construction, weld locations, joint details and certification, and installation of pipe, fittings, specials, and connections, together with complete data covering all materials proposed for use, shall be submitted in accordance with the Submittals Procedures section. The drawings and data shall include, but shall not be limited to, the following:

a. Certifications and Affidavits of Compliance: Design-Builder shall submit all certifications and affidavits of compliance. Performing and paying for sampling and testing as necessary shall be the Design-Builder's responsibility. The following certifications and affidavits of compliance are required for all pipe and other products or materials furnished, as specified in ANSI/AWWA C200 and herein.

(1) Mill Certificates. Material lists and steel reinforcement schedules which describe all materials to be utilized. Metallurgical test reports for steel proposed for use on the project. Chemical and physical test reports from each heat of steel that indicate the steel conforms to the Contract Documents. Records shall indicate heat of steel for each pipe joint listed in the pipe laying schedule.

(2) List cross-referencing pipe mark numbers with pipe sequence numbers, heat numbers, and can numbers.

(3) Hydrostatic test reports.

(4) Results of production weld tests.

(5) Sand, cement and mortar tests.

(6) Rubber gasket tests and gaskets certification by pipe manufacturer, including a written statement from the gasket material manufacturer, certifying that the gasket materials are compatible with the joints specified and are recommended for the specified field test pressure and service conditions.

(7) All materials in contact with treated or potable water are ANSI/NSF 61 approved.

(8) Certification of the proof-of-design tests for rubber gasketed bell and spigot joints (stab joints), or field experience documentation, as specified.

(9) Pipe temperature complies with Contract Documents prior to placing backfill material and prior to and during welding.

(10) All welds were performed in conformance with these Contract Documents.

(11) Affidavit of compliance for each ANSI/AWWA standard covering materials and work furnished for the project.

(12) Certification of pipe manufacturer's minimum experience requirements. Certification to be submitted prior to award of contract if required in the bidding documents or requested by Engineer.

b. Shop Drawings: The Design-Builder shall submit Shop Drawings of piping in accordance with the requirements of ANSI/AWWA C200 and the following supplemental requirements:

(1) Certified dimensional drawings of all pipe, fittings, specials, and appurtenances. The ASTM designation for the material from which each class of pipe is fabricated.

(2) Production schedule for manufacturing/fabricating pipe for the work as part of Design-Builder's Progress Schedule. Steel pipe production schedule shall be included in all versions of the Design-Builder's Progress Schedule beginning with the first Progress Scheduled submittal.

(3) Joint and pipe wall construction details which indicate the type and thickness of cylinder; the position, type, size and area of wire or other reinforcement; coatings and linings including holdbacks; manufacturing tolerances; maximum angular joint deflection limitations; and all other pertinent information required for the manufacture and installation of the product. Joint details and design criteria shall be submitted for all welded joint types, including beveled ends for alignment conformance and any deep butt strap joints required for control of temperature stresses.

(4) Pipe design criteria sufficient to ascertain conformance of pipe and fittings with the Contract Documents. Pipe design criteria shall include, but shall not be limited to, minimum pipe diameter, minimum pipe wall thickness, pressures, external loads, yield strength, allowable fiber stress, longitudinal stress for restraint, temperature changes, lining and coating materials, and other factors used for pipe design.

(5) Table(s) showing E', K, soil weight, deflection lag factor, external loads, and percent deflection from minimum to maximum cover depth shown in the Steel Pipe Schedule in one foot increments covering each size and class of pipe. Two tables shall be submitted for each size and class of pipe, one with live load and the design deflection lag factor specified herein and one without live load and a deflection lag factor of 1.0.

(6) Ground Elevation and Utility Locations:

(a) Design-Builder shall verify the existing ground elevations and the location and depth of all underground utilities using centerline stakes at no more than 100 feet intervals.

(7) Pipe Laying Schedule Information:

(a) Pipe laying schedule and marking diagrams compatible with the requirements of AWWA Manual 11 (M11) which indicate the specific number of each pipe, fitting, and special and the location and direction of each pipe fitting, and special in the completed pipeline. In addition, the pipe laying schedule shall include: the station and centerline or invert elevation coordinated with the Drawings to which the bell end of each pipe will be laid; all elements of curves and bends, both in horizontal and vertical alignment; and the limits within each reach of restrained and/or welded joints or of concrete encasement. The location of all mitered pipe sections, beveled ends for alignment conformance, and any deep butt strap joints for temperature stress control shall be clearly indicated on the diagrams.

The pipe laying schedule shall have a sequence of laying and an explanation of all abbreviations used in the schedule. For long, straight pipe runs, the pipe laying schedule shall list the pipeline station and either the pipe centerline or invert elevation coordinated with the Drawings at least every 100 feet.

(b) Drawings showing the location and details of bulkheads for hydrostatic testing of the pipeline including details for removal of test bulkheads and repair of the lining.

(c) Details and locations of closures and cutoffs for length adjustment, temporary access manholes, vents and weld lead pass holes as specified or indicated on the Drawings, and as required for construction convenience.

(d) The method that the Design-Builder proposes to use for measuring deflection of pipe joints.

(e) Annotated laying schedule showing all changes made during the progress of the Work.

(8) Welding Information: Submit the following prior to performing any welding work:

(a) Full and complete information regarding location, type, size and extent of all welds with reference called out for Welding Procedure Specifications (WPS) numbers shall be shown on the Shop Drawings. The Shop Drawings shall distinguish between shop and field welds. Shop Drawings shall indicate welding symbols for the details of the welded joints, and the preparation of parent metal required to make them. Joints or groups of joints in which welding sequence or technique are especially important shall be carefully controlled to minimize shrinkage stresses and distortion.

(b) Written welding procedures for shop and field welds (including Welding Procedure Specifications (WPS's) and Procedure Qualification Records (PQR's). All WPS used to fabricate and install pipe shall be qualified under the provisions of ANSI/AWS D1.1 – Structural Welding code – Steel or the ASME Boiler and Pressure Vessel Code (BPVC) for shop welds and ANSI/AWS D1.1 for field welds. Written WPS shall be required for all welds, both shop and field. WPS's qualified per the ASME BPVC shall include Supplementary Essential Variables for notch-tough welding. All provisions of ANSI/AWS D1.1 pertaining to notch-tough welding shall apply.

(c) Written nondestructive testing (NDT) procedure specifications and NDT personnel qualifications.

(d) Current welder performance qualifications (WPQ'S) shall be submitted for each welder prior to performing any work either

in the shop or field. Qualification testing shall be in accordance with ASME Section IX or AWS B2.1 and as defined in Section 4 of ANSI/AWWA C206 or ANSI/AWWA C200, as applicable.

(e) Credentials of the Design-Builder's certified welding inspectors (CWI's) and quality control specialists for review prior to starting any welding in the shop or field. The credentials shall include, but not be limited to, American Welding Society QC-1 Certification. Other NDT quality control personnel shall be certified as required by AWS D1.1 and in accordance with written practice ASNT SNT-TC-1A.

(f) All NDT data for each shop-welded and field-welded joint. This data shall include all testing on each weld joint, including re-examination of repaired welds, using visual, radiographic, magnetic particle, dye penetrant examination, ultrasonic or air test examination methods specified. Test data shall be reviewed and signed by the welding inspector(s).

(g) Welder logs for field and shop welding. Logs shall list all welders to be used for the work, the welding process, position, welder stamp number, certification date and certification status for each welder.

(h) A welding map showing the sequence of welds for all field welds.

(i) A written weld repair procedure for each type of shop and field weld proposed for use on the project.

(j) A written rod control procedure for shop and field operations demonstrating how the Design-Builder intends to maintain rods in good condition throughout the work. The rod control procedure shall also demonstrate how the Design-Builder intends to ensure that the proper rods are used for each weld.

(9) Control of Temperature Stresses for Welded Joints:

(a) Plan and installation instructions to avoid the accumulation of expansion and contraction to minimize temperature stresses in the pipe wall during installation and when the pipeline is in service. The plan and installation instructions shall include the sequencing of events during and after installation, including backfilling and welding, use of a lengthened bell, and other methods to control temperature stresses in the pipeline.

(b) Plan for monitoring pipeline temperatures.

(10) Detail drawings indicating the type, number and other pertinent details of slings, strutting, and other methods proposed for pipe support and handling during manufacturing, transport, and installation. The recommended methods of handling and placement of the pipe shall be submitted as a record copy prior to transporting any pipe to the Site. All pipe handling equipment and methods shall be acceptable to the Engineer.

(11) For record copy, detailed drawings indicating loading and shipping procedures that are designed to minimize damage to coating.

(12) Pipe manufacturer's written Quality Assurance/Control Program.

1-5. SHIPPING, HANDLING, AND STORAGE. Pipe, fittings, and accessories shall be handled and stored as recommended by the pipe manufacturer and shall be handled in a manner that will ensure installation in sound, undamaged condition. Equipment, tools, and methods used in handling and installing pipe and fittings shall not damage the pipe and fittings. Forks and other lifting devices shall have broad, well-padded contact surfaces.

Design-Builder shall repair any damage to pipe coatings and linings before the pipe is installed.

1-5.01. Stulling. Adequate stulling shall be designed and provided by the pipe manufacturer on all specials, fittings, and straight pipe so as to avoid damage to the pipe during handling, storage, hauling, and installation. The stulling shall be tight fitting to prevent pipe deflection and to maintain roundness of +/- 1.0 percent. Stulling shall not damage the lining. The stulling shall be placed as soon as practicable after the pipe lining is applied and shall remain in place while the pipe is loaded, transported, unloaded, and installed at the site.

PART 2 - PRODUCTS

2-1. BASIS OF DESIGN. Steel pipe, fittings, and specials shall be fabricated type for pipe 14 inches and larger, and may be either fabricated or mill type for pipe 12 inches and smaller. All items shall be the sizes, dimensions, and shapes indicated on the Drawings or specified herein.

The specified size of fabricated pipe, fittings, and specials shall be the nominal inside diameter, in inches, where 12 inches and smaller, and the actual inside diameter of pipe lining, where 14 inches and larger. Where stab joint pipe is

permitted and two or more wall thicknesses are required for pipe of the same size, pipe size may be adjusted slightly to allow the different classes of pipe to be stabbed together.

The specified size of mill pipe, fittings, and specials shall be the nominal pipe size as set forth in ANSI/ASME B36.10.

Pipe ellipticity (out-of-roundness) shall not exceed one percent.

Pipe design shall be performed by the pipe manufacturer. Minimum design criteria shall be as specified.

2-1.01. Pipe Wall Thickness. Pipe shall be designed for all conditions indicated in the Steel Pipe Schedule and on the drawings.

The wall thickness for internal pressure due to hoop stress shall be determined by the following formula.

t = (PD)/(2s),
where

t = the pipe wall thickness in inches [mm]

s = the allowable fiber stress in psi [kPa], shall not exceed 50 percent of the minimum yield strength of the steel plate at working pressure or 75 percent of the minimum yield strength at the larger of field test pressure or working pressure plus surge pressure. The yield strength used in the calculation for cement mortar coated pipe shall not exceed 36,000 psi. [248,000 kPa]. The yield strength used in the calculation for cement mortar lined pipe shall not exceed 45,000 psi. [310,000 kPa].

P = the pipe working pressure or the larger of field test pressure or working pressure plus surge pressure in psi [kPa].

D = the pipe outside diameter, in inches [mm], of straight pipe sections or the larger outside diameter of tapered sections.

Unless otherwise indicated, the working pressure and the working pressure plus surge pressure shall be as indicated in the Steel Pipe Schedule.

The pipe wall thickness shall be in accordance with ANSI/AWWA M11, except that all pipe shall have a wall thickness of at least 1/4 inch, and a diameter to wall thickness ratio not to exceed 165unless otherwise indicated in the steel pipe schedule.

Pipe wall thickness shall be constant for the entire length of pipe for each pipe class, location, or service indicated in the Steel Pipe Schedule unless otherwise indicated on the drawings or specified.

External loads on buried pipe shall be based on the prism load and the following design conditions.

Maximum pipe deflection, percent of nominal pipe diameter	3.0
Minimum design cover depth	See Drawings
Maximum design cover depth	See Drawings
Total design external load on pipe	See Pipe Schedule
E', Modulus of Soil Reaction	1,400 psi
K, Bedding Constant	0.090
Weight of soil	120 lbs/cu. ft.
Deflection Lag Factor	1.25
Live load	AASHTO HS-20
Impact Factor	1.5]

The maximum pipe deflection shall be reduced if required by the jointing system furnished

Cement mortar lining or coating shall not be used in the pipe deflection calculations.

The pipe shall be designed to withstand full internal vacuum (0 psia) under the buried conditions and for external loading under the flood conditions at ground surface or as otherwise indicated on the Drawings, when empty.

2-1.02. Fitting Dimensions. The dimensions of steel pipe fittings shall be as indicated on Figures 1-40 05 24(A) and 1-40 05 24(B) and shall be designed by the pipe manufacturer. Any fittings used for buried vertical bends and buried eccentric reducers shall be restrained.

2-1.03. Reinforcement of Fittings and Specials. Whether or not shown on the drawings, all bends, fittings, branch connections, reducers, and special sections shall be reinforced, or the pipe wall thickness shall be increased, so that the combined stresses due to internal pressure (circumferential and longitudinal) and bending will not exceed the allowable stresses specified in the Pipe Wall Thickness paragraph. Where external piping reinforcement interferes with other construction the pipe wall thickness shall be increased and external reinforcement eliminated as necessary for acceptable clearances.

Where suspended, the design of reinforcement or wall thickness shall also take into consideration the weight of the piping and appurtenances full of water.

Where buried, the design of reinforcement or wall thickness shall also take into consideration the external load.

Wall thicknesses of reducing sections shall be not less than the required thicknesses for the larger ends.

2-1.04. Joints. Acceptable joints of the type indicated on the Drawings and as specified herein shall be provided for all pipe installations in the locations indicated or accepted by Engineer. To facilitate installation, additional field-welded or mechanically coupled joints may be provided, but shall be kept to a minimum, and their locations shall be acceptable to Engineer. Field-welded joints shall not be used in pipe smaller than 30 inches [750 mm], except in locations where the interior coating can be satisfactorily repaired and inspected.

Buried pipelines shall have [stab (rubber-gasketed bell and spigot)] [lap-welded] [either stab (rubber-gasketed bell and spigot) or lap-welded] joints unless otherwise specified or indicated on the drawings. Restrained joints shall be lap-welded unless otherwise specified or indicated on the drawings.
Each joint, including restrained joints,shall be checked by Design-Builder as recommended by the pipe manufacturer to verify that the joint and the restraints are installed properly. The pipe manufacturer shall furnish a metal gauge or other tools as required to measure joints.

2-2. MATERIALS.

Pipe, Fittings, and Specials	ANSI/AWWA C200. All steel shall be fully killed, with a maximum carbon content of 0.25 percent, made to a fine austenitic grain size practice, and manufactured from continuous cast steel. Minimum yield strength (point) for the grade of steel used shall not exceed 45,000 psi *or be less than 36,000 psi.*
Gaskets – All Joint Types	Synthetic rubber unless otherwise specified; natural rubber will not be acceptable. All gaskets shall be furnished by the pipe manufacturer, unless another manufacturer's product is specified. Pipe manufacturer shall submit certificates of gasket suitability, certifying that the gasket materials are compatible with the joints

	specified and are recommended for the specified field test pressure and service conditions. Gaskets for treated or potable water service shall also be certified for chlorinated and chloraminated potable water.
	Gas and oil-resistant gaskets shall be made of Nitrile (NBR [Acrylonitrile Butadiene]) rubber unless a different gasket material is recommended by the pipe manufacturer and accepted by the Engineer. The name of the material shall be permanently marked or molded on the gasket. Gaskets shall also be certified as suitable where soils may be contaminated with gas and oil products.
Joint Lubricant	Vegetable-based lubricant recommended by the pipe manufacturer. Petroleum or animal-based lubricants will not be acceptable. Lubricants that will be in contact with treated or potable water shall be certified as being in compliance with ANSI/NSF 61.
Joint Diapers	
Diapers	Non-woven polypropolene fabric, lined with polyethylene foam, minimum weight 3 oz. per square yard. “Typar” as recommended by pipe manufacturer for the joint furnished.
Liner	100 percent closed cell polyethylene foam, 1.9 to 2.1 pounds per cubic foot density, Dow Chemical Company “Ethafoam 221”, minmum thickness of ¼ inch and full width of diaper.
Steel Straps	Class 1, Type 1, hot-rolled or heat treated cold rolled, Fed Spec QQ-S-781H, 0.020” thick, waxed or painted and waxed.

Seal Clips			Push or overlap type, providing single notch-joint on ½ inch or 5/8 inch wide seals; double notch joint on on ¾ inch wide seals.
Flanged Joints			
	Flanges		ANSI/AWWA C207, slip-on, except where otherwise specified or indicated on the Drawings.
		Dimensions and Drilling	ANSI/AWWA C207, Class Dexcept as otherwise indicated on the Drawings or specified.
	Blind Flanges		ANSI/AWWA C207, Class Dexcept as otherwise indicated on the Drawings or specified.
	Gaskets		ANSI/AWWA C207. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets – All Joint Types.
	Insulated Flanges		
		Flanges	As specified herein, except bolt holes shall be enlarged as needed to accept bolt insulating sleeves.
		Insulation Kits	As manufactured by Advanced Products or Pipeline Seal and Insulator, Inc.
		Insulating Gaskets	Type E, G10, 1/8 inch thick, with Nitrile or EPDM sealing element unless otherwise required by pipe manufacturer and acceptable by Engineer. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets – All Joint Types.
		Bolt Insulating Sleeves	G-10, 1/32 inch thick.
		Insulating Washers	G-10, 1/8 inch thick, two for each flange bolt.
		Backing	Steel, 1/8 inch thick, two for each

		Washers	flange bolt.
	Flange Bolting		
		Material	ANSI/AWWA C207, unless otherwise required by the pipe manufacturer including higher strength and accepted by the Engineer.
		Type	Bolt and nut; bolt-stud and two nuts permitted for 1 inch [25 mm] and larger.
		Bolts and Bolt-Studs	
		Length	As required for ends to project 1/4 to 1 inch beyond outer face of nut.
		Ends	Chamfered or rounded.
		Threading	ANSI/ASME B1.1, coarse thread series, Class 2A fit. Bolt-studs may be threaded full length.
		Bolt Head Dimensions	ANSI/ASME B18.2.1; regular pattern for square, heavy pattern for hexagonal.
		Nuts	Hexagonal.
		Dimensions	ANSI/ASME B18.2.2, heavy, semi-finished pattern.
		Threading	ANSI/ASME B1.1, coarse thread series, Class 2B fit.
Stab Joints			Bell-and-spigot, with rubber gasket as sole element depended upon for water tightness.
	Bells and Spigots		Rolled groove, Carnegie shape, or fabricated type, as permitted.
	Rubber Gaskets		Continuous O-ring; ANSI/AWWA C200, Section 4.13, except basic polymer shall be synthetic rubber. Natural rubber will not be acceptable. Pipe manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets – All Joint Types.

Coupled Joints		
Mechanical Couplings		
Gaskets		Gaskets shall be as recommended by the coupling manufacturer. Coupling manufacturer shall submit certification of gaskets furnished as indicated above under Gaskets – All Joint Types.
Full Ring Type		
	Insulating	Baker "Series 216", Dresser "Style 39", or Smith-Blair "416"; without pipe stop.
	Reducing	Baker "Series 220", Dresser "Style 62", or Smith-Blair "413" and "415"; without pipe stop.
	All Others	Baker "Series 200", Dresser "Style 38", or Smith-Blair "411 Steel Coupling"; without pipe stop.
Split Ring Type – Nonrestrained		Victaulic Depend-O-Lok, Inc. "ExE Type 1" or "ExE Type 2".
Split Ring Type - Restrained		
	16 inches or smaller	Victaulic Depend-O-Lok, Inc. “FxF Type 1”.
	Larger than 16 inches	Victaulic Depend-O-Lok, Inc. “FxF Type 2”.
	Buried Service	Victaulic Depend-O-Lok, Inc. “FxF Type 2 HP (RC)”.
Flanged Coupling Adapters		
	Restrained (4 inch through 12 inch). Unless otherwise indicated on the Drawings, flanged coupling adapters shall be restrained.	Dresser “Style 128”, Smith-Blair "Type 913", or Romac "Style FCA501", with anchor studs of sufficient size and number to withstand test pressure.
	Unrestrained (14	Smith-Blair "Type 913" or Romac

inch and larger)	"Style FC400", 14 inches and larger.
Dismantling Joints	
Restrained 3 inch [350] mm and larger. Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.	Romac "DJ400", Dresser "Style 131 Dismantling Joint", or Viking Johnson. For use in potable water systems, coating to be in accordance with NSF-61.
Grooved Couplings	
When Joint Movement and Deflection is not Acceptable	ANSI/AWWA C606; Victaulic "07 Zero-Flex".
When Joint Movement and Deflection is Acceptable	ANSI/AWWA C606; Victaulic "Style 77".
Restrained Joints	
Welded	ANSI/AWWA C200 and C206.
Lugs or Collars	ASTM A283, Grade B or C; or ASTM A36.
Tie Bolts	ASTM A193, Grade B7.
Threading	ANSI/ASME B1.1, Class 2A fit, coarse thread series for 7/8 inch and smaller, and 8-thread series for 1 inch and larger.
Ends	Chamfered or rounded.
Nuts	Hexagonal, ASTM A194, Grade 2H or better.
Threading	As specified for tie bolts, except Class 2B fit.
Dimensions	ANSI/ASME B18.2.2, heavy semifinished pattern.
Flat Washers	Hardened steel, ASTM A325.

Small Branch Connections	
Pipe Nipples	Seamless black steel pipe, ASTM A53, standard weight (Schedule 40).
Welding Fittings	
Threaded Outlets	Bonney Forge "Thredolets" or Flowserve/Vogt "Weld Couplets".
Welded Outlets	Bonney Forge "Weldolets" or Flowserve/Vogt "Weld Couplets".
Coatings and Linings	All materials in contact with treated or potable water shall be certified as being in compliance with ANSI/NSF 61.
Liquid Epoxy	ANSI/AWWA C210.
Tape Coating	ANSI/AWWA C209 and C214 or C216, with ultraviolet light stabilizers, manufactured by PolyKen.
Cement Mortar	ANSI/AWWA C205 and C602.
Cement	ASTM C150, Type II.
Sand	ANSI/AWWA C205, Section 4.2.3, except sand for field-applied lining shall pass a No. 16 sieve.
Epoxy Bonding Agent	ASTM C881, Type II, moisture insensitive and suitable for service conditions.
Latex Admixture	Euclid "Flex-Con" or Sika "SikaLatex".
Universal Primer	Pipe manufacturer’s standard.
Watertight/Dusttight Pipe Sleeves	“GPT Link-Seal", insulating type with modular rubber sealing elements, nonmetallic pressure plates, and stainless steel bolts and nuts.
Anti-Seize Thread Lubricant	Jet-Lube "Nikal", John Crane "Thred Gard Nickel", Bostik/Never-Seez "Pure Nickel Special" or

	Permatex "Nickel Anti-Seize".
Anchor Bolts	ASTM A307.
Joint Grout and Diapers	ANSI/AWWA C205.
Corrosion Protection	
Heat–shrinkable Coating and Primer (Shrink Sleeve)	ANSI/AWWA C216, cross-linked polyethylene sheeting precoated with adhesive; minimum 80 mils; type and recovery as recommended by Shrink Sleeve manufacturer; Canusa-CPS or Berry Plastics Water Wrap.
Underlying Sleeve	Heavy cross-linked polyethylene backing; Canusa-CPS I2/PE Backing.
Wax Tape and Primer	ANSI/AWWA C217. Cold-applied petroleum wax primer and cold-applied petroleum wax tape; Trenton Wax-Tape and Primer.
Medium Consistency Coal Tar	Carboline "Bitumastic 50" or Tnemec "46-465 H.B. Tnemecol".

2-3. ENDS OF SECTIONS.

2-3.01. For Field Welding. Ends of pipe, fittings, and specials for joints butt-welded in the field shall have the ends beveled for butt welding in accordance with the governing standards.

Ends of pipe, fittings, and specials for field-welded lap joints, Figures3-40 05 24(A) and 3-40 05 24(B), shall have both the bell and the spigot expanded by pressing, if necessary, (not rolling) to obtain the required shape and welding tolerances.

2-3.02. For Fitting with Flanges. Ends to be fitted with slip-on flanges shall be prepared to accommodate the flanges in accordance with the governing standards.

2-3.03. For Stab Joints. Stab joints shall be designed so that the gasket will maintain a watertight joint under all conditions of service, including expansion, contraction, and earth settlement. The gasket shall not support the entire weight of the pipe. Spigot ends shall have a groove to retain the gasket. Pipe ends shall be self-centering without the aid of the gasket.

2-3.04. For Mechanical Couplings. Ends to be joined by mechanical couplings shall be plain end type. Pipe seam welds on ends to be joined by mechanical couplings without pipe stops shall be ground flush to permit slipping the coupling in at least one direction to clear the pipe joint. The welds on ends to be joined by split ring type couplings shall be ground flush to allow uniform contact of the shoulder and pipe wall. Outside diameter and out-of-round tolerances shall be within the limits specified by the coupling manufacturer.

Where retainer rings for split ring mechanical couplings are required to be fixed to the ends of pipe to provide restraint within a mechanical coupling, at least one of the restraint rings shall be welded in place in the field to assure the coupling is installed with the pipe in a fully-extended position.

2-3.05. For Grooved Couplings. Ends to be joined by grooved couplings shall be of the shouldered type, conforming to the governing standard and as recommended by the coupling manufacturer for the size and wall thickness of the pipe, fitting, or special being coupled, and for the maximum test or working pressure to which the couplings will be subjected.

2-3.06. For Flanged Coupling Adapters. Ends to be fitted with flanged coupling adapters shall be plain end type in accordance with the governing standard for mechanical couplings. Welds shall be ground flush to permit installation of the coupling. For restrained flange coupling adapters, holes shall be field drilled at the proper location for anchor studs.

2-3.07. For Connection to Dissimilar Pipe Materials. Steel pipe connections to buried or submerged concrete pipe or cast or ductile iron pipe shall be made with insulated flanges.

2-4. SEAMS. Except for seamless mill-type pipe, all piping shall be made from steel plates rolled into cylinders or sections thereof with the longitudinal seams butt-welded, or shall be spirally formed and butt-welded. There shall be not more than two longitudinal seams. Girth seams shall be butt-welded and shall be spaced not closer than 10 feet apart except in specials and fittings.

2-5. PIPE LENGTHS. Straight pipe section lengths shall be pipe manufacturer's standard lengths, unless otherwise indicated on the Drawings.

All pipe to be connected with mechanical couplings shall be fabricated so that the space between pipe ends within the couplings will not exceed the amount recommended by the coupling manufacturer, but shall be at least 1/2 inch.

2-6. SMALL BRANCH CONNECTIONS. Branch connections 2-1/2 inches and smaller shall be made with welding fittings with threaded outlets. Where the

exact outlet size desired is in doubt, but is known to be less than 1 inch, a 1 inch outlet shall be provided and reducing bushings used as needed.

Branch connections sized 3 through 12 inches shall be made with pipe nipples or with welding fittings with welded outlets. Pipe nipples and welding fittings shall be welded to the pipe shell and reinforced as needed to meet design and testing requirements.

Small branch connections shall be so located that they will not interfere with joints, supports, or other details, and shall be provided with caps or plugs to protect the threads during shipping and handling.

2-7. ACCESS MANHOLES. The type of access manholes shall be indicated on the Drawings.

2-7.01. Type I Manholes. A Type I manhole shall consist of a 30-inch flanged outlet with a blind flange cover. Covers shall have two handles fabricated from 1-inch diameter rod.

At the option of Design-Builder, reinforced or dished covers of lighter weight than a standard blind flange and equal strength may be provided.

2-8. DRAINS AND VENTS. Pipe used for drain and vent piping shall be ASTM A53, standard weight, black steel pipe. Drain valves shall be hose valves. Vent valves shall be resilient seat globe valves. Drain and vent valves shall comply with the requirements of the valves section.

2-9. FLANGED JOINTS. Flange faces of flanged joints shall be normal to the pipe axis. Angular deflection (layback) of the flange faces shall not exceed the allowable set forth in ANSI/AWWA C207. All flanges shall be refaced after welding to the pipe, if necessary to prevent distortion of connecting valve bodies from excessive flange bolt tightening and to prevent leakage at the joint.

Pipe lengths and dimensions and drillings of flanges shall be coordinated with the lengths and flanges for valves, pumps, and other equipment to be installed in the piping. All mating flanges shall have the same diameter and drilling and shall be suitable for the pressures to which they will be subjected.

Flanges shall be of the slip-on type, except that welding-neck or slip-on flanges welded to short lengths of pipe shall be used where installation of flanges in the field is permitted or required.

For welding neck flanges, the pipe shall be concentrically reduced as necessary for proper alignment of the pipe wall with the welding neck flange for butt

welding. The interior of the weld joint and flange shall be cement lined in the shop as specified in ANSI/AWW C205.

2-10. STAB JOINTS. Rubber-gasketed bell-and-spigot (stab type) steel pipe shall be furnished where indicated or specified.

2-10.01. Proof of Design. Proof of Design will be required for each stab joint configuration of each diameter of pipe to be supplied. The tests do not have to be made on pipe joints manufactured specifically for this project. The manufacturer shall have qualified the joint by having performed the specified factory tests and shall submit certified reports covering the results of the tests. Certified reports covering tests on other pipe joints of the same size and design produced by the same manufacturer from materials of equivalent type and quality may be accepted as adequate proof of design. Any new proof-of-design testing to meet the requirements for this project shall be independently verified and the Owner shall be given the opportunity to witness the testing. As an alternative to the Proof of Design Testing, the Proof of Design Requirements can be met by the manufacturer meeting the field experience requirements as described herein.

Test results for a larger diameter joint may be used to allow the use of a smaller diameter joint, provided the two joints are identical in all other aspects.

The joint shall be tested at a pressure not less than 2 times the working pressure or 1-1/2 times the test pressure of the pipeline, whichever is greater. In addition to samples tested in the undeflected condition, at least one sample of each size and type shall be tested to the angle recommended as maximum by the manufacturer.

2-10.02. Field Experience. As an alternative to the Proof-of-Design testing for stab joints, field experience requirements shall be met for each joint configuration of each diameter of pipe to be supplied. The field experience shall reflect a working pressure, test pressure, and transient pressure not less than that of the pipeline(s) specified hereunder. Field experience requirements shall include:

a. Documentation of one or more pipelines with a combined service history of a minimum of ten years. No documented pipeline shall have less than five years of service. No documented pipeline shall have had a joint failure during the documented service period.
b. For each documented pipeline, the following information shall be submitted: Owner; pipeline identification; diameter; type of service; external load; internal working, test, and transient pressure; and Owner contact information. Dimensioned joint details including description of all joint and gasket materials, shall also be submitted.

c. The manufacturer shall furnish an affidavit of compliance stating that the field experience requirements have been met as described herein, and the manufacturer shall include documentation verifying the field experience requirements outlined in Items a and b above.

2-11. MECHANICAL COUPLINGS. The middle ring of mechanical couplings shall have a thickness at least equal to the wall thickness specified herein for the size of pipe on which the coupling is to be used. If the coupling manufacturer's standard thickness is less, that thickness may be used unless allowable pressures are exceeded. The length of each middle ring shall be not less than 10 inches for 36 inches and larger pipe and not less than 7 inches for pipe smaller than 36 inches.

All surfaces, including the interior surfaces of the middle rings, shall be prepared for coating in accordance with the coating manufacturer's instructions and shall then be coated with liquid epoxy in accordance with ANSI/AWWA C210.

Factory pipe spacers shall be provided where indicated on the drawings. The spacers shall be factory coated and lined with 16 mils of liquid epoxy.

All split ring style couplings shall be designed for not less than 150 psi working pressure. Where pressure may exceed 150 psi, the coupling shall be designed for the required pressure and provided with the coupling manufacturer's "high pressure modification". Use of the FxF Type 1 split ring coupling shall be limited to piping 16 inches and less in diameter. A FxF Type 2 split ring coupling shall be provided for pipe diameter greater than 16 inches size. Where split ring couplings are permitted in buried applications, they shall be FxF Type 2 HP (RC).

2-12. GROOVED COUPLINGS. Grooved couplings shall be sized for proper installation on the pipe ends provided. The couplings shall be restrained or have movement and deflection requirements as required.

After fabrication, all housing clamps forming the coupling shall be cleaned and primed (as specified for the pipe) by the coupling manufacturer.

2-13. FLANGED COUPLING ADAPTERS. Flanged coupling adapters shall be provided for restrained couplings 12 inches and smaller and unrestrained couplings 14 inches and larger. Unless otherwise indicated on the Drawings, all 12 inches and smaller flange coupling adapters shall be restrained and all 14 inches and larger flange coupling adapters may only be used in unrestrained applications.

The inner and outer surfaces of couplings, except flange mating surfaces, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall then be coated with liquid epoxy in accordance with

ANSI/AWWA C210. The flange mating surfaces shall be cleaned and shop primed with universal primer.

2-14. DISMANTLING JOINTS. Dismantling joints shall be provided for restrained couplings 6 inches and larger. Dismantling joints shall comply with AWWA C219 and shall be restrained flange by flange couplings manufactured as a single unit. Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.

The inner and outer surfaces of dismantling joints, except flange mating surfaces, shall be prepared for coating in accordance with instructions of the coating manufacturer and shall then be coated with liquid epoxy in accordance with ANSI/AWWA C210. The flange mating surfaces shall be cleaned and shop primed with universal primer.

2-15. RESTRAINED JOINTS. Restrained joints shall be flanged, welded, flanged coupling adapters with anchor studs, split ring fixed type couplings, rigid groove couplings, or harnessed, as specified or as indicated on the Drawings.

Where indicated on the Drawings, mechanically coupled or stab type joints shall be restrained with harness bolts and lugs or collars. Joint harnesses shall conform to the details indicated on the Drawings. Lugs or collars shall be shop welded to the pipe and coated as specified for the adjacent pipe.

Split ring style couplings used for restraint shall be shoulder style. Grooved couplings used for restraint shall be rigid type.

Any fittings used for buried vertical bends and eccentric reducers shall be restrained.

2-16. PROTECTIVE COATINGS AND LININGS. All steel pipe, fittings, specials, wall fittings, and accessories shall be lined, coated, or wrapped as specified herein.

2-16.01. Type of Coating and Lining. Surface preparation shall be in accordance with the pipe manufacturer's and coating and lining manufacturer's instructions. Types of protective coating and lining shall be as follows:

Exterior Surfaces in Interior Locations	Shop-applied universal primer.
Exterior Surfaces Underground, Including those Encased in Concrete	Cement mortar, ANSI/AWWA C205. The governing standards shall be as modified herein.

Exterior Surfaces in Contact with Potable Water or Submerged in Water Treatment Process Waters		Cement mortar, ANSI/AWWA C205.
Interior Surfaces		Cement mortar - shop applied, ANSI/AWWA C205. The governing standards shall be as modified herein.
Pipe Joints		
	Couplings	Shop coating as specified for each type of coupling. Field coating as specified for ends of sections in the Joint Holdbacks and Coatings and Linings paragraph and the Corrosion Protection paragraph for buried couplings.
	Ends of Sections	As specified in the Joint Holdbacks and Coatings and Linings paragraph.
	Machined Surfaces	Rust-preventive compound.
Blind Flanges		Shop coat with 20 mil dry film thickness of liquid epoxy in accordance with ANSI/AWWA C210.

2-16.02. Modifications to the Governing Standards.

2-16.02.01. Cement Mortar Lining. Cement mortar lining for all pipe shall be shop applied Except as modified herein, shop-applied mortar linings shall comply with ANSI/AWWA C205.

Specials. Wire fabric reinforcement shall be used in the lining of fittings and specials in accordance with ANSI/AWWA C205.

Adjacent to Valves. If the specified nominal pipe size is the actual outside diameter, cement mortar lining installed in steel pipe adjacent to butterfly valves shall be tapered so that the lining material will not interfere with the valve disc during valve operation.

2-16.02.02. Tape Coating. Except as modified or supplemented herein, tape coating shall be shop applied and comply with ANSI/AWWA C214 for straight pipe sections, and ANSI/AWWA C209 for fittings and specials. The tape coating system shall consist of a primer layer, an inner layer of tape for corrosion protection, and two outer layers of tape for mechanical protection. The total thickness of the tape coating system shall be at least 80 mils. The outer layer of tape shall be white with ultraviolet light stabilizers.

2-17. MARKING. In addition to the pipe markings required by ANSI/AWWA C200, each pipe section, fitting, and special shall be clearly marked to indicate the service, the wall thickness, and the minimum yield strength of the pipe material. Pipe piece identification shall be shown on both the inside and outside of each pipe section, fitting, and special.

2-18. SHOP INSPECTION AND TESTING. Except as otherwise indicated or acceptable to Engineer, all materials and work shall be inspected and tested by the pipe manufacturer in accordance with ANSI/AWWA C200. All costs in connection with such inspection and testing shall be borne by Design-Builder.

Copies of all test reports shall be submitted in accordance with the Submittals Procedures section.

Owner reserves the right to sample and test any pipe after delivery and to reject all pipe represented by any sample which fails to comply with the specified requirements.

Steel greater than or equal to 1/4 inch thickness used in production manufacturing of pipe and specials shall be tested for notch toughness using Charpy V-Notch tests in accordance with ASTM A370 – Test Methods and Definitions for Mechanical Testing of Steel Products. The test acceptance for full size specimens (0.394 in. by 0.394 in. size) shall be 25 foot-pounds at a test temperature of 32 degrees F; tests shall include three impact specimens and shall be conducted in the direction transverse to the final direction of rolling. When full-size specimens are not obtainable, the minimum required Charpy value is permitted to be reduced by multiplying the ratio of the (actual width along the notch / 0.394 in.) x 25 ft-lbs. For sub size specimens the test temperature shall be reduced as follows: Width along the notch > 0.296 in. (no reduction required); 0.295 in. (3/4 size bar): 5 degrees F reduction; 0.236 in.: 15 degrees F reduction. Straight line interpolation for intermediate values shall be used. Tests shall be conducted in accordance with ASTM A20 for two coils of each heat. Only welding consumables that are classified by the applicable AWS filler metal standard (e.g. A5.1, A5.17, A5.18, A5.20) with Charpy impact test requirements at a temperature 32 degrees F or lower are permitted.

2-18.01. Owner's Inspection at the Shop. If Owner elects to inspect any work or materials, as permitted under Section 5.1 of ANSI/AWWA C200, all costs in connection with the services of Owner's inspector will be paid for by Owner.

A fabrication schedule shall be prepared at least 30 days prior to fabrication activities. The Design-Builder shall notify the Owner’s Representative at least 5 days prior to any change in the revised and current schedule. If the Owner's representatives make an inspection and the manufacturer is not performing the work as indicated in the revised and current schedule for that date, the expense shall be the sole responsibility of the Design-Builder.

Additional weld test specimens shall be furnished to Owner's inspector for testing by an independent testing laboratory whenever, in the judgment of Owner's inspector, a satisfactory weld is not being made. Test specimens shall also be furnished when Owner's inspector desires. The entire cost of obtaining, inspecting, and testing of such additional specimen plates, welds, or materials will be borne by Owner. If any specimen is found not to conform to the specified requirements, the materials represented by the specimen will be rejected. The expense of all subsequent tests due to failure of original specimens to comply with the specifications shall be the responsibility of Design-Builder.

In addition to making or witnessing specified tests and submitting any required reports to Owner, Owner's inspector will submit written reports to Design-Builder concerning all materials rejected, noting the reason for each rejection.

Inspection by Owner's inspector, or Owner's option not to provide inspections, shall not relieve Design-Builder of his responsibility to provide materials and to perform the work in accordance with the Contract Documents.

The Owner reserves the right to sample and test any pipe after delivery and to reject all pipe represented by any sample which fails to meet with the specified requirements.

PART 3 - EXECUTION

3-1. INSPECTION. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation. Pipe ends shall be examined with particular care. All defective pipe and fittings shall be removed from the Site.

All shop-applied exterior tape or other dielectric coatings on pipe, fittings, or specials shall be electrically inspected for holidays and other defects, and repaired if necessary. All electrical inspection shall be made in accordance with the standard to which the coating was applied.

Inspection and repair of linings and coatings shall be performed by and at the expense of Design-Builder, after receipt of the pipe, fittings, or specials on the Site and before installation. Electrical inspection of exterior tape or other dielectric coatings after installation of the pipe, fitting, or special in the trench shall be made where, in the opinion of Engineer, the coating may have been damaged by handling during installation.

3-1.01. Confined Space Entry Supervision. Design-Builder shall provide above ground confined space entry supervision whenever Engineer is required to enter the pipe to verify Design-Builder's deflection measurements, inspect joints, or any other time the Engineer is required to enter the pipe.

3-2. PROTECTION AND CLEANING. The interior of all pipe and fittings shall be thoroughly cleaned of all foreign material prior to installation and shall be kept clean until the work has been accepted. Before jointing, all joint contact surfaces shall be wiped clean.

Precautions shall be taken to prevent foreign material from entering the pipe during installation and until the work has been accepted.

Whenever pipe laying is stopped, the open end of the pipe shall be closed to prevent entry of dirt, mud, rodents, and other material. All water in the trench shall be removed prior to removing the closure.

3-3. ALIGNMENT AND GRADE. Buried pipe shall be laid to the lines and grades as specified and indicated on the Drawings. Pipelines or runs intended to be straight shall be laid straight. Curves in stab joint pipe may be formed by opening the joint. Maximum joint openings and deflections shall be as recommended by the pipe manufacturer. For welded lap joints, deflections up to 4-1/2 degrees may be made by shop-mitering the bell end of one pipe. For welded butt joints, deflections up to 22-1/2 degrees may be made by shop-mitering the ends of two adjacent sections of pipe by equal amounts. Deflections greater than 22-1/2 degrees shall be made by use of fabricated bends.

Where deflections would exceed the pipe manufacturer's recommendations, either shorter pipe sections or fittings shall be installed where needed to conform to the alignment or grade indicated on the Drawings and as acceptable to the Engineer.

High points which allow air to collect in pipelines will not be permitted unless an air release valve is indicated on the Drawings at that location.

Unless otherwise specified or acceptable to Engineer, laser beam equipment, surveying instruments, or other suitable means shall be used to maintain alignment and grade. At least one elevation reading shall be taken on each length of pipe. If laser beam equipment is used, periodic elevation measurements shall be made with surveying instruments to verify accuracy of grades. If such measurements indicate thermal deflection of the laser beam due to differences between the ground temperature and the air temperature within the pipe, precautions shall be taken to prevent or minimize further thermal deflections.

Additional requirements for alignment and grade are covered in the Project Requirements and Trenching and Backfilling sections and on the Drawings.

3-3.01. Tolerances. Each section of pipe shall be laid to the alignment and grade indicated on the Drawings and pipe laying schedule with pipe ends within the following tolerances;

+/- 0.10 foot in grade at any point
+/- 0.20 foot in alignment at any point

In addition, piping shall be visually straight or on a smooth curve between the points of deflection or curvature indicated on the Drawings. Stricter tolerances than specified above shall be used as necessary to maintain minimum cover, to maintain required clearances, to maintain the correct slope to avoid high or low points along the pipeline other than at locations indicated on the Drawings, or to meet other restrictions as required or directed by the Design-Builder.

3-3.02**.** Anotated Pipe Laying Schedule**.** The pipe laying schedule shall be annotated during the progress of the Work to show all changes made during construction for record documentation. Upon completion of the installation of the piping, the annotated pipe laying schedule shall be submitted to Engineer in accordance with the Submittals Procedures section.

3-4. INSTALLATION.

3-4.01. Buried Piping. Field installation of buried steel water piping shall be in accordance with ANSI/AWWA C604 unless otherwise specified or indicated on the Drawings.

For buried piping, all trenching, embedment, and backfilling shall conform to the Trenching and Backfilling section and the details indicated on the Drawings.

Pipe embedment and backfilling shall closely follow the installation and jointing of steel pipe in the trench to prevent floatation of the pipe by water and minimize longitudinal movement caused by thermal expansion or contraction of the pipe. Pipe shall be protected from floatation during installation when subjected to groundwater or flood conditions.

Each joint, including restrained joints, shall be checked by Design-Builder as recommended by the pipe manufacturer to verify that the joint and the restraints are installed properly.

For restrained joint pipe, not more than 160 feet of pipe shall be exposed ahead of the backfilling in any section of trench. The backfill adjacent to field joints may be temporarily omitted to provide adequate space for field coating the joints. Closure welds on restrained joint pipe shall be made during the cool part of the day*.*

3-4.02. Pipe Deflection. All buried pipe larger than 30 inches in diameter shall be tested for excessive deflection.

3-4.02.01. Test Section. At the beginning of pipe laying operations, the Design-Builder shall install a test section to demonstrate that the means and methods to be utilized will satisfy the pipe embedment requirements and deflection criteria. The length of the test section shall be approximately 400 feet. The Design-Builder shall perform and document deflection measurements and also document the successful means and methods to be used as a guide for subsequent pipe installation. The Engineer will observe construction of the test section and verify deflection measurements. The Design-Builder shall not proceed with production pipe laying beyond the test section without the Engineer's acceptance of the test section including documentation. Deflection measurements shall be performed as specified under Deflection Measurements.

If embedment materials or placement methods are changed, a new test section shall be made to demonstrate that the means and methods satisfy pipe embedment requirements and deflection criteria.

3-4.02.02. Deflection Measurements. Pipe deflection for all buried pipe shall be determined by measuring initial pipe vertical and horizontal inside diameters before the backfill load is supported by the pipe and a second vertical and horizontal inside diameters at least 24 hours after the backfill load is supported by the pipe. The second pipe deflection measurement shall be taken and the results determined before 1,000 feet of pipe is laid ahead of the initial measurement. Initial and second measurements shall be made for at least two locations on each piece of pipe and approximately equally spaced along the pipe. The points of initial deflection measurements shall be marked so that final deflection measurements are at the same points. The tolerance for deflection measurements shall be 1/8 inch. The percent deflection shall be the largest difference between the initial and second measurements at each point divided by the nominal pipe diameter. Pipe embedment and backfill not exceeding one foot above the top of pipe shall be in place during initial measurements. Struts that allow access may remain in place during initial measurements but shall be removed after initial measurements. Pipe deflection will be measured and documented by Design-Builder and verified by Engineer for each piece of pipe. Engineer shall be notified in advance of when deflection measurements are made. The deflection documentation shall be submitted daily unless otherwise acceptable to the Engineer.

3-4.02.03. Allowable Deflection. The allowable deflection shall be the calculated design percent of nominal diameter with a deflection lag factor of 1.0 andexcluding live load, for the depth of the installed pipe to the nearest foot. Pipe exceeding the allowable deflection shall be uncovered and the embedment and backfill replaced as needed to prevent excessive deflection. After replacing

embedment and backfill, the pipe shall be retested. Pipe damaged by over deflection or otherwise shall be satisfactorily repaired or removed and replaced with new pipe.

3-4.03. Flanged Joints. Flange faces shall be flat and perpendicular to the pipe centerline. The rust-preventive coating on the flange faces shall be soluble and shall be removed before the joint is made.

Care shall be taken in bolting flanged joints to avoid restraint on the opposite end of the pipe or fitting, which would prevent uniform gasket compression or would cause unnecessary stress in the flanges. The pipe or fitting shall be free to move in any direction while the flange bolts are being tightened. Bolts shall be tightened gradually in a crisscross pattern at a uniform rate, to ensure uniform compression of the gasket around the entire flange. All flange joint bolting procedures shall be in accordance with the pipe manufacturer's recommendations.

Care shall be taken when connecting piping to pumping equipment to ensure that piping stresses are not transmitted to the pump flanges. All connecting piping shall be permanently supported to obtain accurate matching of bolt holes and uniform contact over the entire surface of flanges is obtained before any bolts are installed in the flanges.

Pump connection piping shall be free to move parallel to its longitudinal center line while the bolts are being tightened. Each pump shall be leveled, aligned, and wedged into position which will fit the connecting piping, but shall not be grouted until the initial fitting and alignment of the pipe so that the pump may be shifted on its foundation if necessary to properly install the connecting piping. Each pump shall, however, be grouted before final bolting of the connecting piping.

After final alignment and bolting, the pump connections shall be tested for applied piping stresses by loosening the flange bolts which, if the piping is properly installed, should result in no movement of the piping relative to the pump or opening of the pump connection joints. If any movement is observed, the piping shall be loosened and re-aligned as needed and then the flanges bolted back together. The flange bolts then shall be loosened and the process repeated until no movement is observed.

3-4.04. Insulated Flanged Joints. Insulated flanged joints shall be installed where indicated on the Drawings. In addition to one full-faced insulating gasket, each flange insulating assembly shall consist of one full-length sleeve, two insulating washers, and two backing washers for each flange bolt. The insulating gasket ID shall be 1/8 inch less than the ID of the flange in which it is installed. The insulated flanged joint accessories shall be installed in accordance with the instructions and recommendations of the insulating kit manufacturer.

3-4.05. Stab Joints. Gasket installation and other jointing procedures shall conform to the instructions and recommendations of the pipe manufacturer. All joint surfaces shall be lubricated with heavy vegetable soap solution immediately before making the joint. The lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean. Measurements shall be taken at the joints after installation to ensure that the specified clearances have not been exceeded.

3-4.06. Welded Joints. All welds shall be sound and free from embedded scale or slag and shall be watertight. Butt welds shall have tensile strength across the weld not less than that of the thinner of the connected sections., Butt welds shall be used for all welded joints in pipe assemblies and in the fabrication of bends and other specials. Field-welded joints, where permitted, shall be either butt-welded or lap-welded Lap-welded joints shall have full fillet welds. Any weld that undercuts the parent metal shall be cut out, filled, and ground smooth.

Field welding of joints shall conform to ANSI/AWWA C206 and M11. Where acceptable to the Engineer, single field-welded butt joints with outside backing rings may be used for pipe larger than 30 inches in diameter. Backing rings will not be permitted for 30 inch and smaller pipe. Butt straps shall be welded on both the inside and outside of the pipe and at each end of the pipe and strap to avoid stress multiplication.

Field-welded lap joints may have only a single fillet weld on the inside of the pipe joint as detailed in Figure)3-40 05 24(B), except where double-welded joints as detailed in Figure 3-40 05 24(B) are indicated on the Drawings or specified. The interior joint may be welded after the exterior joint has been coated with a shrinkable wrapped sleeve or other specified coating and backfilled with at least 3 feet [900 mm] of backfill material. The field welding shall be performed so that the interior lining, the exterior coating, and the field applied joint coating are not damaged.

A field test, including excavation of a welded joint for inspections, shall be performed to verify that the interior lining, the exterior coating, and the field applied joint coating are not damaged by the interior welding at the start of the project. The field test shall be repeated if welding procedures are modified.

Provisions shall be made to minimize stresses in welded steel pipe to account for temperature changes and to avoid the accumulation of expansion and contraction during installation and after the pipe is in service as recommended by the pipe manufacturer and in accordance with ANSI/AWWA M11 and C604. The allowable temperature range of the pipe during welding shall be established by the pipe design and monitored during installation as recommended by the pipe manufacturer.

3-4.06.01. Standard Inspection and Testing. Standard shop inspection and testing shall be in accordance with the shop inspection and testing provisions specified herein.

Field weld test specimens shall be furnished to Engineer for testing by an independent testing laboratory whenever, in the judgment of Engineer, a satisfactory weld is not being made. Test specimens shall also be furnished when Engineer desires. All costs for this testing will be paid by Owner.

3-4.07. Couplings. Surfaces of pipe ends and couplings in contact with the sealing gasket shall be clean and free from foreign material when the coupling is installed on the pipe. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. All bolts shall be tightened by approximately the same amount, with all parts of the coupling square and symmetrical with the pipe. Following installation, the exterior coating of each coupling shall be touched up or re-primed.

Where restraint is required, Design-Builder shall verify that tie bolts have been stressed to assure the pipe will not creep when pressurized. When split ring, fixed type couplings are installed, piping shall be in a fully-extended position to engage the restraint rings at the pipe ends.

3-4.07.01. Flanged Coupling Adapters. Flanged coupling adapters shall be installed in accordance with the coupling manufacturer's recommendations. After the pipe is in place and all bolts have been properly tightened, the location of holes for the anchor studs shall be determined and the pipe shall be field drilled. Holes for anchor studs shall extend completely through the pipe wall. Hole diameter shall be not more than 1/8 inch [3 mm] larger than the diameter of the stud projection. Unless otherwise indicated on the Drawings, all 12 inches [300 mm] and smaller flange coupling adapters shall be restrained and all 14 inches [350 mm] and larger flange coupling adapters may only be used in unrestrained applications.

3-4.07.02. Dismantling Joints. Dismantling joints shall be installed in accordance with the coupling manufacturer’s recommendations. Unless otherwise indicated on the Drawings, dismantling joints shall be restrained.

3-4.07.03. Mechanical Couplings. Mechanical couplings shall be installed in accordance with the coupling manufacturer's recommendations. A space of at least 1/4 inch, but not more than 1 inch, shall be left between the pipe ends. Pipe and coupling surfaces in contact with gaskets shall be clean and free from dirt and other foreign matter during assembly. All assembly bolts shall be uniformly tightened so that the coupling is free from leaks, and all parts of the coupling are square and symmetrical with the pipe. Following installation of the coupling, damaged areas of shop coatings on the pipe and coupling shall be repaired to the satisfaction of Engineer.

3-4.07.04. Grooved-End Joints. Grooved-end joints with rigid type grooving shall be installed in accordance with the coupling manufacturer's recommendations. Completed joints shall be rigid and shall allow no angular deflection or longitudinal movement. Except for closure pieces, field grooving of pipe will not be acceptable.

Grooved-end couplings shall not be used in the following applications: chemical services, except lime slurry piping; flammable liquid or flammable gas piping, compressed air or compressed gas piping operating at pressures above 25 psi; toxic gas piping; hot liquid with operating temperatures above 120º F; or steam piping.

3-5. WALL SLEEVES AND WALL PIPES. Wall sleeves and wall pipes shall be installed as indicated on the Drawings and shall be installed where steel pipe passes through concrete or masonry walls, unless otherwise noted.

Where harness lugs are attached to wall sleeves, the sleeves shall be carefully aligned to permit installation of the tie rods. In flange and mechanical joint wall sleeves and wall pipe, holes in the mechanical joint bells and flanges shall straddle the top (or side for vertical piping) center line. The top (or side) center line shall be marked on each flange and mechanical joint piece at the fabricating shop.

Where specified or indicated on the Drawings for sleeves detailed, one or two sets of modular casing seals shall be installed at the face of walls to seal against soil or provide a dust or water tight seal. Design-Builder shall coordinate the diameter of wall sleeve with the modular casing seal manufacturer. When soil may be present at wall sleeves, a set of modular casing seals shall be installed at each face of the wall. Modular casing seals shall not be used in submerged conditions unless the hydrostatic pressure is less than 20 feet and piping is less than 24 inches size.

3-6. REDUCERS. Reducers shall be eccentric or concentric as indicated on the Drawings. Reducers of eccentric pattern shall be installed with the straight side on top, so that no air traps are formed.

3-7. BLOWOFFS. Blowoffs shall be located and arranged as indicated on the Drawings.

3.8. ACCESS MANHOLES. Access manholes shall be the type specified and installed at the locations indicated on the Drawings.

3-9. GAS AND OIL-RESISTANT GASKETS. Gas and oil-resistant gaskets shall be installed where specified, indicated on the Drawings, or directed by Engineer

where jointing gaskets may be subject to permeation when piping passes through areas where soil may be contaminated with gas or petroleum (oil) products or organic solvents or their vapors.

3-10. PIPE ANCHORS, BLOCKING, CONCRETE ENCASEMENT, HANGERS, AND SUPPORTS. Pipe anchors, blocking, hangers, and supports shall be installed where and as specified and indicated on Drawings and shall be fabricated in accordance with thethe details indicated on the Drawings, and shall be furnished and installed complete with all concrete bases, anchor bolts and nuts, plates, rods, and other accessories required for proper support of the piping. All piping shall be rigidly supported and anchored so that there is no movement or visible sagging between supports. Unless otherwise permitted, lugs for lateral or longitudinal anchorage shall be shop welded to the pipe.

Concrete reaction anchorage, blocking, encasements, and supports shall be installed as indicated on the Drawings. Concrete and reinforcing steel for anchorages, blocking, encasements, and supports shall conform to the Cast-in-Place Concrete section. All pipe to be encased shall be suitably supported and blocked in proper position, and shall be anchored to prevent floatation. A pipe joint shall be provided within 12 inches of each end of the concrete encasement.

The concrete blocking size shall be of the dimensions indicated on the Drawings, shall extend from the fitting to solid undisturbed earth, and shall be installed so that all joints are accessible for repair. If adequate support against undisturbed earth cannot be obtained, restrained joints shall be installed to provide the necessary support.

Reaction blocking, anchorages, or other supports for fittings installed in fills or other unstable ground, installed above grade, or exposed within structures, shall be provided as indicated on the Drawings.

All ferrous metal clamps, rods, bolts, and other components of reaction anchorages or joint harness, subject to submergence or in contact with earth or other fill material and not encased in concrete, shall be protected from corrosion as specified in the Corrosion Protection paragraph of this section.

3-11. JOINT HOLDBACKS AND COATINGS AND LININGS

3-11.01. Shop Holdbacks and Coatings and Linings and Field Repair. Entry into the pipe or pipeline for application of interior linings to unlined ends shall be from open ends or through access manholes. Pour holes, where allowed by the Engineer of Record, shall consist of 4-inch standard weight black steel pipe welded to the pipe to be lined and covered with a bolted blind flange.

Holdbacks, coatings and linings for pipe ends at joints shall conform to the following:

For Field-Welded Joints		
	Cement Mortar	Hold back coating and lining 4 to 6 inches from joint. Field repair in accordance with ANSI/AWWA C205 as modified herein.
	Tape Coating	Hold back coating at least 4 to 6 inches from joint. Field repair in accordance with ANSI/AWWA C214 and ANSI/AWWA C604 using Heat Shrinkage Wrap ANSI/AWWA C216, 80 mils. Type I for pipe and fitting joints.
For Flanged Joints		Extend lining to ends of pipe. Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for flanges.
For Stab Joints		
	Cement Mortar	Hold back the coating on spigots and the lining in bells from joints as submitted by the pipe manufacturer and accepted by Engineer. Field repair in accordance with ANSI/AWWA C205 as modified herein.
	Liquid Epoxy	Epoxy shop coating shall extend to ends of pipe. Epoxy shop lining shall extend to ends of pipe. If cement-mortar or tape coating is used, epoxy shop lining shall be extended around the end of pipe to a point 4 inches past the sealing point of the rubber gasket.
	Tape Coating	Hold back the coating on spigots as as submitted by the pipe manufacturer and accepted by Engineer. Field repair in accordance with ANSI/AWWA C214 and ANSI/AWWA C604 using Heat

		Shrinkage Wrap ANSI/AWWA C216, 80 mils, Type I for pipe and fitting joints.
For Mechanically Coupled Joints		

	Cement Mortar	Hold back coating 16 inches (or greater if required to clear harness lugs) from joints. Shop coat exposed surfaces with liquid epoxy to end of pipe in accordance with ANSI/AWWA C210 Epoxy. Lining shall extend to end of pipe. Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for mechanical couplings.
	Liquid Epoxy	Epoxy shop coating shall extend to ends of pipe; epoxy shop lining shall extend to ends of pipe; in accordance with ANSI/AWWA C210 . Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for mechanical couplings.
	Tape Coating	Hold back coating 16 inches (or greater if required to clear harness lugs) from joints. Shop coat exposed surfaces with liquid epoxy to end of pipe in accordance with ANSI/AWWA C210 Epoxy. Field coat buried exterior surfaces as specified in the Corrosion Protection paragraph for mechanical couplings
For Other Type of Joints and Exposed Buried Surfaces		Other types of joints and exposed buried surfaces that cannot be shop coated with the primary coating and lining system shall be shop coated and lined with 20 mil dry film thickness of liquid epoxy in accordance with ANSI/AWWA C210 Epoxy.

3-11.02. Modifications to the Governing Standards.

3-11.02.01. Field Repair of Cement Mortar Lining. Field repair of interior joint surfaces shall be done in accordance with ANSI/AWWA C205, except that an epoxy bonding agent and latex admixture shall be used in conjunction with the sand and cement mortar. The addition of lime or pozzolan will not be permitted.

The exposed steel shall be thoroughly cleaned and all grease shall be removed. A coat of epoxy bonding agent shall be applied over the area to be lined in accordance with the coating manufacturer's recommendations. A soupy mixture of cement and water shall be applied over the epoxy after it becomes tacky. Cement mortar to which the latex admixture has been added shall then be packed into the area to be patched and screeded off level with the adjacent cement mortar lining. The patched area shall be given an initial floating with a wood float, followed by a steel trowel finish.

Defective or damaged cement mortar linings shall be removed, the surfaces cleaned, and the lining repaired as specified above for joint repair. Wire fabric reinforcement shall be used in the lining of fittings and specials in conformance with ANSI/AWWA C205

3-11.02.02. Special Procedure for Exterior Joint Grouting. Each exterior joint recess in cement coated pipe shall be filled with joint grout. A diaper shall be used to prevent foreign material from entering the joint recess before grouting and to serve as a form for the grout. Each diaper shall be of sufficient length to encircle the pipe, leaving enough space between the ends for pouring the grout. Hems shall be stitched into the edges of the diaper to receive steel strapping for attaching the diaper to each side of the pipe joint. The diaper shall have “pouring flap” extensions that fold back while the joint is being poured and that lap over the pouring gap after the diaper is filled with grout. The grout shall be poured or pumped between the diaper and the pipe and shall be allowed to run to the bottom of the pipe on one side until it is observed coming up on the opposite side of the pipe to ensure that the space in the bottom of the joint is filled with grout. Grout can be poured or pumped, topping out on both sides of the pipe, and shall be rodded on the same side of the pipe from which it is pumped or poured, while being poured, using a stiff wire curved to the approximate shape of the pipe to prevent tearing a hole in the diaper. Each joint recess shall be completely filled with grout for the full circumference of the pipe.

Prior to grouting the exterior joints, at least two lengths of pipe shall be in final position, or the pipe shall be backfilled sufficiently to brace and secure it against displacement. Design-Builder shall protect the exterior joint grout against damage during pipe laying or backfilling.

3-12. CORROSION PROTECTION.

3-12.01. Flanged Joints. The flange bolts and nuts on buried flanged joints shall be protected by wrapping them with wax tap in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer.

Following application of the wax tape protection, the entire flanged joint shall be encapsulated with a shrink sleeve. The shrink sleeve shall extend a minimum of 6 inches onto the shop coated pipe on each side of the flange. A primer shall be applied to the piping on each side of the flange prior to installing the shrink sleeve. The installation of the shrink sleeve shall be in accordance with ANSI/AWWA C216 and as recommended by the shrink sleeve manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

Corrosion protection of buried insulated flanges shall be as specified herein unless otherwise shown on the drawings

3-12.02. Valves. Buried valve flanges shall be protected as specified herein for buried flange joints.The corrosion protection for the entire remaining buried valve and actuator to the wrench nut shall be wax tape or shrink sleeve.

3-12.03. Mechanical Couplings. The coupling and its tie bolts and nuts on all buried mechanical couplings shall be coated with two coats, 20 mils minimum, of medium consistency coal tar.

After the protective coating has been applied to the coupling and tie bolts, the entire mechanical coupling shall be encapsulated with a shrink sleeve. The shrink sleeve shall extend a minimum of 6 inches onto the shop coated pipe on each side of the coupling, including covering all epoxy coated steel. A primer shall be applied to the piping on each side of the coupling prior to installing the shrink sleeve. The application of the shrink sleeve shall be in accordance with ANSI/AWWA C216 and as recommended by the shrink sleeve manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

3-12.04. Restrained Mechanical Couplings. Buried mechanical couplings shall be protected with two coats of medium consistency coal tar and shrink sleeve as specified herein for buried mechanical couplings.

The tie rods and bolts of the harness rings or lugs of the restrained coupling assembly shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application of the wax tape shall be as recommended by the wax tape manufacturer.

Following the application of the wax tape, the entire restrained mechanical coupling assembly, including coupling, tie bolts and nuts, pipe, and harness rings or lugs, shall be encapsulated with an underlying sleeve covered by a shrink

sleeve. The underlying sleeve shall extend a minimum of 6 inches onto the pipe beyond each end of the tie rods. The shrink sleeve shall extend a minimum of 6 inches onto the shop coated pipe beyond each end of the underlying sleeve. A primer shall be applied to the piping on each side of the harness assembly prior to installing the shrink sleeve. The application of the shrink sleeve shall be in accordance with ANSI/AWWA C216 and as recommended by the shrink sleeve manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

3-12.05. Other Assemblies. All ferrous metal clamps, tie rods, bolts, and other components of buried joint harnesses, mechanical joints, wall fittings, or pipe reaction anchorages in contact with earth or other fill material and not encased in concrete, shall be protected by wrapping them with wax tape in accordance with ANSI/AWWA C217. A primer shall be applied prior to applying the wax tape. The application for the wax tape shall be as recommended by the wax tape manufacturer. There shall be no bare or unprotected ferrous metal surfaces.

3-12.06. Surfaces Exposed in Manholes and Vaults. Unless otherwise specified, all uncoated metal surfaces exposed in manholes and vaults shall be cleaned and coated with two coats of medium consistency coal tar. The first coat shall be dry and hard before the second coat is applied. There shall be no unprotected, bare, or uncoated ferrous metal surfaces.

3-13. CONNECTIONS WITH EXISTING PIPING. Connections between new work and existing piping shall be made using fittings suitable for the conditions encountered. Each connection with an existing pipe shall be made at a time and under conditions which will least interfere with service to customers, and as authorized by Owner.

Facilities shall be provided for dewatering and for disposal of the water removed from the dewatered lines and excavations without damage to adjacent property.

Special care shall be taken to prevent contamination when dewatering, cutting into, and making connections with potable water piping. Trench water, mud, or other contaminating substances shall not be permitted to enter the lines. The interior of all pipe, fittings, and valves installed in such connections shall be thoroughly cleaned and then swabbed with or dipped in a 200mg/L chlorine solution.

3-14. INSTALLATION IN TUNNELS. Not used.

3-15. PROVISIONS FOR CATHODIC PROTECTION. Cathodic protection shall be provided for buried piping as specified in the Cathodic Protection section. Provisions shall be made for cathodic protection of underground steel pipelines.

An insulated type joint shall be provided at each connection to a steel water tank, each branch connection to an existing or future water line, each connection between concrete pipe or ductile iron pipe and steel pipe, each connection through a structure wall, and where indicated on the Drawings. An electrical bond shall be provided across all other gasketed pipeline joints. Test lead stations for monitoring electrical currents on the pipeline shall be provided at locations indicated on the Drawings.

3-15.01. Insulated Joints. Insulated flange type joints shall be provided where indicated on the Drawings or specified. After installation, corrosion protection shall be provided for the joint as specified in the Corrosion Protection paragraph.

3-15.02. Electrical Bond Across Rubber-Gasketed Joints. Two electrical bonding cables shall be bonded to and across each mechanical coupling, stab joint, or other rubber-gasketed stab joint. Before the field joint coating is applied to mechanical couplings, two small areas of metal shall be exposed on the pipe surface each side of the coupling, on the middle ring, and on each follower ring. Before the field joint coating is applied to stab joints, two small areas of metal shall be exposed on each side of the joint. Each area shall be thoroughly cleaned, and two cathodic protection cables shall be bonded to the pipe, one on either side of the joint, and to the middle ring and follower rings for mechanically coupled joints. Each cable shall be bonded by the thermite process. The completed connections and exposed metal surfaces shall be coated as specified for field repair of coatings in the Corrosion Protection paragraph.

3-15.03. Electrical Bond Across Valves and Flanges. Two electrical bonding cables shall be provided across valves and flanged connections other than insulated flanges. The electrical bond shall be provided as specified for bond across rubber-gasketed joints.

3-15.04. Bonding Cables and Test Lead Wires. Bonding cables and test lead wires shall be not less than 6 AWG, Type CP copper cathodic protection cable, with low density, high molecular weight polyethylene insulation.

3-15.05. Test Lead Stations. Test lead stations shall be provided where specified or indicated on the Drawings. The test lead stations shall be in accordance with the details indicated on Figure 2-40 05 24, and as specified herein. The test lead wires shall be terminated on the ground surface in a standard connection box at a protected location acceptable to Engineer. Standard connection boxes for test lead stations shall be C.P. Test Services "NM-7" plastic terminal boxes, 18 inches long, with 5 inches inside diameter, a locking cast iron lid, a terminal block with seven terminals, and the inscription "CP TEST" cast into its cover.

3-16. PRESSURE AND LEAKAGE TESTS. After installation, pipe and fittings shall be subjected to a pressure test and a leakage test. The Design-Builder shall provide all necessary pumping equipment; piping connections between the piping and the nearest available source of test water; pressure gauges; and other equipment, materials, and facilities necessary for the tests. The minimum test pressure shall be as indicated in the Pipeline Schedule.

All pipe, fittings, valves, pipe joints, and other materials which are found to be defective shall be removed and replaced with new and acceptable materials, and the affected portion of the piping shall be retested by and at the expense of Design-Builder.

All joints shall be watertight and free from visible leaks.

3-17. DISINFECTION. Disinfection of pipelines is not required.

End of Section

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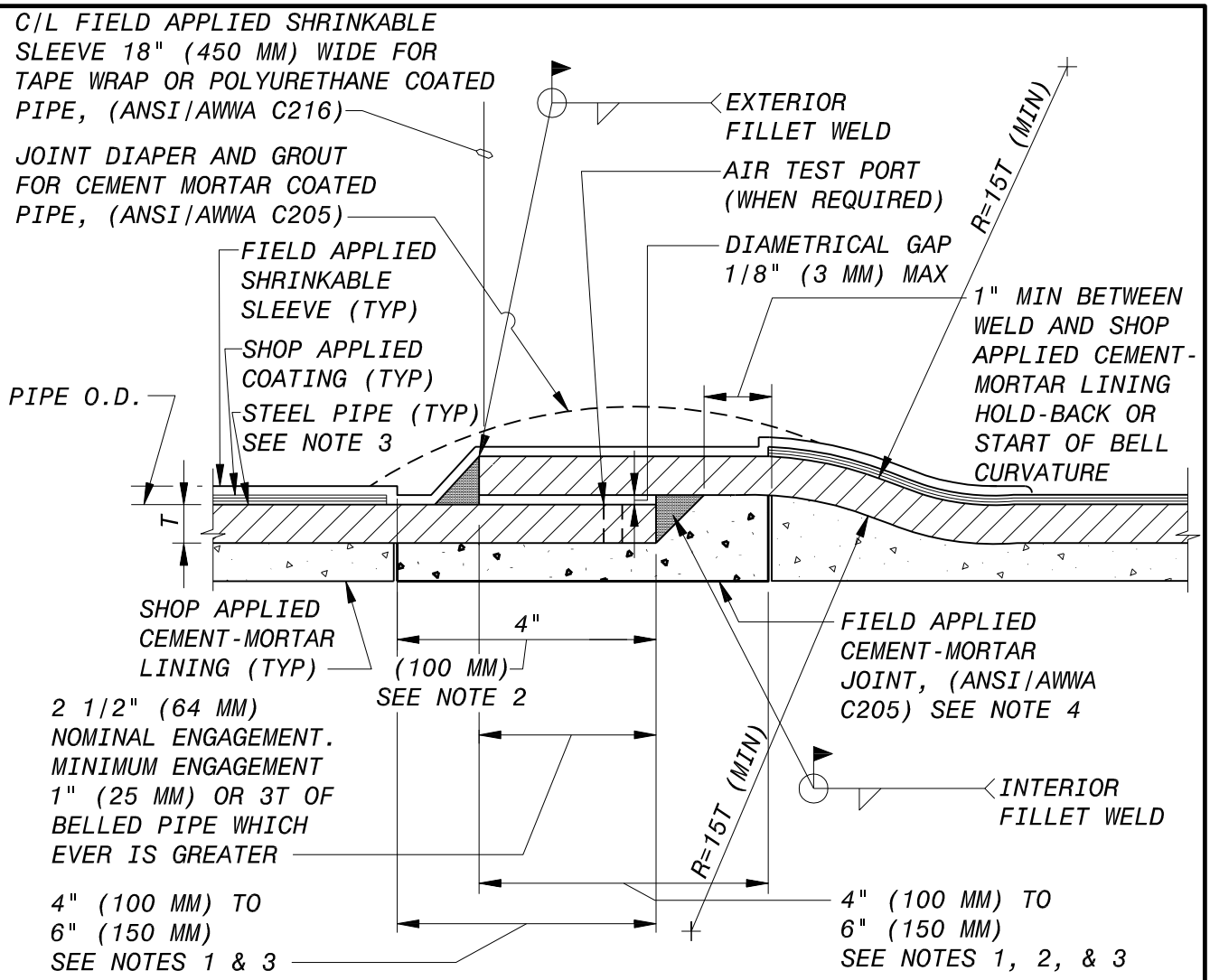


DOUBLE WELDED BELL/SPIGOT DETAIL

NO SCALE (INTERIOR WELD AFTER BACKFILL)

NOTES:

1. HOLD TAPE MATERIALS BACK 4" (100 MM) TO 6" (150 MM) ON THE SPIGOT OD AND ON BELL OD. LEAVE CUT-BACK BARE STEEL.

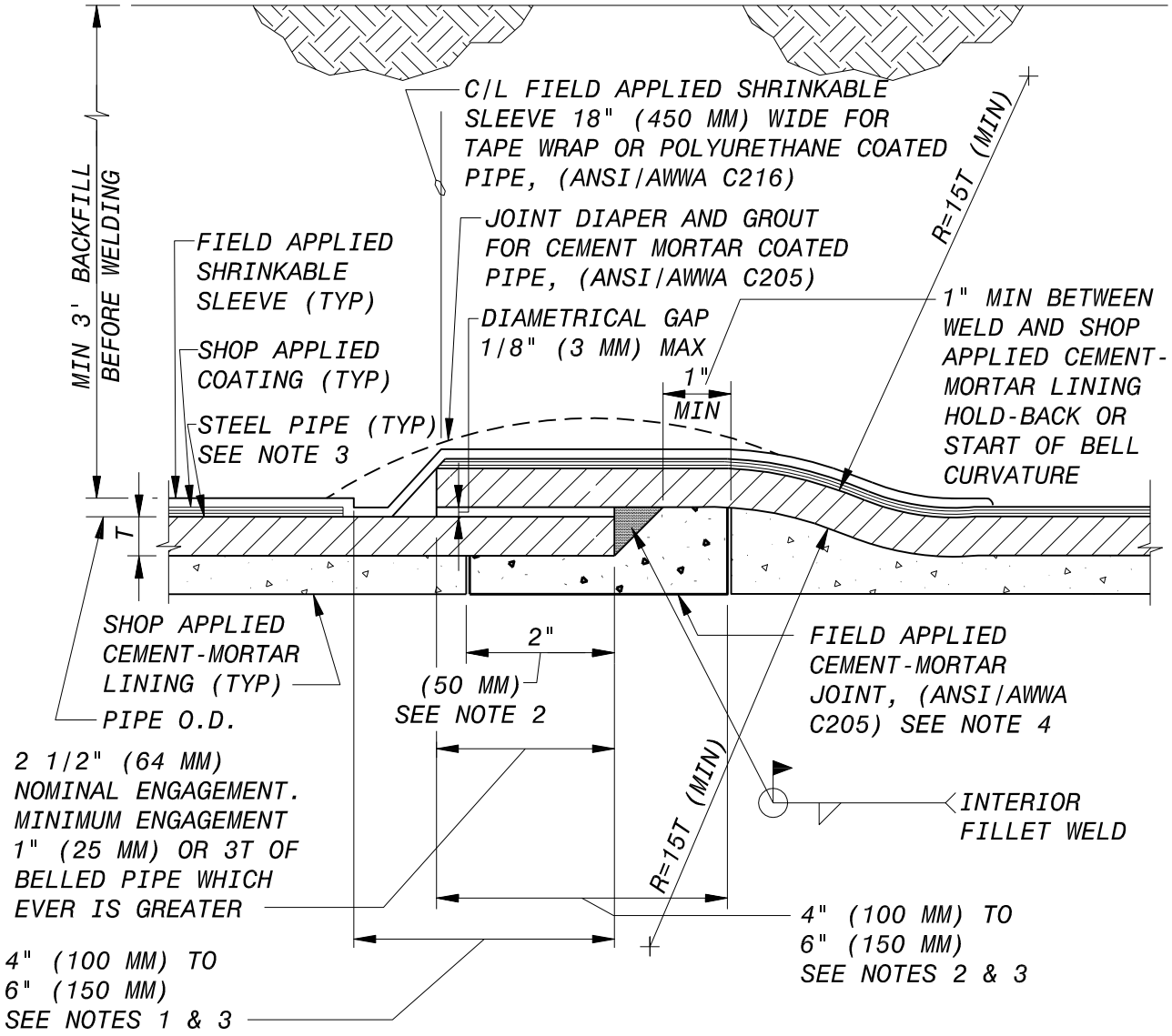
2. HOLD CEMENT-MORTAR LINING BACK 4" (100 MM) TO 6" (150 MM) ON BELL ID AND 4" (100 MM) ON SPIGOT ID. LEAVE CUT-BACK BARE STEEL.

3. GRIND SPIRAL WELD BACK 18" (450 MM) ON BELL AND SPIGOT OD. GRIND SPIRAL WELD BACK 4" (100 MM) TO 6" (150 MM) ON BELL ID.

4. FILL JOINT GAP IN LINING BY FIELD APPLIED CEMENT-MORTAR PER ANSI/AWWA C205.

FIELD-WELDED LAP JOINT DETAIL

BLACK & VEATCH	STEEL PIPE	FIG 3-40 05 24(A)



SINGLE WELDED BELL/SPIGOT DETAIL (WELD AFTER BACKFILL)

NO SCALE

NOTES:

1. HOLD TAPE MATERIALS BACK 4" (100 MM) TO 6" (150 MM) ON THE SPIGOT OD. LEAVE CUT-BACK BARE STEEL.

2. HOLD CEMENT-MORTAR LINING BACK 4" (100 MM) TO 6" (150 MM) ON BELL ID AND 2" (50 MM) ON SPIGOT ID. LEAVE CUT-BACK BARE STEEL.

3. GRIND SPIRAL WELD BACK 18" (450 MM) ON BELL AND SPIGOT OD. GRIND SPIRAL WELD BACK 4" (100 MM) TO 6" (150 MM) ON BELL ID.

4. FILL JOINT GAP IN LINING BY FIELD APPLIED CEMENT-MORTAR PER ANSI/AWWA C205.

FIELD-WELDED LAP JOINT DETAIL

BLACK & VEATCH	STEEL PIPE	FIG 3-40 05 24(B)

Section 40 05 24.43

MISCELLANEOUS STEEL PIPE, TUBING, AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous steel pipe, tubing and accessories that for pipe diameters 24 inches and smaller. Pipe and tubing shall be furnished complete with all fittings, flanges, unions, and other accessories specified herein.

Steel pipe for potable and non-potable water conveyance are covered in the Steel Pipe section.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

Supplier shall submit a written statement from the gasket material manufacturer certifying that the gasket materials are compatible with the joints specified herein and are recommended for the specified field test pressures and service conditions.

1-4. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

1-4.01. Coated Pipe. Handling methods and equipment used shall prevent damage to the protective coating and shall include the use of end hooks, padded

calipers, and nylon or similar fabric slings with spreader bars. Bare cables, chains, or metal bars shall not be used. Coated pipe shall be stored off the ground on wide, padded skids. Plastic coated pipe shall be covered or otherwise protected from exposure to sunlight.

PART 2 - PRODUCTS

2-1. GALVANIZED STEEL PIPE.

Galvanized steel pipe materials and service shall be as specified herein.

2-1.01. Material Classification CSG-1.

CSG-1 – Standard Weight Galvanized Steel with Threaded Fittings All pipe sleeves except where plastic sleeves are required.	Pipe Fittings	ASTM A53, Type E, standard weight, Grade A or B; or ASTM A106, of equivalent thickness, galvanized. Cast iron threaded, galvanized. Fittings shall conform to ANSI/ASME B16.4, Class 125.

2-1.02. Material Classification CSG-2.

CSG-2 – Standard Weight Galvanized Steel with Threaded Fittings Grease piping – pumping units. Sump pump discharge piping in interior locations except where buried. Filtrate piping. Drain piping from equipment.	Pipe Fittings	ASTM A53, Type E, standard weight, Grade A or B; or ASTM A106, of equivalent thickness, galvanized. Malleable iron threaded, galvanized. Fittings shall conform to ANSI/ASME B16.3, Class 150, or Fed Spec WW-P-521, Type II.]

2-1.03. Material Classification CSG-3.

CSG-3 – Standard Weight Galvanized Steel with Flanged Fittings. Sump pump discharge piping in interior locations except where buried.	Pipe Fittings	ASTM A53, Type E, standard weight, Grade A or B; or ASTM A106, of equivalent thickness, galvanized. Cast iron flanged, galvanized. Fittings shall conform to ANSI/ASME B16.1, Class 125.

2-1.04. Accessory Materials. Accessory materials for galvanized steel pipe shall be as indicated in the Steel Pipe section of the specification.

2-2. STEEL PIPE. Steel pipe materials and service shall be as specified herein.

2-2.01. Material Classification CS-1.

CS-1 – Standard Weight Steel with Threaded Fittings. Drain piping.	Pipe Fittings	ASTM A53, Type E, standard weight, Grade B; or ASTM A106, of equivalent thickness. Malleable iron threaded. Fittings shall conform to ANSI/ASME B16.3, Class 150, or Fed Spec WW-P-521, Type I.

2-2.02. Material Classification CS-2.

CS-2 – Standard Weight Steel with Socket Welded Fittings. Natural or LP gas piping, buried or interior locations. Steam and condensate piping. Sodium hydroxide solution piping, interior locations or outdoors above grade. Reverse osmosis permeate piping. Aqua ammonia piping interior locations or outdoors above grade. Carbon dioxide gas piping between feeder and injector or diffuser. Heating water system piping. Chilled water system piping. Methanol piping. Compressed air supply piping, 2 inch and smaller up to 250 psig . 2 inch and smaller.	Pipe Fittings	ASTM A53/A106, Type S, standard weight, Grade B; Plain ends. Forged steel socket welded. Fitting shall conform to ANSI B16.11, Class 3000; Bonney, Crane, Ladish, or Vogt.

2-2.03. Material Classification CS-3.

CS-3 – Standard Weight Steel with Buttwelded Fittings. Natural or LP gas piping, buried or interior locations. Sodium hydroxide solution piping, interior locations or outdoors above grade. Sodium hydroxide solution piping, interior locations or outdoors above grade. Compressed air supply piping up to 250 psig. Fuel oil or diesel fuel piping in interior locations or outdoors above grade. 2-1/2 inch and larger.	Pipe Fittings	ASTM A53/A106, Type S, standard weight Grade B; Bevel ends. Buttwelded. Fitting shall conform to ANSI/ASME B16.9, standard weight.

2-2.04. Material Classification CS-4.

CS-4 – Extra Strong Steel with Threaded Fittings. Compressed air supply piping, 251-500 psig. Fuel oil or diesel fuel piping in interior locations or outdoors above grade (seal weld). 2 inch and smaller.	Pipe Fittings	ASTM A53/A106, Type S, extra strong, Grade B; Threaded ends. Forged steel, threaded. Fittings shall conform to ANSI B16.11, Class 2000 or 3000; Bonney, Crane, Ladish, or Vogt.

2-2.05. Material Classification CS-5.

CS-5 – Extra Strong Steel with Socket Welded Fittings.	Pipe Fittings	ASTM A53/A106, Type S, extra strong Grade B; Plain ends. Forged steel, socket welded. Fittings to conform to ANSI B16.11, Class 3000; Bonney, Crane, Ladish, or Vogt.

2-2.06. Material Classification CS-6.

CS-6 – Extra Strong Steel with Buttwelded Fittings. Compressed air supply piping, 2-1/2 inches and larger, 251-500 psi.	Pipe Fittings	ASTM A53, Type E, extra strong, Grade B; or ASTM A106, of equivalent thickness. Bevel ends. Buttwelded. Fittings shall conform to ANSI/ASME B16.9; extra strong.

2-2.07. Material Classification CS-7.

CS -7 – Standard Weight Steel with Threaded Fittings.	Pipe Fittings	ASTM A53/A106, Type S, standard weight Grade B. Threaded ends. Cast iron threaded. Fitting shall conform to ANSI/ASME B16.4, Class 125. When used for lime slurry piping service, fittings and flanges for disassembly and cleaning shall be provided only at the locations indicated on the Drawings. Changes in alignment at other locations shall be accomplished by bending the pipe. All bends shall have a radius of at least 3 feet .

2-2.08. Material Classification CS-8.

CS-8 – Hydraulic Tubing with Compression Fittings. As shown on the Drawings.	Tubing Fittings	ASTM A179, seamless, soft annealed. Required wall thickness: As required. Steel, compression type, Crawford "Swagelok" or Parker Hannifin "CPI".

2-2.09. Material Classification CS-9.

CS-9 – Steel Pipe with PP Lining. As shown on the	Pipe and Lining Fittings	ASTM F492 A587, A106 Grade B, or A53.

Drawings.	

2-2.10. Material Classification CS-10.

CS-10 – Steel Pipe with PVD Lining. As shown on the Drawings	Pipe and Lining Fittings	ASTM F491 A587, A106 Grade B, or A53.

2-2.11. Material Classification CS-11.

CS-11 – Steel Pipe with FRP Lining. As shown on the Drawings.	Pipe and Lining Fittings	ASTM F546 A587, A106 Grade B, or A53.

2-2.12. Material Classification CS-12.

CS-12 – Steel Pipe with PTFE Lining. Sulfuric acid solution piping.	Pipe and Lining Fittings	ASTM F423 A587, A106 Grade B, or A53.

2-2.13. Material Classification CS-13.

CS-13 – Steel Pipe with Glass Lining. As shown in the Drawings.	Pipe Lining Fittings	Standard weight steel pipe with flanged ends and Ceramic Coating "Non-Stick Glass Lining" or Vitco "SG-14 Glass Lined Pipe". Two-coat system applied over blast-cleaned surface; ground and finish coats separately fired; finished lining thickness at least 8 mils , Mohs' Hardness 5 to 6, density 2500 to 3000 kg/m^3 as determined by ASTM D792. Ductile iron, as specified in the Ductile Iron Pipe section, with Ceramic Coating "Non-Stick Glass Lining" or Vitco "SG-14 Glass Lined Pipe".

2-2.14. Material Classification CS-14.

CS-13 – Double-Wall Secondary Containment Pipe. Diesel fuel piping, buried. Fuel oil piping, buried. Gasoline piping, buried. Lubricating oil piping, buried. Waste oil piping, buried.	Mfr.	Perma Pipe/Ricwil Type "Ultra FS".
	Carrier Pipe	Black steel pipe, ASTM A53/A106, Type S, Grade B, Schedule 80.
	Containment Pipe	Black steel pipe, ASTM A53, Type S, Grade B, Schedule 40 with FRP filament wound outer covering bonded to steel containment pipe, minimum 0.100 inch thick.
	Fittings	Factory prefabricated, of the same materials and thickness as the specified pipe.
	Leak Detection	Stainless steel leak detection guide tube and stainless steel cable pull wire to allow pulling of the leak detection cable into the containment pipe, both during and after piping installation.

2-2.15. Accessory Materials. Accessory materials for the miscellaneous steel pipe and tubing systems shall be as indicated.

Nipples	ASTM A733, seamless, extra strong (Schedule 80); "close" nipples will be permitted only by special authorization in each case.
Unions (Malleable Iron)	Fed Spec WW-U-53l, Class 2; Type B (galvanized) for galvanized pipe or Type A (black) for ungalvanized pipe.
Flanges	
Standard Weight Pipe	ANSI/ASME B16.5, Class 150, flat faced when connected to flat faced flanges; otherwise, raised face.
Extra Strong Pipe	
Chemical Gas Piping	ASTM A105, forged steel, tongue and groove flanged union type, with nonmetallic

	gasket; rated for a working pressure of 1,500 psi.
Other services	ANSI/ASME B16.5, Class 300, raised face.
Plastic Lined Pipe	Steel, forged or cast, diameter and drilling in accordance with ANSI/ASME B16.5, Class 150 or 300 as required.
Flange Bolts and Nuts	ASTM A193, Grade B7 with ASTM A194 Grade 2H nuts. Length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.
Flange Gaskets	
For Process Air Service	
Raised Face Flanges	Non-asbestos inorganic fiber with EPDM binder; dimensions to suit flange contact face, 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces, rated for 275°F service; Garlock "IFG 5507".
Flat Faced Flanges	Premium Grade, EPDM, full face, 1/8 inch thick, rated for 275°F service; Garlock "8314".
For Oil Service	Non-asbestos filler with neoprene or nitrile binder; dimensions to suit flange contact face; 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces.
For Heating Water Service	Non-asbestos inorganic fiber with nitrile binder; dimensions to suit flange contact face, 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces; Garlock "IFG 5500".
For Water Service	ASTM D1330, Grade I, red rubber, ring type, 1/8 inch thick.
For Chemical Service	Suitable for chemical.
For Other Services	
Flat Faced Flanges	Non-asbestos filler with neoprene or nitrile binder; dimensions to suit flange contact face; 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum

	thickness for serrated surfaces.
Raised Face Flanges	Continuous stainless steel ribbon wound into a spiral with non-asbestos filler between adjacent coils with a carbon steel gauge ring. Compressed gasket thickness shall be 0.095 inch ±0.005 inch.
Grooved Couplings	
Rigid	AWWA C606; Gustin-Bacon "No. 120 Rigid" or Victaulic "07 Zero-Flex".
Standard	AWWA C606; Gustin-Bacon "No. 100 Standard" or Victaulic "Style 77".
Mechanical Couplings	Dresser "Style 38" or Smith-Blair "Type 411 Flexible Coupling"; without pipe stop.
Expansion Joints	
Process air	Expansion joints shall be the elastomeric, arched type and shall be Mercer “Type 450” with “Type 500” retaining rings and Kevlar reinforcement, or equal. The number of arches shall be as indicated on the Drawings. The connection shall be suitable for a maximum pressure of 15 psig and maximum temperature of 250 F . Expansion joints shall have the following ratings: Number of Arches: 1 Spring rate: ___ lbs/inch Movement: ___ inch Number of Arches: 2 Spring rate: ___ lbs/inch Movement: ___ inch Number of Arches: 3 Spring rate: ___ lbs/inch Movement: ___ inch]
Heating water, chilled water, and other services not specified.	Flexonics "Model H Expansion Compensators" for 3 inch or smaller; Flexonics "Mid-Corr, Series MCB" with flanged ends and stainless steel bellows for 4 inch or larger. Expansion joints shall be suitable for working pressures up to 150 psig .
Material Classification	CS-14: Double wall pipe with leak detection.
Joining	Carrier pipe shall be joined by socket welding.

	Containment pipe shall be joined by split sleeve of the same diameter as containment pipe with minimum 60 mil thick polyethylene jacket.
End Seal	End seals shall be furnished at all terminal ends. The end seal shall be sealed to the containment pipe.
Leak Detection	Microprocessor based monitoring unit, for continuous monitoring by cable of a single line for water and hydrocarbon.
Control Panel	Modified NEMA Type 12 enclosure, with Status and Alarm Data Model "PAL-AT20C". Power supply to the unit will be 120 volt, 1 phase, 60 Hz. Unit shall be UL listed with alarm horn and shall locate leaks and not depend on battery back-up functions. System conditions shall be stored in memory in the event of power failure and shall automatically resume monitoring without reset once power is available. Monitoring unit shall be able to differentiate between water left in pipe during installation and an actual growing leak. Panel shall also be able to detect a break in sensor cable and its location.
Cable	Cable shall be located in the interstitial space between the carrier and containment pipe, shall detect both water and hydrocarbon, and shall be capable of being dried in place without being replaced after exposure to any fluid Type "AGW-Gold". Coaxial cable shall interface monitoring control panel with sensor cable by utilizing waterproof junction box for protecting connection.

2-3. COATINGS. Standard weight steel pipe in buried locations, except hot piping such as aeration air piping, shall have exterior surfaces protected with a shop applied plastic coating. Coatings for hot piping shall be as specified.

Extra strong steel pipe in buried locations shall have exterior surfaces protected with a field or shop applied tape wrap as specified in the Miscellaneous Piping and Accessories Installation section.

All surfaces to be tape-wrapped in the shop shall be thoroughly cleaned and primed in accordance with the tape manufacturer's recommendations immediately before wrapping. The tape shall be applied by two-ply (half-lap)

wrapping or as needed to provide a total installed tape thickness of at least 60 mils .

Shop applied coatings shall be as follows:

External Coatings

Plastic	Liberty Coating Company “Pritec" or Bredero-Shaw “Entec". The products of other manufacturers will not be acceptable.
Tape Wrap	ANSI/AWWA C209, except single ply tape thickness shall not be less than 30 mils [760 µm]; Protecto Wrap "200" or Tapecoat "CT".
High temperature epoxy for aeration and process air piping	Shop or field applied high solids epoxy; suitable for protection at continuous pipe wall temperatures up to 300 F. Coating shall be abrasion resistant. The finished coating shall have a minimum total film thickness of 10 mils. The surface shall be prepared in accordance with SSPC-SP7 as a minimum unless otherwise recommended by the coating manufacturer. The coating shall be Carboline “Thermaline 450”, Ameron “Amerlock 400 with Amercoat 880 Additive”, or approved equal.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 31.12

POLYVINYL CHLORIDE (PVC) PRESSURE PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of 4 through 36 inch buried polyvinyl chloride (PVC) pressure pipe for potable water service, recycled water service, and plant process piping. PVC pressure pipe shall be furnished complete with all fittings, jointing materials, anchors, blocking, encasement, and other necessary appurtenances.

Pressure and watertightness tests, cleaning, and disinfection, are covered in other sections. Pipe trenching, bedding, and backfill are covered in the Trenching and Backfilling section.

Pipe shall be furnished where indicated in the pipeline schedule or where indicated on the Drawings.

1-1.01. Pipe Manufacturer's Experience and Field Services. Not used.

1-2. SPARE MATERIALS. The following spare materials shall be furnished and delivered to the Owner as directed. Owner will inspect the material, unload, and place in storage. If the material is found to be damaged, it shall be replaced.

Spare Material	Quantity
PVC pipe, ductile iron pipe OD, DR25, with stab joints of the type of pipe provided.	2 lengths

1-3. GOVERNING STANDARDS. Except as modified or supplemented herein, all PVC pressure pipe shall conform to the applicable requirements of ANSI/AWWA C900.

The supplementary information required in the governing standards is as follows:

Affidavit of Compliance	Required.
Plant Inspection	Not required.
Special Markings	Not required.
Special Preparation for Shipment	Not required.
Certification	Required.

1-4. SUBMITTALS. Drawings and data shall be submitted in accordance with the Submittals Procedures section. Drawings and data shall include, but shall not be limited to, the following:

Gasket material.

Pipe length.

Pipe Dimension Ratio.

Manufacturer's hydrostatic proof test results for each length of pipe in each lot from which pipe shall be provided for the Project, and results from dimension measurements, flattening tests, and extrusion quality tests performed in accordance with the governing standard, for each lot from which pipe is provided for the Project. Test results shall be submitted in Microsoft Excel format on CD, and shall include a summary of the number of lengths in each lot that fail the tests and the total number of lengths in each lot. The submittal shall also include a listing of the number of lengths of pipe provided from each lot.

Affidavit of Compliance (ANSI/AWWA C900, Sec. 6.3).

Certification (ANSI/AWWA C900, Sec. 4.2.4).

Certificate of Compliance with NSF Standard No. 61.

1-4.01. Emergency Repair Manual. Not used.

1-5. MATERIALS TESTING. Not used.

1-6. DELIVERY, STORAGE AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

Pipe, fittings, and accessories shall be handled in accordance with Chapter 6 of AWWA Manual M23, to ensure installation in sound, undamaged condition. Pipe shall not be stored uncovered in direct sunlight.

PART 2 - PRODUCTS

2-1. DIMENSIONS. The dimension ratios (DRs: outside diameter to wall thickness) of PVC pressure pipe shall be as indicated on the Drawings or the Pipe Schedule.

2-2. MATERIALS.

Pipe	ANSI/AWWA C900; cast iron pipe OD, dimension ratio as specified herein.
Fittings	Ductile iron; ANSI/AWWA C110/A21.10, 250 psi pressure rating, except shorter laying lengths will be acceptable. Tapping saddles/sleeves shall be sized for PVC pipe.
Joints	
PVC to PVC	ANSI/AWWA C900, stab type, with elastomeric synthetic rubber gaskets. Gaskets of natural rubber will not be acceptable.
PVC to Cast Iron	ANSI/AWWA C111/A21.11, except gaskets shall be synthetic rubber. Natural rubber will not be acceptable.
Tapping Saddles	Ductile iron, with galvanized steel straps and synthetic rubber sealing gasket, 250 psi [1.7 MPa] pressure rating.
Restrained Joints	ASTM F1674, EBAA Iron 2000PV series (4 inch through 20 inch), Sigma “One Lok” SLCE series, or concrete thrust blocking.
Tapping Sleeves	Ductile iron, 250 psi [1.7 MPa] pressure rating.
Polyethylene Encasement	Tube or sheet, ANSI/AWWA C105/A21.5.
Joint Tape	Self-sticking, PVC or polyethylene, 10 mils [250 µm] thick; Chase "Chasekote 750", Kendall "Polyken 900", or 3M "Scotchrap 50".
Coal Tar Epoxy	High-build coal tar epoxy; Ameron "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".

Conductive Tracer	Detection tape, 3 inches wide; aluminum foil core, 0.5 mil thick, encased in a protective inert plastic jacket; 5,000 psi min tensile strength; 2.5 lbs per inch per 1,000 feet min mass; color coded in accordance with APWA Uniform Color Code; Lineguard "Type III", or Reef Industries "Terra Tape D".

Manufacturing quality control shall be maintained by frequent, regularly scheduled sampling and testing. Testing shall comply with the governing standards.

2-3. SHOP COATING AND LINING. The exterior surfaces of ductile iron fittings shall be coated with a bituminous coating. The interior surfaces of ductile iron fittings shall be lined with cement mortar.

PART 3 - EXECUTION

3-1. INSPECTION. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation; spigot ends and bells shall be examined with particular care. All defective pipe and fittings shall be removed from the site of the work.

3-2. LAYING PIPE. Pipe shall be protected from lateral displacement by pipe embedment material installed as specified in the Trenching and Backfilling section. Pipe shall not be laid in water or other unsuitable conditions.

Pipe shall be laid with bell ends facing the direction of laying, except when reverse laying is specifically permitted.

Foreign matter shall be prevented from entering the pipe during installation.

Whenever pipe laying is stopped, the open end of the line shall be sealed with a watertight plug. All water shall be removed from the trench prior to removing the plug.

A conductive tracer shall be buried above PVC pipe, not more than 18 inches below the ground surface.

3-2.01. Cleaning. The interior of all pipe and fittings shall be thoroughly cleaned before installation and shall be kept clean until the work has been accepted.

3-2.02. Alignment. Piping shall be laid to the lines and grades indicated on the Drawings. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line or grade shall not exceed the maximum deflections specified by the manufacturer.

Unless otherwise specified or indicated on the Drawings, either shorter pipe sections or fittings shall be installed as required to maintain the indicated alignment or grade.

3-3. CUTTING PIPE. Cutting shall comply with the pipe manufacturer's recommendations and with Chapter 7 of AWWA Manual M23. Cuts shall be smooth, straight, and at right angles to the pipe axis. After cutting, the end of the pipe shall be dressed to remove all roughness and sharp corners and shall be beveled in accordance with the manufacturer's instructions.

3-4. JOINTS. Joints shall be gasketed push on type meeting the requirements of ASTM D3139 unless otherwise indicated on the Drawings.

3-4.01. Gasketed Push-on Type Joints. Jointing shall conform to the instructions and recommendations of the pipe manufacturer. All surfaces of the spigot end of the gasketed joints shall be lubricated immediately before the joint is completed. Gaskets and lubricants shall be supplied by the pipe manufacturer, shall be suitable for use in potable water, shall be compatible with the pipe materials, shall be stored in closed containers, and shall be kept clean. Each spigot shall be suitably beveled to facilitate assembly.

3-4.02. Mechanical Joints. Mechanical joints shall be carefully assembled in accordance with the manufacturer's recommendations. If effective sealing is not obtained, the joint shall be disassembled, thoroughly cleaned, and reassembled. Over-tightening of bolts to compensate for poor installation practice will not be permitted.

3-5. POLYETHYLENE ENCASEMENT. All cast iron fittings, tapping saddles, tapping sleeves, valves, or other cast iron accessories shall be provided with polyethylene tube or sheet protection installed in accordance with ANSI/AWWA C105/A21.5, Method A or C.

3-6. CONNECTIONS WITH EXISTING PIPING. Connections with existing pipes shall be made using fittings suitable for the conditions encountered. Each connection with an existing pipe shall be made at a time and under conditions which will least interfere with service to customers, and as authorized by Owner. Facilities shall be provided for proper dewatering and for disposal of water removed from the dewatered lines and excavations without damage to adjacent property.

Special care shall be taken to prevent contamination of potable water lines when dewatering, cutting into, and making connections with existing pipe. No trench water, mud, or other contaminating substances shall be permitted to enter the lines. The interior of all pipe, fittings, and valves installed in such connections shall be thoroughly cleaned and then swabbed with, or dipped in, a 200 mg/L chlorine solution.

3-7. SERVICE CONNECTIONS. Tapping saddles or tapping sleeves shall be used for all service connections 2 inches and smaller. Direct tapping of PVC pipe will not be permitted. Fittings shall be used for service connections larger than 2 inches.

3-8. CONCRETE ENCASEMENT. Concrete encasement shall be installed as indicated on the Drawings. Concrete and reinforcing steel shall be as specified in the Cast-in-Place Concrete section. All pipe to be encased shall be suitably supported and blocked in proper position and shall be anchored against flotation.

3-9. RESTRAINED JOINTS. All bell-and-spigot or all-bell tees, Y-branches, bends deflecting 11-1/4 degrees or more, valves, and plugs which are installed in piping subjected to internal hydrostatic heads in excess of 30 feet [9 m] shall be provided with suitable restraint.

Concrete blocking shall extend from the fitting to solid, undisturbed earth and shall be installed so that all joints are accessible for repair. The dimensions of concrete reaction blocking shall be as indicated on the Drawings.

Reaction blocking, anchorages, or other supports for fittings installed in fills or other unstable ground shall be provided as indicated by the Drawings.

All steel clamps, rods, bolts, and other metal accessories used in tapping saddles or reaction anchorages subject to submergence or in contact with earth or other fill material, and not encased in concrete, shall be coated in accordance with the Protective Coatings section.

All steel clamps, rods, bolts, and other metal accessories used in tapping saddles or reaction anchorages subject to submergence or in contact with earth or other fill material, and not encased in concrete, shall be protected from corrosion by two coats of medium consistency coal tar applied to clean, dry metal surfaces. The first coat shall be dry and hard before the second coat is applied.

3-10. PRESSURE AND LEAKAGE TESTS. After installation, PVC piping shall be hydrostatically tested for defective workmanship and materials as specified in the Pipeline Pressure and Leakage Testing section.

3-11. LEAKAGE. All PVC piping shall be watertight and free from leaks. Each leak which is discovered within the correction period stipulated in the General Conditions shall be repaired.

3-12. CLEANING AND DISINFECTION. After installation, PVC piping shall be cleaned and disinfected as specified in the Cleaning and Disinfection of Water Pipelines section.

End of Section

Section 40 05 31.16

POLYVINYL CHLORIDE (PVC) SEWER PIPE

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing polyvinyl chloride (PVC) gravity sewer pipe and fittings, complete with all jointing materials and appurtenances. Ribbed pipe or open profile pipe will not be acceptable.

Pipe trenching, bedding, and backfilling are covered in the Trenching and Backfilling section.

1-2. SUBMITTALS. Drawings and data shall be submitted in accordance with the Submittals Procedures section. Drawings and data shall include, but shall not be limited to, the following:

Details of joints.

Gasket material.

Pipe length.

Certification in accordance with ASTM D3034, Section 11; ASTM F679, Section 10; ASTM F1803, Section 12.

1-3. DELIVERY, STORAGE AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

Pipe, fittings, and accessories shall be handled in accordance with Chapter 6 of AWWA Manual M23, to ensure installation in sound, undamaged condition. Pipe shall not be stored uncovered in direct sunlight.

PART 2 - PRODUCTS

2-1. MATERIALS.

Pipe and Fittings.

Solid wall 4 through 15 inches.	ASTM D3034, Minimum SDR 35, Minimum Cell Classification 12354.
18 through 48 inches.	ASTM F1803, or ASTM F679, Minimum Pipe Stiffness of 46 psi, Minimum Cell Classification 12354.

Jointing Materials.	
Bell-and-Spigot Joints.	ASTM D3212, integral bell push-on type elastomeric gasket joints.
Gaskets.	ASTM F477, synthetic rubber. Natural rubber will not be acceptable.
Field-Cut Joints and Connections to Other Piping Materials.	Fernco "Flexible Couplings" or Mission "Eastern Standard Band-Seal Couplings" with stainless steel shear rings.
For Grouted Connections to Cast-in-Place Concrete Manholes	Rubber ring water stop.
Conductive Tracer	Detection tape, 3 inches [75 mm] wide; aluminum foil core, 0.5 mil [13 µm] thick, encased in a protective inert plastic jacket; 5,000 psi [35 MPa] min tensile strength; 2.5 lbs per inch per 1,000 feet [45 g/mm per 300 mm] min mass; color coded in accordance with APWA Uniform Color Code; Lineguard "Type III", or Reef Industries "Terra Tape D".

PART 3 - EXECUTION

3-1. INSTALLATION AND TESTING. Pipe shall be installed and tested in accordance with the Sewer Pipe Installation and Testing section.

End of Section

Section 40 05 32

MISCELLANEOUS PLASTIC PIPE, TUBING, AND ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous plastic pipe, tubing, and accessories. Pipe and tubing shall be furnished complete with all fittings, flanges, unions, jointing materials and other necessary appurtenances.
1-2. See Scope of Supply Section for requirements.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

Contractor shall obtain and submit a written statement from the gasket material manufacturer certifying that the gasket materials are compatible with the joints specified herein and are recommended for the specified field test pressures and service conditions.

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

Pipe, tubing, and fittings shall be stored between 40°F and 90°F [4°C and 32°C].

PART 2 - PRODUCTS

2-1. FRP PIPE. Not used.

2-2. PVC PIPE MATERIALS.
PVC pipe materials and services shall be as specified herein.

2-2.01. Material Classification PVC-1.

PVC-1 – Schedule 40 PVC Pipe with Solvent Welded Joints. Compressed air piping. Foul air piping. Microfiltration filtrate piping. Other piping shown on Drawings.	Pipe Fittings	ASTM D1785, Cell Classification 12454, bearing NSF seal, Schedule 40. ASTM D2466, Cell Classification 12454, bearing NSF seal.

2-2.02. Material Classification PVC-2.

PVC-2 – Schedule 80 PVC Pipe with Solvent Welded Joints. Compressed air piping. Drain piping. Filter backwash piping. Indirect potable reuse water piping. Microfiltration filtrate piping. Non-potable water piping. Overflow piping. Plant outfall water piping. Polymer piping. Reclaimed water piping. Reverse osmosis feed, permeate, concentrate, and forward flush piping. Ultraviolent treatment effluent piping. Waste activated sludge piping Other piping shown on Drawings.	Pipe Fittings	ASTM D1785, Cell Classification 12454, bearing NSF seal, Schedule 80. ASTM D2467, Cell Classification 12454, bearing NSF seal. Flanges or unions shall be provided where needed to facilitate disassembly of equipment or valves. Flanges or unions shall be joined to the pipe by a solvent weld. When acceptable to Design-Builder, threaded joints may be used instead of solvent welded joints in exposed interior locations for the purpose of facilitating assembly. The use of threaded joints in this system shall be held to a minimum.

2-2.03. Material Classification PVC-3.

PVC-3 – Schedule 80 PVC Pipe with Threaded Joints. Swing joints in irrigation system piping.	Pipe Fittings	ASTM D1785, Cell Classification 12454, bearing NSF seal, Schedule 80. ASTM D2464, Cell Classification 12454, bearing NSF seal.

2-2.04. Material Classification PVC-4. Not used.

2-2.05. Material Classification PVC-5. Not used.

2-2.06. Material Classification PVC-6. Not used.

2-2.07. Material Classification PVC-7. Not used.

2-2.08. Material Classification PVC-8. Not used.

2-2.09. Accessory Materials. Accessory materials for the PVC Pipe systems shall be as indicated.

Flanges	Diameter and drilling shall conform to ANSI/ASME B16.5, Class 150. Schedule 80 for DWV systems.
Flange Bolts and Nuts	ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut. Stainless steel for DWV and chemical feed systems, galvanized steel for all other systems.
Flat Washers	ANSI B18.22.1, plain. Same material as bolts and nuts.
Flange Gaskets	Full face, 1/8 inch thick, chemical-resistant elastomeric material suitable for the specified service.
Expansion Joints	Edlon "Thermo-molded TFE" or Resistoflex "Style R6905" molded expansion joint.

2-3. CPVC PIPE. CPVC pipe materials and services shall be as specified herein.

2-3.01. Material Classification CPVC-1.

2-3.02. Material Classification CPVC-2.

CPVC-2 – Schedule 80 CPVC Pipe with Solvent Welded Joints. Antiscalent piping. Sodium bisulfate piping. Sodium hydroxide solution piping, buried or submerged. Sulfuric acid piping. Reverse osmosis permeate and CIP return and supply piping. Other piping shown on Drawings	Pipe Fittings	ASTM F441, Cell Classification 23447, bearing NSF seal, Schedule 80. ASTM F439, Cell Classification 23447, bearing NSF seal. Flanges or unions shall be provided where needed to facilitate disassembly of equipment or valves. Flanges or unions shall be joined to the pipe by a solvent weld. When acceptable to Design-Builder, threaded joints may be used instead of solvent welded joints in exposed interior locations for the purpose of facilitating assembly. The use of threaded joints in this system shall be held to a minimum.

2-3.02. Accessory Materials. Accessory materials for the CPVC Pipe systems shall be as indicated.

Flanges	Diameter and drilling shall conform to ANSI/ASME B16.5, Class 150.
Flange Bolts and Nuts	ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut. Stainless steel for chemical feed systems, galvanized steel for all other systems.
Flat Washers	ANSI B18.22.1, plain. Same material as bolts and nuts.
Flange Gaskets	Full face, 1/8 inch thick, chemical-resistant elastomeric material suitable for the specified service.
Expansion Joints	Edlon "Thermo-molded TFE" or Resistoflex "Style R6905" molded expansion joint.]

2-4. PE PIPE.PE pipe materials and services shall be as specified herein.

2-4.01. Material Classification PE-1. Not used.

2-4.02. Material Classification PE-2. Not used.

2-4.03. Material Classification PE-3. Not used.

2-4.04. Material Classification PE-4. Not used.

2-4.05. Material Classification PE-5. Not used.

2-4.06. Material Classification PE-6. Not used.

PE-6 – Polyethylene Tubing in carrier pipe. Antiscalaent Citric Acid Sodium Hydroxide Sodium Bisulfate Other piping shown on Drawings	Tubing and Fittings	1/8 through 3/4 inch [3 through 19 mm] OD, 1/16-inch wall thickness, 130°F maximum operating temperature with compression fittings.

2-4.07. Accessory Materials. Accessory materials for the PE Pipe systems shall be as indicated.

Flanges	Schedule 80 PVC; diameter and drilling shall conform to ANSI/ASME B16.5, Class 150.
Flange Bolts and Nuts	ANSI B18.2.1, ASTM A193, AISI Type 304, heavy hex head, length such that after installation the bolts will project 1/8 to 3/8 inch beyond outer face of the nut. ASTM A194, AISI Type, ANSI/ASME B18.2.2, heavy hex pattern.
Fittings and Flange Adapters	Molded or manufactured from the pipe; cell classification of material and pressure rating same as for pipe.

2-5. POLYPROPYLENE PIPE.

2-5.01. Material Classification PP-1. Not used.

2-5.02. Material Classification PP-2. Not used.

2-5.03. Material Classification PP-3. Not used.

2-6. PVDF PIPE. Not used.

2-7. REINFORCED PLASTIC TUBING. Not used.

2.8. FLEXIBLE PFA TUBING. Not Used.

2.9 TEFLON (PFA) HOSE. PFA hose materials and services shall be as specified herein.

2-9.01. Material Classification TEFL-1.

TEFL-1 – Teflon Hose in carrier pipe. Sodium Hypochlorite Sulfuric Acid Other piping shown on Drawings	Hose	Polypropylene braided, convoluted PFA Teflon Hose; PureFlex Inc "ProFlex", or preapproved equal.
	Fittings	Connections shall be accomplished using ProFlex Style 11 or equal fittings constructed of solid Kynar and installed at the factory. Splices and hose fittings shall be factory installed. Tubing connections to hard pipe shall be flange type or as recommended by the tubing manufacturer with wetted parts suitable for the chemical. Where barbed fittings are required the clamps shall be of stainless steel with blow-off proof crimping collar. Field connections shall be accomplished using ProFlex Style 03 or equal fittings constructed of solid Kynar.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 41

MISCELLANEOUS PIPING AND PIPE ACCESSORIES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous piping and pipe accessories. Miscellaneous piping shall be furnished complete with all fittings, flanges, unions, and other accessories specified herein.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section and the Schedule of Submittals Section 00300. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

Name of Manufacturer
Type and model
Construction materials, thickness, and finishes
Pressure and temperature ratings

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the general Terms and Conditions section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

PART 2 - PRODUCTS

2-1. MATERIALS. Miscellaneous piping materials shall be as specified herein.

2-1.01. Material Classification BR-1.

BR-1 – Regular Weight Brass Pipe Gauge piping for hot/cold water. Gauge piping for seal water. Gauge piping for compressed air.	Pipe Fittings	ASTM B43, red brass, seamless, regular weight. ANSI/ASME B16.15, Class 125.

2-1.02. Material Classification BR-2. Not used.

2-1.03. Material Classification HS-1.

HS-1 – Hose with Insert Type Couplings Flexible connections in chemical piping. Overflow lines from chlorine feeders and residual analyzers. Chemical transfer. Lime slurry at slakers and slurry pumps. Lime slurry in pump discharge.	Hose Couplings	ID not smaller than nominal size. Boston " Crosslinked Polyethylene Hose" or Gates "Renegade", "Mustang 45 HW" or "Stallion" acid-chemical hose. To be selected for resistance to the service chemical. Rigid PVC or other material suitable for service conditions, with band type stainless steel clamps.

2-1.04. Material Classification HS-2.

HS-2 – Hose with Quick Disconnect Couplings Flexible connections in chemical piping. Overflow lines from chlorine feeders and residual analyzers. Lime slurry. Chemical transfer. Lime slurry at slakers and slurry pumps. Lime slurry in pump discharge.	Hose Couplings	ID not smaller than nominal size. Boston "Crosslinked Polyethylene Hose" or Gates "Renegade", "Mustang 45 HW" or "Stallion" acid-chemical hose. To be selected for resistance to the service chemical. Cam-lock type quick connect/disconnect couplers and adapters as manufactured by OPW or PT

2-1.05. Material Classification TG-1. Not used.

2-1.06. Material Classification CRP-1.

CRP-1 – Carpenter 20-Cb3 Pipe with Socket Weld Fittings Sulfuric acid piping Other piping shown on Drawings.	Welded Seamless Fittings	ASTM B464 - UNS NO8020, schedule 40. ASTM B729 - UNS NO8020, schedule 40. Socket weld, Class 3000, ASTM B462 - UNS NO8020. The use of flanged fittings shall be limited to equipment connections.

2-1.07. Accessories. Accessories for the miscellaneous piping systems shall be as indicated.

Unions for brass pipe — Fed Spec A-A-59617, Class 125.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

End of Section

Section 40 05 51.13

VALVE INSTALLATION

PART 1 - GENERAL

1-1. SCOPE. This section covers the installation of new valves and actuators purchased by Design-Builder as part of this Work or purchased by others under the valve specifications. The equipment to be furnished by others for installation by Design-Builder is identified in the applicable valve schedules.

Cleaning, disinfection, pressure and leakage testing, insulation, and pipe supports are covered in other sections if required.

The following specification sections are applicable to all valves to be installed on the project.

1-2. GENERAL. Equipment installed under this section shall be erected and placed in proper operating condition in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer.

Any valves and actuators that are identified as being provided by others will be furnished complete for installation by Design-Builder. Technical specifications under which the equipment will be purchased are available.

1-2.01. Coordination. When manufacturer's field services or installation check services are provided by the valve manufacturer, Design-Builder shall coordinate the services with the valve manufacturer.

Flanged, push-on, and grooved connections to valves including the bolts, nuts, and gaskets are covered in the appropriate pipe specification section. Valve ends shall match piping.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3-1. INSPECTION. All valves and accessories shall be inspected for damage and cleanliness before being installed. Any material damaged or contaminated in handling on the job shall not be used unless it is repaired and re-cleaned to the original requirements by Design-Builder.

3-2. INSTALLATION.

3-2.01. General. Valves shall be installed with sufficient clearance for proper operation of any external mechanisms, and with sufficient clearance to dismantle the valve for in-place maintenance. Installation shall be in accordance with the valve manufacturer's recommendations.

Valves shall be installed and their operators oriented in such a manner that they can be operated from the main operating floors or platforms without the use of ladders or special operating devices.

Valve operators shall be accessible and access shall not be impeded by pipe, equipment, building components, etc.

Valves shall be installed such that the orientation of the operator complies with the manufacturer's recommendations.

Valve operators shall not create a hazard by extending into walkways below a minimum elevation of 7'-6" above the walkway floor.

Some drawings may indicate the dimensions of the major lines. These dimensions are subject to change to accommodate the equipment, valves, and fittings actually furnished and the variations in equipment as actually installed. If the equipment, valves, fittings, and other components of the piping systems actually furnished differ in dimensions from those indicated, the piping systems shall be altered by the Design-Builder with approval of the Engineer of Record as required to accommodate these changes. If, due to some unforeseen circumstance, the installation of the piping as indicated would result in an interference, the modifications or corrections required to install the piping free from interferences shall be made by the Subcontractor.

Valves shall be installed such that primary direction of flow through the valve matches the direction of flow as marked on the valve body or otherwise specified by the manufacturer.

Valves shall be installed in accordance with manufacturer's requirements for upstream and downstream distance from pumps, elbows and any other turbulence creating devices.

3-2.02. Installation Checks. When specified in the valve sections, the valve manufacturer will provide installation checks. For installation checks, the manufacturer's field representative will inspect the valve installation immediately following installation by Design-Builder. The manufacturer's representatives will revisit the site as often as necessary to ensure installation satisfactory to Owner.

3-2.03. AWWA Butterfly Valves. Not used.

3-2.04. Check Valves.

3-2.04.01. Lift Check Valves. Horizontal lift checks shall be installed in a level horizontal position so that the internal parts rise and fall vertically, unless the

valve is spring loaded. Angle pattern lift checks shall be installed in vertical pipe with flow upward from beneath the disc.

3-2.04.02. Swing Check Valves. Install valves oriented for the correct flow direction. Only valves designed for vertical installation shall be installed in vertical piping.

3-2.04.03. Low Pressure Air Service Check Valves. Dual disc wafer check valves installed in the discharge piping of centrifugal blowers shall be positioned with the valve hinge perpendicular to the impeller shaft of the blower.

3-2.05. Plug Valves.

3-2.05.01. Eccentric Plug Valves. Eccentric plug valves shall be installed with the shaft horizontal and the plug in the upper half of the valve body. Valves in horizontal wastewater, sludge, or scum lines shall be installed with the seat on the upstream end. Valves in all vertical piping shall be installed with the seat at the upper end of the valve.

3-2.05.02. Plug Valves. Not used.

3-2.06. Resilient Seated Gate Valves.

3-2.06.01. Resilient Seated Gate Valves. Valves shall be handled and installed in accordance with the recommendations set forth in the Appendices to ANSI/AWWA C509 and C515 and with the recommendations of the manufacturer.

3-2.06.02. Double Disc Gate Valves. Not used.

3-2.07. Air Release and Combination Air Valves. The exhaust from each valve shall be piped to a suitable point. Air release valve exhaust piping leading to a trapped floor drain shall terminate at least 6 inches above the floor.

3-2.08. Hydrants. Fire hydrants and yard hydrants shall be installed per the City of Morro Bay standards.

3-2.09. Valve Boxes. Valve boxes shall be set plumb. Each valve box shall be placed directly over the valve it serves, with the top of the box brought flush with the finished grade. After each valve box is placed in proper position, earth fill shall be placed and thoroughly tamped around the box.

3-3. VALVE ACTUATORS. Valve actuators and accessories shall be factory mounted on the valve, calibrated, and tested by the valve or actuator manufacturer.

3-4. FIELD QUALITY CONTROL.

3.4.01. Field Testing. After installation, all valves shall be tested in accordance with the Pipeline Pressure and Leakage Testing section.

3-4.01.01. Pressure Tests. Pressure testing shall be in accordance with the Pipeline Pressure and Leakage Testing section.

3-4.01.02. Leakage Tests. All valves shall be free from leaks.

3-5. ADJUSTING. After installation, the opening and closing time shall be adjusted as needed for each pneumatic, hydraulic and electric actuated valve.

End of Section

Section 40 05 51.16

GATE INSTALLATION

PART 1 - GENERAL

1-1. SCOPE. This section covers the installation of new gates and actuators.

The following specification sections are applicable to gates to be installed under this contract:

Cast-Iron Slide Gates

Open-Channel Metal Slide Gates and Weir Gates

1-2. GENERAL. Equipment installed under this section shall be erected and placed in proper operating condition in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

Any gates and actuators identified as being provided by others will be furnished complete for installation by Design-Builder.

1-2.01. Coordination. When installation check services are provided by the gate manufacturer, Design-Builder shall coordinate the services with the gate manufacturer. Design-Builder shall give Owner's Representative written notice at least 30 days prior to the need for manufacturer's installation check services.

PART 2 - PRODUCTS

2-1. MATERIALS. Materials shall be as follows:

Grout	As specified in the Grouting section.

PART 3 - EXECUTION

3-1. INSPECTION. All gates and accessories shall be inspected for damage and cleanliness before being installed. Any material damaged or contaminated in handling on the job shall not be used unless it is repaired and recleaned to the original requirements by Design-Builder. Such material shall be segregated from the clean material and shall be inspected and approved by Owner or his representative before its use.

3-2. INSTALLATION.

3-2.01. General. Gates and appurtenances shall be installed with sufficient clearance for proper operation of any external mechanisms, and with sufficient clearance to dismantle the gate for maintenance. Installation shall be in accordance with the manufacturer's recommendations and the requirements specified herein.

All bolts shall be tightened and all items requiring lubrication, including pivot pins, shall be lubricated. Anti-seize thread lubricant shall be liberally applied to the threaded portion of stainless steel anchor bolts during the installation and tightening of nuts. Excess lubricant shall be thoroughly removed following final tightening.

The threaded portion of each plastic stem cover shall be wrapped in at least two layers of teflon thread tape, and the threaded portion of steel pipe stem covers shall be coated with teflon thread sealer immediately prior to installation of the cover on the actuator.

Each gate shall be adjusted so that it does not bind or leak in excess of specified requirements. After installation, each gate shall be operated through at least two complete open-close cycles, re-adjusted and re-operated as necessary, and left in a condition acceptable to Engineer.

3-2.02. Installation Checks. When specified in the gate sections, the gate manufacturer will provide installation checks. For installation checks, the manufacturer's field representative will inspect the gate installation immediately following installation by Design-Builder. The manufacturer's representatives will revisit the site as often as necessary to ensure installation satisfactory to Owner.

3-2.03. Cast-Iron and Fabricated Stainless Steel Slide GatesEach cast-iron and fabricated stainless steel slide gate shall be carefully installed and adjusted for proper operation. Care shall be taken to avoid warping the gate frames and to maintain tolerances between seating faces.

Wall thimbles, if required, shall be accurately positioned and supported to prevent shifting during placement of surrounding concrete. Square or rectangular thimbles shall be carefully braced both horizontally and vertically to prevent distortion.

Gates mounted directly on the vertical face of concrete walls shall be adjusted and grouted in place with non-shrinking grout in accordance with the manufacturer's recommendations.

Gates shall be installed so that frame members and anchor bolts do not rest upon or contact steel reinforcing bars. Anchor bolts shall be set using a template.

Grout fill shall be placed in the pit in front of each flush bottom closure gate after the gate has been adjusted.

Each actuator shall be accurately set and plumbed and shall be in proper alignment with the gate and stem before the actuator is grouted in place. Operating stems shall be installed in proper alignment and shall not bind in the lift nut or stem guides.

3-2.05. Open-Channel Metal Slide Gates and Weir Gates. Each open-channel slide gate or weir gate shall be carefully installed and adjusted for proper operation. Care shall be taken to avoid deformation of the gate frames and to maintain tolerances between seating faces.

Each embedded frame shall be carefully braced in the forms before concrete is placed, or a space shall be boxed out and the frame shall be grouted in place later. Care shall be exercised to ensure that frame members and anchor bolts do not rest upon or contact steel reinforcing bars.

Components of aluminum open-channel slide gates or weir gates installed in contact with concrete, shall be coated with epoxy in accordance with the Protective Coatings section prior to installation. Damaged areas of shop-applied coatings shall be re-coated and allowed to cure before placement of concrete or grout. Anchor bolts shall be carefully set using a template.

3-3. GATE ACTUATORS. Gate actuators and accessories shall be installed in accordance with the equipment manufacturer's recommendations.

3-4. FIELD QUALITY CONTROL.

3-4.01. Field Testing. After installation, all gates shall be pressure tested for leakage at the hydrostatic heads specified. Leakage exceeding the specified limits which is discovered within the correction period stipulated in the General Conditions shall be repaired by and at the expense of Design-Builder.

3-4.01.01. Cast-Iron Slide Gates. For the maximum seating heads, the leakage shall not exceed 0.1 gpm per foot of seating perimeter. For the maximum unseating heads, the leakage shall not exceed 0.2 gpm per foot of the seating perimeter.

3-4.01.02. Fabricated Stainless Steel Slide Gates. For the maximum seating and unseating heads, the leakage shall not exceed 0.1 gpm per foot of seating perimeter.

3-4.01.03. Open-Channel Metal Slide Gates. For the maximum seating and unseating heads, the leakage shall not exceed 0.1 gpm per foot of seating perimeter.

3-5. ADJUSTING. After installation, the opening and closing time shall be adjusted as needed for each pneumatic, hydraulic, or electric actuated gate.

End of Section

Section 40 05 56

MISCELLANEOUS VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous valves as specified herein and as indicated in the Yard Hydrant Schedule and Fire Hydrant Schedule, except where specific requirements are stipulated in other sections.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Identification. Valves specified herein shall be tagged in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete drawings, details, and specifications, covering the valves and their appurtenances shall be submitted in accordance with the Submittals Procedures section. Included in the submittal shall be drawings by the valve manufacturer to indicate the position of the valve actuator and valve shaft.

PART 2 - PRODUCTS

2-1. CONSTRUCTION.

2-1.01. Length Tolerance. Unless otherwise specified, the actual length of valves shall be within ±1/16 inch of the specified or theoretical length.

2-1.02. Shop Coatings. All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop coated for corrosion protection. The valve manufacturer's standard coating will be acceptable, provided it is functionally equivalent to the specified coating.

Coating Materials

Coal Tar Epoxy	High-build coal tar epoxy; PPG Amercoat "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Epoxy (for liquid service)	PPG Amercoat "Amerlock 400 High-Solids Epoxy Coating", Carboline "Carboguard 891", Sherwin-Williams “Macropoxy 646NSF”or Tnemec "Series N140 Pota-Pox Plus".
Rust-Preventive Compound	As recommended by the manufacturer.

Surfaces To Be Coated

Unfinished Surfaces	
Interior Surfaces	
Liquid Service	Epoxy enamel.
Exterior Surfaces of Valves to be Buried, Submerged, or Installed in Manholes or Valve Vaults	Coal tar epoxy or Epoxy.
Exterior Surfaces of all Other Valves	Universal primer.
Polished or Machined Surfaces	Rust-preventive compound.
Actuators and Accessories	Universal primer.

2-2. HOSE FAUCETS, HYDRANTS, AND CURB STOPS.

2-2.01. Hose Faucets, VHF-1.

VHF-1	Type	Faucet, threaded bonnet.
	Body/Bonnet	Brass.
Hose	Trim	

faucet	Seat	Manufacturer's standard.
	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	End Connection	Threaded, male NPT x male HPT.
	Temp. Limitations	32°F to 212°F.
	Valve Operator	T-handle.
	Manufacturers	Prier Brass "C - 138NP.75" or Dearborn Brass.

2-2.02. Wall Hydrants, VHF-2.

VHF-2	Type	Freezeproof.
	Body/Bonnet	Brass or bronze.
Wall	Trim	
hydrant	Seat	Manufacturer's standard.
	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	End Connection	Threaded, NPT x male HPT.
	Temp. Limitations	32°F to 212°F [0°C to 100°C].
	Valve Operator	Removable key.
	Manufacturers	Smith "5609", Wade " 8600", Woodford "65" or "67, or Zurn "Z-1315".

2-2.03. Wall Hydrants with Vacuum Breaker, VHF-3.

VHF-3	Type	Freezeproof, with vacuum breaker.
	Body	Brass or bronze.
Wall hydrants	Trim	
with vacuum	Seat	Manufacturer's standard.
breaker	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	End Connection	Threaded, NPT x male HPT.
	Temp. Limitations	32°F to 212°F.
	Valve Operator	Removable key.
	Manufacturers	Smith "5609", or Wade " 8600".

2-2.04. Box Type Yard Hydrants, VHF-4.

VHF-4	Type	Nonfreeze, box type.
	Body	Brass or bronze.

Yard hydrant	Trim	
	Seat	Manufacturer's standard.
	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	Box, Cover, Casing	Bronze.
	End Connection	Threaded, NPT x HPT.
	Temp. Limitations	32°F to 212°F.
	Valve Operator	Removable key.
	Manufacturers	Josam "Series 71600", Smith "5810", or Zurn "Z-1360/1365".

2-2.05. Post Type Yard Hydrants, VHF-5.

VHF-5 Post type yard hydrant	Type	Nonfreeze, post type.
	Body	Brass or bronze.
	Trim	
	Seat	Manufacturer's standard.
	Disc	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	End Connection	Threaded, NPT x HPT.
	Temp. Limitations	32°F to 212°F [0°C to 100°C].
	Valve Operator	Removable key.
	Manufacturers	Smith "5910/5914", Wade "8610", or Zurn "Z-1385/1390".

2-2.06. Curb Stops, VCS-1

VCS-1 Curb stop	Code	ANSI/AWWA C800.
	Type	Straight-through.
	Body	Brass or bronze.
	Trim	
	Seat	Manufacturer's standard.
	Plug/Ball	Manufacturer's standard.
	Stem	Manufacturer's standard.
	Stem Seal	Manufacturer's standard.
	End Connection	Threaded.
	Temp. Limitations	32°F to 212°F [0°C to 100°C].
	Valve Operator	T-handle.
	Manufacturers	Ford Meter Box "Ford Ball Valve", Hays "Nuseal Curb Stop", or Mueller "Mark II Oriseal".

2-2.07. Fire Hydrants

Fire hydrants shall conform to ANSI/AWWA C502. The information required by Paragraph III. A. of the ANSI/AWWA C502 foreword shall be as indicated below.

Affidavit of compliance	Not required.
Catalog and maintenance data	Required.
Type of shutoff	Compression or gate.
Size of hydrant (valve opening)	as indicated in the Fire Hydrant Schedule.
Inlet connection	6 inch, locked push-on.
Harnessing lugs	Not required.
Depth of bury	As indicated on the Drawings.
Outlet nozzles	Two 2-1/2 inch hose nozzles and one 4 inch pumper nozzle.
Outlet nozzle threads	See Note 1.
Direction to open	Counterclockwise.
Stem seals	O-ring.
Outlet nozzle cap chains	Required.
Drain outlet	Required.
Operating nut	See Note 2.
Outlet nozzle cap nut	See Note 2.

Notes

1. Outlet nozzle threads shall be the Owner's standard thread.
2. The operating nut and outlet nozzle cap nut shall be of the Owner'sstandard shape and size.

2-3. BASIN VALVES.

2-3.01. Basin Floor Pressure Relief Valves Pressure relief valves shall be provided in basin bottom concrete slabs at the locations indicated on the Drawings. The valves shall be the size indicatedon the Drawings, with cast iron body, nonseparating cast iron or bronze cover, neoprene or Buna-N seat, and bottom strainers, and shall be of a length suitable for the depth of concrete in which they are installed. Pressure relief valves shall be Trumbull Industries, Inc. "Tank Pressure Relief Valve - Floor Type" or Neenah "R-5000, Type C".

Crushed rock or gravel shall be installed below the slab as indicated on the Drawings. The crushed rock or gravel fill shall be covered with polyethylene film before the concrete slab is placed. After the slabs are completed, holes shall be punched in the film beneath each valve.

2-3.02. Basin Wall Pressure Relief Valves. Pressure relief valves shall be provided in concrete basin sidewalls at the locations indicated on the Drawings. The valves shall be the size indicated on the Drawings, cast iron, bronze-mounted, with neoprene or Buna-N seat, and shall be Trumbull Industries, Inc. "Tank Pressure Relief Valve - Wall Type" or Neenah "R-5002, Type B". Each valve shall be provided with a strainer plug and a flange by the bell wall pipe. The flanged end of the wall pipes shall be set flush with the wall and shall be tapped for studs. Each wall pipe and pressure relief valve shall be installed so that flange bolt holes straddle the top center line. The strainer plug of each valve shall be caulked into the bell of the wall pipe with lead wool. Crushed rock or gravel shall be installed at the exterior of the basin wall as indicated on the Drawings.

2-3.03. Mud Valves. Mud valves shall be flanged or spigot end, nonrising or rising stem type as indicated on the Drawings, with threaded stem, seat ring, and gate ring of bronze. Each valve shall be provided with coupling nut, extension stem, stem guides, and operating stand, wheel, or wrench nut, as indicated on the Drawings. Mud valves shall be installed with the valve seat level.

2-3.04. Shear Gates. Shear gates shall be of cast iron, flanged end, with bronze seat rings, and shall be by Clow. Each gate shall be equipped with a lift handle of proper length for easy operation and shall be provided with a hook support to hold the gate in the fully open position and to support the lever when the gate is in the closed position.

2-4. VALVE ACTUATORS. Requirements for valve actuators shall be as specified in the Valve and Gate Actuator section.

2-5. ACCESSORIES. When the Drawings indicate the need for extension stems; position indicator; floor boxes; or operating stands, refer to the Valve and Gate Actuator section.

2-5.01. Valve Boxes. Each valve buried to a depth of 4 feet or less shall be provided with a slide type valve box. Valve boxes shall be cast iron, extension sleeve type, suitable for the depth of cover indicated on the Drawings. Only one extension will be allowed with each slide type valve box. Valve boxes shall be at least 5 inches in inside diameter, shall be at least 3/16 inch thick, and shall be provided with suitable cast iron bases and covers.

Each valve buried deeper than 4 feet shall be provided with a valve box consisting of a cast iron cover and base, and a 6 inch cast iron pipe section. The cover and base shall be Clay & Bailey "No. 2193NS". The pipe shaft shall extend from the valve to 5 inches inside the valve box base.

All parts of valve boxes, bases, and covers shall be shop coated with the manufacturer's standard coating.

Valve boxes which are to be provided with position indicators shall have top sections and covers designed for proper installation of the position indicator and accessories.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section shall be installed in accordance with the Valve Installation section.

End of Section

Section 40 05 57

VALVE AND GATE ACTUATORS

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing manual and powered valve and gate actuators and accessories as specified herein.

1-2. GENERAL. Equipment provided under this section shall be fabricated and assembled in full conformity with Drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Design-Builder.

Actuators shall be furnished with all necessary parts and accessories indicated on the Drawings, specified, or otherwise required for a complete, properly operating installation and shall be the latest standard products of a manufacturer regularly engaged in the production of actuators.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Governing Standards. Except as modified or supplemented herein, cylinder and vane type actuators shall conform to applicable requirements of ANSI/AWWA C541.

Except as modified or supplemented herein, electric motor actuators shall conform to applicable requirements of ANSI/AWWA C542.

Except as modified or supplemented herein, actuators for butterfly and eccentric plug valves shall conform to the applicable requirements of ANSI/AWWA C504.

Except as modified or supplemented herein, manual actuators for ball valves shall conform to the applicable requirements of ANSI/AWWA C507.

Except as modified or supplemented herein, actuators for cast-iron slide gates shall conform to the applicable requirements of ANSI/AWWA C560.

Except as modified or supplemented herein, actuators for open channel slide gates and weir gates shall conform to the applicable requirements of ANSI/AWWA C513.

Except as modified or supplemented herein, actuators for stainless steel slide gates shall conform to the applicable requirements of ANSI/AWWA C561.

Except as modified or supplemented herein, actuators for composite slide gates shall conform to the applicable requirements of ANSI/AWWA C563.

1-2.03. Power Supply. Power supply to electric actuators will be as indicated in the valve and gate schedules.

1-2.04. Marking. Each actuator shall be marked with the manufacturer's name, model number, and the country of origin. An identifying serial number shall be stamped on a corrosion-resistant plate attached to the actuator.

1-2.05. Temporary Number Plates. Each actuator shall be factory tagged or marked to identify the actuator and the applicable valve or gate by number or service as indicated in the valve or gate schedule.

1-3. SUBMITTALS. Complete drawings, details, and specifications covering the actuators and their appurtenances shall be submitted in accordance with the Submittal Procedures section and the Schedule of Submittals. Submittal drawings shall clearly indicate the country of origin of each actuator and its components.

Submittal drawings shall include separate wiring diagrams for each electrically operated or controlled actuator and the electrical control equipment. Each actuator drawing shall be identified with the respective valve number or name.

For electric or cylinder actuators, certified copies of reports covering proof-of-design testing of the actuators as set forth in Section 5 of ANSI/AWWA C541 or ANSI/AWWA C542 respectively, together with an affidavit of compliance as indicated in Section 6.3 of ANSI/AWWA C541 or ANSI/AWWA C542 respectively, shall be submitted to Design-Builder before the actuators are shipped.

PART 2 - PRODUCTS

2-1. PERFORMANCE AND DESIGN REQUIREMENTS.

2-1.01. General. Actuators and appurtenances shall be designed for the conditions and requirements as indicated in the respective valve and gate sections.

Liberal factors of safety shall be used throughout the design, especially in the design of parts subject to intermittent or alternating stresses. In general, working stresses shall not exceed one-third of the yield point or one-fifth of the ultimate strength of each material.

2-1.02. Valve Actuators. Each actuator shall be designed to open or close the valve under all operating conditions. Actuators shall be designed for the maximum pressure differential across the valve and maximum velocities through the valve where indicated in the respective valve schedules.

Valve actuators shall be provided and adjusted by the valve manufacturer. Actuator mounting arrangements and positions shall facilitate operation and maintenance and shall be determined by the valve manufacturer unless indicated otherwise on the Drawings or directed by Design-Builder.

When valves are to be buried, submerged, or installed in vaults; the actuators and accessories shall be sealed to prevent the entrance of water. The design water depth shall be as indicated in the respective valve schedules but not less than 20 feet.

2-1.03. Gate Actuators. Actuators shall be sized to produce the torque or thrust required to operate the gate when subject to the seating and unseating operating heads as indicated in the respective gate schedules.

Both the design head and the operating head shall be measured from the surface of the liquid to the center line of the gate.

2-1.04. Limit Switches. Limit switches shall be provided as indicated on the Drawings or in the valve and gate schedules.

For manual or cylinder type actuators, each limit switch shall be heavy duty type, with a cast NEMA Type 4 enclosure, a spring return roller lever, and four isolated contacts (two normally open and two normally closed) rated 10 amperes at 120 to 480 volts ac and 5 amperes at 125 volts dc. The switches shall be Allen Bradley "802T" or Square D "9007 Type C".

Limit switches for intelligent and standard electric actuators shall be as indicated in their respective paragraphs.

2-2. MATERIALS. Except as modified or supplemented herein, materials used in the manufacture of actuators shall conform to the requirements of the applicable governing standard(s).

2-3. VALVE MANUAL ACTUATORS.

2-3.01. General. Manual actuators of the types listed in the valve specifications or schedules shall be provided by the valve manufacturer.

Unless otherwise indicated or specified, each geared manual actuator shall be equipped with an operating handwheel.

The direction of rotation of the wheel, wrench nut, or lever to open the valve shall be to the left (counterclockwise). Each valve body or actuator shall have cast thereon the word "Open" and an arrow indicating the direction to open.

The housing of traveling-nut type actuators shall be fitted with a removable cover which shall permit inspection and maintenance of the operating mechanism without removing the actuator from the valve. Travel limiting devices shall be provided inside the actuator for the open and closed positions. Travel limiting stop nuts or collars installed on the reach rod of traveling-nut type operating mechanisms shall be field adjustable and shall be locked in position by means of a removable roll pin, cotter pin, or other positive locking device. The use of stop nuts or adjustable shaft collars which rely on clamping force or setscrews to prevent rotation of the nut or collar on the reach rod will not be acceptable.

Each actuator shall be designed so that shaft seal leakage cannot enter the actuator housing.

Valves for throttling service shall be equipped with an infinitely variable locking device or a totally enclosed gear actuator.

Actuators shall produce the required torque with a maximum pull of 80 lbs on the lever, handwheel, or chain. Actuator components shall withstand, without damage, a pull of 200 lbs on the handwheel or chainwheel or an input of 300 foot-lbs on the operating nut.

2-3.02. Handwheels. Handwheel diameters shall be at least 8 inches but not more than 24 inches for 30 inch and smaller valves and not more than 30 inches for 36 inch and larger valves.

2-3.03. Chainwheels. Unless otherwise specified in the valve schedules, all valves with center lines more than 7'-6" above the floor shall be provided with chainwheels and operating chains. Each chainwheel operated valve shall be equipped with a chain guide which will permit rapid handling of the operating chain without "gagging" of the wheel and will also permit reasonable side pull on the chain. Suitable extensions shall be provided, if necessary, to prevent interference of the chain with adjacent piping or equipment. Operating chains shall be hot-dip galvanized or zinc plated carbon steel and shall be looped to extend to within 4 feet of the floor below the valve.

2-3.04. Levers. Levers shall be capable of being locked in at least five intermediate positions between fully open and fully closed. In any building or structure containing lever operated valves, at least two operating levers shall be provided for each size and type of lever operated valve.

2-3.05. Chain Levers. Suitable actuator extensions shall be provided, if necessary, to prevent interference of the chain with adjacent piping or

equipment. Operating chains shall be hot-dip galvanized carbon steel and shall be looped to extend to within 4 feet [1.2 m] of the floor below the valve.

2-3.06. Wrench Nuts. Unless otherwise specified in the valve schedules or on the Drawings, wrench nuts shall be provided on all buried valves and on all valves that are to be operated through floor boxes. Unless otherwise directed by Owner, all wrench nuts shall comply with Section 4.4.13 of ANSI/AWWA C500. At least two operating keys shall be furnished for operation of the wrench nut operated valves.

2-3.07. Operating Stands. Operating stands shall be provided in the locations indicated on the Drawings or as indicated in the valve and gate schedules. Operating stands shall support the handwheel approximately 36 inches [900 mm] above the floor. A sleeve made from standard weight galvanized steel pipe shall be provided for the opening in the floor beneath each operating stand. When stems are 10 feet [3 m] or longer, a suitable thrust bearing shall be provided in each operating stand to carry the weight of the extension stem.

2-3.08. Wall Brackets. Wall brackets shall be provided to support manual actuators in the locations indicated on the Drawings or in the respective valve schedules. The horizontal face of the bracket shall be predrilled to accept the actuator and the stem without modification. The top of the bracket shall extend sufficiently to bear on and transfer thrust loads to the top of the supporting structure.

2-4. GATE MANUAL ACTUATORS.

2-4.01. General. Manual actuators of the types listed in the gate schedules shall be provided by the gate manufacturer. Unless otherwise specified, actuators shall conform to ANSI/AWWA C560.

All bearings and gears shall be totally enclosed in a weathertight housing having a sufficient number of fittings to permit periodic lubrication of all internal moving components without partial or total disassembly of the mechanism. The pinion shaft of crank-operated mechanisms shall be supported by roller bearings or needle bearings.

The direction of rotation of the wheel, crank, or wrench nut to open the gate shall be to the left (counterclockwise).

Actuators for rising stem self-contained gates shall be designed for mounting directly on the frame yoke.

When indicated in the gate schedules, crank-operated actuators shall be suitable for operation with a portable actuator specified herein. A suitable adapter coupling shall be furnished with each crank actuator to couple the portable actuator to the crank actuator pinion shaft as required.

2-4.02. Remote Actuators. Not used.

2-4.03. Dual Actuators. Dual actuators shall be provided where indicated in the gate schedules. Dual actuators shall be interconnected by a cross shaft complete with required couplings so both stems move at the same rate. Each cross shaft shall be protected by a full length removable aluminum or stainless steel cover attached to the yoke beam or actuator.

2-4.04. Floorstands. Floorstands shall be designed to transfer operating thrusts to the supporting structure. Each floorstand shall be designed to position the crank or the handwheel approximately 36 inches above the frame yoke, supporting surface, or adjacent operating floor or platform.

2-4.05. Wall Brackets. Wall brackets shall be provided to support manual actuators in the locations indicated on the Drawings or indicated in the respective gate schedules. The horizontal face of the bracket shall be predrilled to accept the actuator and the stem without modification. The top of the bracket shall extend sufficiently to bear on and transfer thrust loads to the top of the supporting structure.

2-4.06. Stem Covers. Rising stem manual actuators shall be provided with a stem cover as indicated in the gate schedules. Stem covers shall conform to Section 4.4 of ANSI/AWWA C560.

2-4.06.01. Plastic Covers. Covers shall be constructed of transparent plastic pipe and shall be furnished with an end cap, condensation vents, and a clear mylar position-indicating marking tape. The marking tape shall be adhesive backed and shall be permanently marked and calibrated in feet and inches [meters and millimeters]. The tape shall be applied to the stem cover after the gate has been installed and shall be so positioned that the height of the slide will be indicated by reference to the top of the stem.

2-4.06.02. Steel Covers. Covers shall be constructed from steel pipe and shall be furnished complete with a threaded end cap. All steel components of each cover shall be hot-dip galvanized following fabrication.

The operating mechanism shall be furnished with a digital or dial type mechanical position indicator. The indicator mechanism shall be installed inside a weatherproof housing and shall be clearly visible through a transparent, weatherproof window.

2-5. INTELLIGENT ELECTRIC ACTUATORS. Not used.

2-6. STANDARD ELECTRIC ACTUATORS.

2-6.01. General. Standard electric actuators as listed in the valve and gate schedules shall be provided by the valve or gate manufacturer.

Electric actuators with torque output requirements of 750 ft-lbs and less for butterfly valves and eccentric plug valves shall be quarter-turn type and shall be Auma "SGBV 05.1 through SGBV 12.1", EIM “Series P, Q, or R” or Limitorque "LY" without exception.

All other electric actuators for open-close service shall be multi-turn type and shall be Auma "SABV 07.1 through SABV 48.1", EIM “Series 2000”, Limitorque "L120", or Rotork “AWT Series” without exception.

All other electric actuators for modulating service shall be multiturn type and shall be Auma "SARBV 07.1 through SARBV 16.1", EIM “Series 2000”, Limitorque "L120", or Rotork “AWT Series” without exception.

All other electric actuators for Explosion-proof service shall be multiturn type and shall be Auma "SAExBV/SARExBV 07.1 through SAExBV/SARExBV 16.1", EIM “Series 2000”, Limitorque "L120", Rotork “AWT Series” or equal.

Each standard electric actuator shall be furnished complete with a motor, gearing, handwheel, limit switches and torque sensors, lubricants, heating elements, wiring, and terminals. Each actuator shall be constructed as a self-contained unit with a cast iron or aluminum alloy housing, of a type as indicated in the valve and gate schedules, and shall be integrally assembled on the applicable valve or gate by the valve or gate manufacturer.

Actuators shall be designed to cycle the valve or gate from the fully open to the fully closed position or the reverse in approximately 60 seconds or as indicated in the valve and gate schedules.

Actuator motors may be mounted horizontally adjacent to or vertically above the reduction gearing. All gearing shall be oil or grease lubricated.

2-6.02. Motors. Motors shall be totally enclosed, high torque design made expressly for valve and gate actuator service, capable of operating the valve or gate under full differential pressure for two complete strokes or one complete cycle of travel without overheating. Motors shall be designed in accordance with NEMA standards and shall operate successfully at any voltage within 10 percent above or below rated voltage. Motor bearings shall be permanently lubricated. Motors for open-close service shall be rated for a minimum of 60 starts per hour and motors for modulating service shall be rated for a minimum of 1,200 starts per hour.

2-6.03. Power Gearing. Power gearing shall consist of hardened steel spur or helical gears and alloy bronze or hardened steel worm gear, all suitably lubricated, designed for 100 percent overload, and effectively sealed against entrance of foreign matter. Steel gears shall be hardened to at least 350 Brinell. Planetary or cycloidal gearing or aluminum, mild steel, or nonmetallic gears will not be acceptable. Gearing shall be designed to be self-locking so that actuation of a torque switch or electronic torque protection device by a torque overload condition will not allow the actuator to restart until the torque overload has been eliminated. If a secondary gear box is required, it shall be designed to withstand the locked rotor torque of the actuator.

2-6.04. Handwheel Mechanism. The handwheel shall not rotate during motor operation. During handwheel operation the motor shall not affect the actuator operation. The actuator shall be responsive to electrical power and control at all times and, when under electrical control, shall instantly disengage the handwheel. The handwheel shall rotate counterclockwise to open the valve. An arrow indicating the opening direction and the word "Open" shall be cast on the handwheel. The force required to operate the handwheel shall not exceed 80 lbs [350 N]. The handwheel shall have a padlockable declutch lever.

2-6.05. Torque Sensing. Torque and thrust loads in both closing and opening directions shall be limited by a torque sensing device. Each torque sensing device shall be provided with an adjustment setting indicator. The adjustment shall permit a variation of approximately 40 percent in torque setting. Switches shall have a rating of not less than 6 amperes at 120 volts ac and 0.5 ampere at 115 volts dc.

2-6.06. Limit Switches. Each standard electric actuator shall have a minimum of four internal limit switch assemblies which are field adjustable. Each switch assembly shall consist of at least three separate limit switches, shall be operated by the driving mechanism, and shall be independently adjustable to trip at any point at and between the fully open and fully closed valve positions. All switches shall have an inductive contact rating of not less than 15 amperes at 250 volts ac and 10 amperes at 30 volts dc with a switching load limited to 5 amperes maximum for both AC and DC.

2-6.07. Position Transmitter. When indicated in the valve and gate schedules, actuators shall be provided with an electronic type position transmitter. The transmitter output shall be an isolated 4-20 mA dc capable of driving an external load of 0 to 400 ohms. Accuracy of the transmitted signal shall be ±2 percent of span. Repeatability and hysteresis shall be within 1 percent. The transmitter shall transmit to a remote position indicator which is specified in the Instrumentation section.

2-6.08. Heating Elements. Space heating elements shall be provided to prevent condensation in the motor and limit switch housing. Space heating elements shall not be required for actuators which are of a sealed design utilizing double

O-ring seals in the motor and controls housing. Heating elements shall be rated 120 volts ac. Heaters shall be continuously energized.

2-6.09. Terminal Facilities. Terminal facilities for connection to motor leads, switches, position transmitter, and heating elements shall be provided in readily accessible terminal compartments. Each terminal compartment shall have at least two openings for external electrical conduits, one sized at least 3/4 inch [19 mm] and the other at least 1-1/4 inches. Each terminal compartment shall be large enough to allow easy routing and termination of fifteen 12 AWG conductors.

2-6.10. Controller. Each valve or gate shall be furnished with a reversing controller located inside the actuator enclosure and shall have controller devices as indicated in the valve and gate schedules. The controller shall be equipped with:

a. A motor overload protective device in each phase or solid state motor protection.
b. A space heater element, rated 120 volts ac, sized to be continuously energized for prevention of condensation within the controller enclosure.
c. A fused control power circuit taken from one power lead on the load side of the breaker and line side of the reversing starter to ground. If power supply is greater than 120 volts ac, a control power transformer with fused secondary, with volt-ampere capacity suitable for starter control plus continuous service to space heater elements in motor housing, limit switch compartment, and controller enclosure.
d. A terminal block with connectors for all external controls. All leads from the actuator motor and limit switch assembly shall be routed to terminal connections in the controller for external connections to all other control devices.
e. Auxiliary control contacts as indicated in the electrical schematics.

Reversing controllers shall be both mechanically and electrically interlocked and shall be provided with the necessary direct-operated auxiliary contacts for required interlocking and control.

Valve controllers shall be expressly selected for long life and reliable, low maintenance service under rugged service conditions.

2-6.11. Control Module. Valves or gates indicated for modulating service in the valve and gate schedules shall be provided with a control module for position modulating type service. The control module shall be mounted within the valve actuator limit switch housing. The module shall accept a standard 4-20 mA dc

analog input signal with a load impedance of not greater than 400 ohms. The control module shall contain adjustments for span, zero, gain, and deadband.

The actuator shall have a slide-wire type position feedback potentiometer or electronic current position transmitter which provides a position feedback signal to the control module.

2-6.11.01. Control Performance. For any operating torque within the specified range of the valve actuator, the valve and actuator shall perform within these specified limits:

Linearity	Linearity of actual valve position as compared to demand signal shall be within ±4 percent of span over the entire operating range.
Repeatability	For any repeated demand signal to the valve actuator, the actual valve position shall be repeated.
Deadband	Deadband of the valve actuator shall be adjustable from 1 to 10 percent of span.
Hysteresis	For any repeated demand signal to the valve actuator, from either an increasing or a decreasing direction, the actual valve position shall be repeated within 1 degree of valve shaft rotation.

2-7. HYDRAULIC CYLINDER ACTUATORS. Not used.

2-8. AIR CYLINDER ACTUATORS. Provide supplier standard as required for the MBR system.

2-9. VANE TYPE PNEUMATIC ACTUATORS. This section is provided if the MBR System Supplier requires pneumatically actuated valves for their standard system.

2-9.01. General. Vane type pneumatic actuators as listed in the valve schedules shall be provided by the valve manufacturer.

2-9.02. Vane Type Pneumatic Actuators. Vane type actuators shall be sized to provide a safety factor of 25% for open-close service and 50% for modulating service, shall be designed to provide satisfactory operation using dry, oil free instrument air at 80 psig [550 kPa gauge] pressure, and shall be shop tested at 225 psig [1550 kPa gauge]. Pneumatic vane type actuators shall be as manufactured by Kinetrol, Ltd. or K-Tork International, without exception.

Actuator shaft and vane shall be a single machined part. Vane lip seals shall be constructed by the dual opposed injection molded method. Stainless steel

expanders shall be fitted beneath the vane lip seals to ensure continual seal-to-case contact. All actuators shall be fitted with stainless steel threaded travel stops allowing adjustment at each end of actuator stroke.

Manufacturer shall provide all linkages, brackets, mounting accessories, and couplings required for a complete installation of the actuator to the valve. All components, except stainless steel, shall have the specified external coating.

2-9.03. Control Devices. When open-close service is specified in the respective valve schedule, a solenoid valve shall be provided to control the operation of each vane type pneumatic actuated valve. Each solenoid valve shall be a heavy-duty, single solenoid, two-position type rated for a differential operating air pressure as required. Each valve shall be designed and constructed for exceptionally long life, with forged brass body; poppet type seats and discs; continuous duty, molded, Class F coil; NEMA Type 4 solenoid enclosure; and 1/2 inch [12.7 mm] threaded conduit connection. Solenoid valves shall be rated for use with a power supply as indicated in the respective valve schedule and the air pressure specified herein, and shall be ASCO series 8344 4-way pilot operated solenoid valves with manual override features.

Each air connection on each vane type actuator shall be equipped with an adjustable flow control valve. The flow control valves and connecting piping shall be arranged to permit control of the flow rate of exhaust air from the actuator and to permit independent adjustment and control of valve opening and closing speeds. Control valves shall be sized so that the time required for the vane to complete its stroke is adjustable between 20 and 120 seconds, with an air supply pressure of 80 psig [550 kPa gauge]. Flow control valves shall be manufactured from brass or stainless steel and shall be Parker Hannifin "Colorflow F Series" or Mead "Dyla-Trol".

As an alternative to a separately mounted solenoid valve and flow control valves, actuators for open-close service may be provided with solenoid valves having integral flow controls, that are directly mounted to the actuator body. Solenoids valves shall be provided with NEMA 4 enclosures, with manual override, and 1/2 inch [12.7 mm] threaded conduit connection. Solenoid valves shall be rated for use with a power supply as indicated in the respective valve schedule and the air pressure specified herein.

An externally mounted gauge manifold with gauges shall be provided on each actuator to monitor and display air supply pressure and actuator output pressure.

Where specified for modulating service in the respective valve schedule, pneumatic vane type actuators shall be provided with an electro-pneumatic positioner provided by the actuator manufacturer. Positioner shall have an output shaft to allow direct mounting to the actuator. The positioner shall accept a 4-20 mA control signal and a nominal 80 to 100 psig air supply. Steady state air consumption shall not exceed 0.5 scfm. Linearity of the actual valve position as

compared to the control signal shall be within ±0.7 percent of span. Repeatability and hysteresis of the valve position as compared to the control signal shall be ±0.7 percent of span. Positioners shall have gauges for signal pressure and positioner output pressures. Positioner enclosures shall be NEMA 4X.

Each positioner shall provide a 4-20 mA dc analog position transmitter feedback output capable of driving an external load of 0 to 500 ohms and shall be directly coupled to the actuator mechanism. Linearity shall be ±2 percent as compared to actual valve position. Repeatability and hysteresis shall be ±0.5 percent of span.

2-9.04. Single Acting-Spring Return Pneumatic Vane Type Actuators. When specified in the respective valve schedules, pneumatic vane type actuators of the single acting-spring return type shall be provided by the valve manufacturer. The actuator shall be configured such that on power failure, the spring shall drive the valve open or closed as needed. Springs shall be clock type. Each actuator shall be furnished with a 3 way solenoid valve. A flow control valve shall be furnished and installed in the solenoid valve vent.

Actuator manufacturers shall have 5 years experience with the spring return model to be provided and shall furnish references with contact information on request.

2-9.05. Actuator Assembly. Each actuator shall be factory assembled with piping and all required accessories including solenoid valve, positioner, flow control valves, and other accessories required for a properly operating system.

2-9.06. Remote Vane Type Pneumatic Actuator Control Station. Not used.

2-9.07. Extended Warranty. The pneumatic actuator manufacturer shall warrant the actuators against faulty or inadequate design, defective materials, defective workmanship, and improper assembly for a period of three years beyond Substantial Completion.

2-10. AIR-OIL CYLINDER ACTUATORS. Not used.

2-11. PORTABLE ELECTRIC ACTUATORS. Not used.

2-12. PORTABLE HYDRAULIC ACTUATORS. Not used.

2-13. ACTUATOR ACCESSORIES.

2-13.01. Extension Stems. Extension stems and stem guides shall be furnished when indicated in the respective valve schedules, indicated on the Drawings, or otherwise required for proper valve operation. Extension stems shall be of solid steel and shall be not smaller in diameter than the stem of the actuator shaft. Extension stems shall be connected to the actuator with a single Lovejoy

"Type D" universal joint with grease-filled protective boot. All stem connections shall be pinned.

At least two stem guides shall be furnished with each extension stem, except for buried valves. Stem guides shall be of cast iron, bronze bushed, and adjustable in two directions. Stem guide spacing shall not exceed 100 times the stem diameter or 10 feet, whichever is smaller. The top stem guide shall be designed to carry the weight of the extension stem. The extension stem shall be provided with a collar pinned to the stem and bearing against the stem thrust guide.

Extension stems for chemical resistant butterfly valves located in drainage sumps shall be the two-piece type with stainless steel stem, PVC housing, wall support, and collar. Unless otherwise indicated on the Drawings, the length of the stem extension shall be as necessary to position the valve operator 12 inches above the maximum liquid level in the immediate area.

Extension stems for buried valve actuators shall extend to within 6 inches of the ground surface, shall be centered in the valve box using spacers, and shall be equipped with a wrench nut.

Extension stems for buried valve actuators shall be provided with position indicators as specified in the valve schedules.

2-13.02. Position Indicators. Unless otherwise specified, each valve actuator shall be provided with a position indicator to display the position of the plug or disc relative to the body seat opening.

For quarter turn plug, ball, or cone type valves installed in interior locations, the indicating pointer shall be mounted on the outer end of the valve operating shaft extension and shall operate over an indicating scale on the operating mechanism cover. Where the shaft passes through the cover, a suitable stuffing box or other seal shall be provided to prevent the entrance of water.

Each actuator for butterfly valves, except where located in manholes, buried, or submerged, shall have a valve disc position indicator mounted on the end of the valve shaft. A disc position indicator shall also be provided on each operating stand or the actuator mounted thereon.

2-13.02.01. Position Indicators for Buried Actuators. When specified in the respective valve schedules, each buried valve actuator shall be equipped with a position indicator. Position indicators shall be Indico "Model 179 Valve Position Indicators" manufactured by the Mills Engineering Company, Needham Heights, Massachusetts, or "Diviner" ground level position indicator manufactured by the Henry Pratt Company, Aurora, Illinois. Each indicator assembly shall be designed for installation on the extension stem connected to the operating stem of the buried actuator mechanism and shall be mounted in the top section of the

valve box beneath the valve box cover. Each indicator shall be equipped with a wrench nut. Internal gearing shall be sealed and protected from the elements.

2-13.03. Floor Boxes. Openings through concrete slabs provided for key operation of valves shall be provided with a cast iron floor box complete with cover. The floor box shall be of the depth indicated on the Drawings. Where the operating nut is in the slab, the stem shall have a guide to maintain the nut in the center of the box; where the nut is below the slab, the opening in the bottom of the box shall accommodate the operating key.

Each floor box and cover shall be shop coated with manufacturer's standard coating.

2-13.04. Torque Tubes. Torque tube shall utilize pipe rather than solid shafting between the valve input shaft and the output shaft of the valve floorstand operator. An adjustment of 2 inches [50 mm] shall be provided in the torque tube installation. Torque tube shall be coated with the same material as the submerged valve.

2-13.05. Valve Boxes. Each valve buried to a depth of 4 feet or less shall be provided with a slide type valve box. Valve boxes shall be cast iron, extension sleeve type, suitable for the depth of cover indicated on the Drawings. Only one extension will be allowed with each slide type valve box. Valve boxes shall be at least 5 inches in inside diameter, shall be at least 3/16 inch [4.7 mm] thick, and shall be provided with suitable cast iron bases and covers.

Each valve buried deeper than 4 feet shall be provided with a valve box consisting of a cast iron cover and a 6 inch Cast Iron Pipe section. The cover shall be Clay & Bailey "No. 2193". The pipe shaft shall extend from the valve to 5 inches inside the valve box cover.

All parts of valve boxes, bases, and covers shall be shop coated with manufacturer's standard coating.

Valve boxes which are to be provided with position indicators shall have top sections and covers designed for proper installation of the position indicator and accessories.

2-14. SHOP PAINTING. All ferrous metal surfaces, except bearing and finished surfaces and stainless steel components of valve actuators and accessories, shall be shop painted for corrosion protection. The valve manufacturer's standard coating will be acceptable.

The following surfaces shall be painted:

Polished or Machined Surfaces	Rust-preventive compound.

Other Surfaces	Epoxy.
Actuators and Accessories	Universal primer.

PART 3 - EXECUTION

3-1. INSTALLATION. Actuators will be installed on the valves in accordance with the Valve Installation section and on gates in accordance with the Gate Installation section.

End of Section

Section 40 05 59.13

OPEN-CHANNEL METAL SLIDE GATES AND WEIR GATES

PART 1- GENERAL

1-1. SCOPE. This section covers furnishing slide gates and actuators as specified herein and as indicated in the Open Channel Metal Slide Gate and Weir Gate Schedule. Slide gates shall be furnished complete with frames, slides, seals, actuators, operating stems, and appurtenances as specified herein, as indicated in the schedule and as specified in the Valve and Gate Actuator section.

1-2. GENERAL. Equipment furnished under this section shall be fabricated and assembled in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

Gates and actuators shall be furnished with all necessary parts and accessories indicated on the Drawings, specified, or otherwise required for a complete, properly operating installation and shall be the latest products of a manufacturer engaged in the production of slide gates.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Governing Standard. Except as modified or supplemented herein, all slide gates shall conform to the applicable requirements of ANSI/AWWA C561 and ANSI/AWWA C562.

1-2.03. Identification. Slide gates specified herein shall be tagged as specified in the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete drawings, construction details, and specifications covering the slide gates and appurtenances shall be submitted in accordance with the Submittals Procedures section. Each drawing shall be identified with the slide gate designation.

PART 2- PRODUCTS

2-1. SERVICE CONDITIONS. The gates will isolate the BNR mixing chimney from the 2 different anoxic zones. The liquid passing over the gate is mixed liquor.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Slide gates shall be designed for the conditions and requirements indicated in the Slide Gate Schedule.

2-2.01. Design. Liberal factors of safety shall be used throughout the design, especially in the design of parts subject to intermittent or alternating stresses. In general, working stresses shall not exceed one-third of the yield point or one-fourth of the ultimate strength of each material.

Gates shall be designed for the seating and unseating heads indicated in the Slide Gate Schedule.

Gates shall be designed to fit into the structures indicated on the Drawings.

2-3. ACCEPTABLE MANUFACTURES. For slide gates acceptable manufactuers are Coldwell-Wilcox, Golden Harvest, Hydro Gate, Waterman, Fontaine, Rodney Hunt, and Whipps.

2-4. MATERIALS.

Frames, Guides, Slides, Reinforcing Members, and Yoke Beams	Stainless steel, ASTM A276, 304L or 316L and ASTM A240, 304L or 316L.
Flush Bottom Closure Seal	Compressible neoprene.
Hollow Bulb J-Seals	Compressible neoprene.
Seal Retainer Bar	Aluminum, ASTM B211 or B221, Alloy 6061-T6.
Slide Seats and Bearing Bars	UHMW polyethylene.
Operating Stems	Stainless steel, AISI Type 304 or 316.
Assembly Fasteners	Stainless steel, AISI Type 302, 303, or 304.
Epoxy Enamel	PPG-Amercoat "Amercoat 385 Epoxy", Carboline "Carboguard 890", Sherwin-Williams "Macropoxy 646" or Tnemec "Series N69 Hi-Build Epoxoline II".

2-5. CONSTRUCTION.

2-5.01. Frames. Each frame shall be an integral unit of extruded or welded structural shapes at least 1/4 inch thick. Frames shall be designed for embedment in concrete or installation on the face of concrete walls as indicated in the Slide Gate Schedule. Embedded frames shall be recessed so that the waterway is not obstructed.

Guides shall be provided on each side of each frame. Guides shall be sufficiently strong to require no further reinforcing where they extend above the operating floor, and shall support the entire height of the slide in all positions.

Full-length plastic slide seats or bearing bars shall be provided on the downstream side of the slide on gates subject to seating pressure from one direction. Gates subject to seating pressure from either direction shall be provided with plastic seats or bearing bars on both faces of the slide. Seats and bars shall be mechanically retained in the frame.

Self-contained gates shall be equipped with a yoke, shop welded to the top of vertical frame members to support the actuator. Yokes shall be fabricated from a pair of rolled or extruded channels or angles and shall be designed to deflect not more than 1/360 of the span when the gate is operated at the maximum actuator thrust with the safety factor as indicated in the governing standard. Each yoke shall be designed to permit vertical removal of the slide. Actuators shall be mounted so that no eccentric loads are transmitted to the yoke.

2-5.02. Slides. Slides shall be at least 1/4 inch [6 mm] thick and shall be provided with welded stiffeners to limit deflection to 1/360 under the maximum seating or unseating head indicated in the Slide Gate Schedule. Slides shall be adequately reinforced to withstand, without permanent distortion, the maximum thrust which can be transmitted by the operating stem. Each slide shall have a reinforced pocket or an internally threaded nut welded to the slide for connection of the stem. The pocket or nut shall be designed to withstand the maximum thrust which can be transmitted by the operating stem.

2-5.03. Closures. The bottom of each slide gate frame shall be recessed so that the waterway is not obstructed. A compressible seal shall be securely attached to the bottom of the slide or to the frame invert. The seal shall be of sufficient length to seal the bottom corners of each slide.

Where indicated in the Slide Gate Schedule, gates shall be provided with resilient hollow bulb J-seals attached to the frame members.

For weir service, slides may be lowered below the bottom of the opening. A frame member shall be provided at the bottom of the opening to seal the space between the slide and the adjacent concrete. The side guides shall be extended below the bottom of the wall opening. A resilient hollow bulb J-seal shall be

attached to the frame along the invert of the opening and up both sides to seal the slide in any positions.

Each J-seal shall be provided with a full-length retainer bar which shall compress the seal and prevent leakage between the seal and the frame member. The method of attachment of J-seals to frame members shall permit replacement of the seals without disassembling or removing the gate.

An acceptable alternative to J-seal is a UHMW polyethylene seal/seat. A UHMW polyurethane seat/seal extruded shape shall fit into a dovetail grove in the guide section, and shall seal on both upstream and downstream sides of the slide. The seat/seal system shall act as both a bearing surface and as a seal, and the seal system shall be self-adjusting. The seat/seals shall be easily replaced without removing the gate from the wall. For flush bottom application, the invert shall have a replaceable resilient neoprene seal mounted on the frame invert.

2-5.04. Operating Stems. Operating stems shall conform to the requirements of Section 4.3.6 of the governing standard. Contact surfaces of threads shall be rolled or machined to a 63 microinch finish, or smoother. Each stem shall be securely attached to the slide.

2-5.05. Stainless Steel. All stainless steel shall be pickled in accordance with ASTM A380 at the mill before being shipped. Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. After fabrication, pickled surfaces shall be subjected to a 24 hour water test or a ferroxyl test to detect the presence of residual embedded iron. All pickled surfaces damaged during fabrication including welded areas shall be repickled or passivated in accordance with ASTM A380 as needed to remove all traces of iron contamination. All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces.

2-6. ACTUATORS. Actuators and their accessories shall be the type as indicated in the Slide Gate Schedule and as specified in the Valve and Gate Actuator section.

Stem covers for manual actuators shall be UV resistant clear plastic, polycarbonate, or steel pipe as indicated in the Slide Gate Schedule and as specified in the Valve and Gate Actuator section.

2-7. SHOP PAINTING. All surfaces of aluminum which will be in contact with concrete, mortar, grout, or dissimilar metals shall be given a coat of epoxy enamel or coal tar epoxy.

2-8. SHOP TESTING. Gates shall be completely assembled in the shop to ensure that all parts fit together properly.

PART 3 - EXECUTION

3-1. INSTALLATION. Slide gates and appurtenances shall be installed in accordance with the Gate Installation section.

3-1.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Engineer.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the contract price.

End of Section

Section 40 05 61.43

KNIFE GATE VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing all Knife Gate Valves as required by the Work and as indicated in the Knife Gate Valve Schedule. Knife Gate Valves shall be furnished complete with actuators and accessories as specified herein, as indicated in the schedule, and as specified in the Valve and Gate Actuators section.

1-2. GENERAL. Equipment provided under this section shall be fabricated and assembled in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Design-Builder.

Gates shall be furnished with all necessary parts and accessories indicated on the Drawings, specified, or otherwise required for a complete, properly operating installation and shall be the latest standard products of a manufacturer regularly engaged in the production of valves.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all equipment and materials furnished under this section. If the requirements in this section are different from those in the General Equipment Stipulations, the requirements in the section shall take precedence.

1.2.02. Governing Standard. The publications referred to hereinafter form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. The latest edition of referenced publications in effect at the time of the bid shall govern. In case of conflict between the requirements of this section and the listed references, the requirements of this section shall prevail.

Reference	Title
ASME B16.5	Pipe Flanges and Flanged Fittings
MSS SP-135	High Pressure Knife Gate Valves

1-3. SUBMITTALS. In addition to the information/data required per the contract, the supplier shall provide the remaining submittals in accordance with the requirements specified herein and the Schedule of Submittals section. The Bid Submittals shall also be as detailed in the Schedule of Submittals section. The following information shall be submitted for review in accordance the Submittal Procedures section.

1. A copy of this specification section, with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.
2. Manufacturer's product data.
3. Certified factory leakage tests.
4. Spare parts listing.

PART 2 - PRODUCTS

2-1. ACCEPTABLE PRODUCTS. Knife Gate Valves shall be manufactured by DeZURIK (Hilton Valve), or approved equal.

2-2. MATERIALS. Materials used in the manufacture of Knife Gate Valves shall be as indicated:

Body	Fabricated Steel.
Bonnet	Fabricated Steel.
Wetted interior parts and fasteners	Stainless Steel, Type 316. Body cladding and face rings shall be welded to the body.
Gate	Stainless Steel, Type 316, polished to minimum surface finish of 32 micro-inch/inch RMS.
Stem and stem coupling	Stainless Steel, Type 316.
Packing gland and follower	Stainless Steel, Type 316.
Yoke	Fabricated Steel.
Resilient Seats	EPDM.

2-3. VALVE CONSTRUCTION.

2-3.01. General. Knife Gate Valves shall be bi-directional resilient seated with a pressure-retaining bonnet that fully encloses the gate. Bonnetless Knife Gate Valves are not acceptable. The bonnet shall be rated at the same pressure as the valve body and shall not include any type of internal gate packing or gate

wiper. A packing gland shall be located at the top of the bonnet to provide a tight seal around the stem.

A bevel gear operator with 2-inch nut shall be provided with each Knife Gate Valve. Operators shall be oriented on the valve yoke.

Except for the resilient seats, all wetted parts of the body and bonnet shall be 316 SS, including fasteners. Exterior flanges and stiffeners shall be cast or fabricated carbon steel.

All valves shall be capable of zero leakage shutoff in either flow direction where required and dead end isolation service with the downstream pipe flange removed.

2-3.01. Valve Body. Knife Gate Valves shall have fabricated steel bodies conforming to the general requirements of MSS SP-135. Valves shall be provided Class 125 flanges conforming to ANSI B16.1.

2-3.02. Shaft Coupling. A shaft coupling shall be provided between the valve bonnet and the top of the yoke to allow separate removal of upper portion of stem, yoke and operator prior to removal of valve from the valve vault. The yoke and shaft shall be extended as necessary to accommodate the shaft coupling while allowing normal operation from fully open to fully closed and to meet the dimensional requirements for locating the operator as shown on the drawings.

2-3.03. Seats. The resilient seats shall be EPDM, installed in a self-retaining groove that is cut into the 316 SS seat ring, and shall be replaceable without removing the valve from the pipeline.

2-3.04. Lining. The 316 body cladding and face rings shall be fully welded to the carbon steel body – “floating” body liners are not acceptable.

2-3.05. Packing. The valve bonnet shall be sealed against external leakage by Teflon impregnated synthetic fiber packing with an adjustable packing gland. The bottom of the gland shall be machined to mate with the machined stem back-seating ring, to allow the packing to be replaced with the valve pressurized. The back-seating ring shall also include a Teflon O-ring for improved sealing.

2-3.06. Gate. The gate shall be beveled and machined to evenly match the seating area in the valve body.

2-4. VALVE ACTUATORS. Requirements for valve actuators shall be as specified herein, as indicated in the Knife Gate Valve Schedule, and as specified in the Valve and Gate Actuators section. Valve actuator types shall be as indicated in the Knife Gate Valve Schedule.

Manual valves located above operator level shall be provided with chain driven operators.

2-5. OPERATING DATA. Knife Gate Valves shall be suitable for mixed liquor piping isolation service at a minimum 130 psi service in either direction, a maximum fluid temperature of 80°F, a maximum solids concentration of 1%, and a maximum fluid velocity of 3 feet per second.

2-6. SHOP PAINTING. All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop coated for corrosion protection. The valve manufacturer's standard coating will be acceptable.

2-7. LUBRICATION. Valves shall be designed so that all required lubrication can be completed externally with the valve installed in the pipeline.

2-8. WELDING. All stainless steel welds exposed to the process fluid shall be pickled and passivated.

PART 3 - EXECUTION

3-1. TESTING. Valves shall be factory tested and certified for zero leakage, as follows:

1. Shell Test – Each valve body and bonnet shall be hydrostatically pressure tested at 1.5 times the rated design pressure with no visible leakage allowed (leakage through the packing shall not be cause for rejection, as long as there is no leakage at the rated design pressure). Valves shall be tested with the flanges and body unconstrained to confirm the integrity of the design.
2. Gate/Seat Test – Each valve shall be hydrostatically pressure tested at 1.1 times the maximum operating pressure in both directions of closure with no visible leakage through the gate material and with drip tight seat leakage.
3. Operational Test – Each valve shall be operated from full closed to full open and back to full closed, two times. Operation shall be smooth, with no unusual noise or vibration.

Additionally, valves shall be tested for proper alignment, balancing, and smooth operation.

3-1. INSTALLATION. Gates shall be installed in accordance with Section 15010, Valve Installation.

3-1.01. Installation Check. An installation check by an authorized representative of the manufacturer is not required.

End of Section

Section 40 05 62.16

ECCENTRIC PLUG VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing all eccentric plug valves as required by the Work and as indicated in the Eccentric Plug Valve Schedule. Plug valves shall be furnished complete with actuators and accessories as specified herein, as indicated in the schedule, and as specified in the Valve and Gate Actuators section.

1-2. GENERAL. Equipment provided under this section shall be fabricated in full conformity with Drawings, Specifications, engineering data, and instructions, unless exceptions are noted by Design-Builder.

Valves shall be furnished with all necessary parts and accessories indicated on the Drawings, specified, or otherwise required for a complete, properly operating installation and shall be the latest standard products of a manufacturer regularly engaged in the production of valves.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If the requirements in this section are different from those in the General Equipment Stipulations, the requirements in the section shall take precedence.

1.2.02. Governing Standard. Except as modified or supplemented herein, all eccentric plug valves and manual actuators shall conform to the applicable requirements of ANSI/AWWA C517.

1-2.03. Marking. Each valve shall be marked with the manufacturer's name, valve size, and pressure rating, and the country of origin of the body casting. All markings shall be cast on the exterior surface of the valve body. An identifying serial number shall be stamped on a corrosion-resistant plate attached to the valve body.

1-2.04. Temporary Number Plates. Not used.

1-2.05. Identification. Eccentric plug valves shall be identified in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete drawings, details, and specifications covering the valves and their appurtenances shall be submitted in accordance with the Submittals Procedures section.

First Stage Submittals

Valve and accessory outline with overall dimensions, weights (including operators and accessories), operator removal clearance, end-to-end dimensions, direction of flow, and end connection details

Limit switches, solenoid valves, positioners, position transmitter data including make, model, electrical ratings, and physical arrangements. (Supplier only needs to submit once if components don't change from one valve to the next.)

Valve operator data, including the following: Motor operator sizing and open/close travel times, Pneumatic operator sizing and wiring diagrams

Drawings shall include separate wiring diagrams for each electrically operated or controlled valve and the electrical control equipment. Each drawing shall be identified with the valve number or name as specified in this section.

Second Stage Submittals

Valve pneumatic tubing diagrams

Sectional drawing showing materials and internal construction

Coating and surface preparation specification

Third Stage Submittals

Handling, storage and installation instructions

O&M manuals

Certified copies of test reports for tests described in Section 5. of governing standard, with an affidavit of compliance as indicated in Section 6.3 of governing standard, shall be submitted to Engineer before the valves are shipped.

PART 2 - PRODUCTS

2-1. ACCEPTABLE PRODUCTS. Eccentric plug valves furnished under this section shall be manufactured by Victaulic, Clow, DeZurik, Pratt, Milliken, or equal.

2-2. MATERIALS. Materials used in the manufacture of eccentric plug valves shall be as indicated:

Body	Cast iron, ASTM A126, Class B; or ductile iron, ASTM A536, Grade 65-45-12.
Plug	Cast iron, ASTM A126, Class B; or ductile iron, ASTM A536, Grade 65-45-12.
Plug Facing	Chloroprene, Neoprene or Buna-N, 70 Type A durometer hardness in accordance with ASTM D2240.
Body Seat	Welded nickel overlay.
Upper and Lower Trunnion Bearings	Sleeve type; stainless steel or bronze.
Upper Thrust Bearing	TFE, Nylatron, or Delrin.
Stem Seal	V-type packing or U-cups, Buna-N or TFE.

The following are acceptable shop coatings.

Coal Tar Epoxy	High-build coal tar epoxy; PPG Amercoat "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Epoxy	
For Liquid Service other than in potable water facilities	PPG Amercoat “Amercoat 385 Epoxy”, Carboline “Carboguard 890”, Sherwin-Williams "Macropoxy 646".or Tnemec “Series N69 Hi-Build Epoxoline II”.
For Raw or Treated Water Service in potable water facilities (NSF certified)	PPG Amercoat “Amerlock 400 High Solids Epoxy”, Carboline “Carboguard 891”, Sherwin-Williams "Macropoxy 646NSF" or Tnemec “Series N140 Pota-Pox Plus”.

2-3. VALVE CONSTRUCTION.

2-3.01. Valve Body. The valve port area of each valve shall be at least 80 percent of the cross section of the connecting piping for 20 inch and smaller valves and 70 percent for 24 inch and larger valves. Valves shall provide tight shutoff at the rated pressure from either direction. An adjustable closed position plug stop shall be provided.

Valve ends shall be compatible with connecting piping. All valves shall have flanged, grooved or mechanical joint ends as indicated in the Eccentric Plug Valve Schedule. Flange diameter and drilling shall conform to ANSI B16.1, Class 125. Flanges shall be flat faced and finished to true plane surfaces within a tolerance limit of 0.005 inch. The finished face shall be normal to the longitudinal valve axis within a maximum angular variation tolerance of 0.002 inch per foot of flange diameter. Grooved end dimensions shall conform to ANSI/AWWA C606, Table 5, for rigid joints. When grooved end valves are to be installed in flanged piping, two flange adapters compatible with the connecting piping shall be provided with each valve. Mechanical joint ends shall conform to ANSI/AWWA C111/A21.11.

2-3.02. Plug. The plug shall be of one-piece construction and shall have a cylindrical or spherical seating surface eccentrically offset from the center of the plug shaft. The interference between the plug face and the body seat, with the plug in the closed position, shall be externally adjustable in the field with the valve in the line under pressure. Plug surfaces shall be faced with a resilient material.

2-3.03. Seats. Seats shall be cast in the body and shall have raised, welded-in nickel overlay not less than 0.050 inch thick on all surfaces in contact with the plug face. The overlay shall be at least 90 percent nickel and have a Brinell hardness of 200 or greater.

2-3.04. Stem Seals. The valve shaft shall be sealed by U-cups or by at least four self-adjusting chevron type packing rings.

2-3.05. Working Pressure. Valves shall be rated for a minimum working pressure as specified below, except where otherwise indicated in the Eccentric Plug Valve Schedule.

Size in inches(mm)	Pressure Rating in psi
3 to 12	175
14 to 72	150

2-4. VALVE ACTUATORS. Requirements for valve actuators shall be as specified herein, as indicated in the Eccentric Plug Valve Schedule, and as specified in the Valve and Gate Actuators section.

Geared actuators shall be used for manually operated valves in the following applications:

a. For all 4 inch and larger buried valves.

b. For all 8 inch and larger valves.

c. For all 6 inch and larger valves in throttling or free discharge applications.

d. For all 6 inch and larger valves where the unseating pressure exceeds 25 psi.

e. For all chainwheel operated valves.

f. For all valves in gas service.

Geared actuators for plug valves unless otherwise specified or listed in the Eccentric Plug Valve Schedule shall be rated for a differential pressure across the valve, on the seating side, of 100 psi for 6 inch to 8 inch valves, 50 psi for 10 inch and larger valves, and 25 psi for gas service valves and a maximum flow of 8 ft/s.

2-5. SHOP PAINTING. All interior and exterior ferrous metal surfaces, except bearing and finished surfaces and stainless steel components of valves and accessories, shall be shop painted for corrosion protection. The valve manufacturer's standard coating will be acceptable, provided it is functionally equivalent to the specified coating and is compatible with the specified field painting.

Surfaces shall be painted as follows:

Unfinished Surfaces	
Interior Surfaces	
For Liquid Service	Epoxy.
Exterior Surfaces of Valves to be Buried, Submerged, or Installed in Manholes or Valve Vaults	Coal tar epoxy or Epoxy.
Exterior Surfaces of All Other Valves	Universal primer.
Polished or Machined Surfaces	Rust-preventive compound.

Interior epoxy coatings shall comply with ANSI/AWWA C550 and shall be free of holidays.

The total dry film thickness of shop-applied coatings shall be not less than:

Type of Coating	Minimum Dry Film Thickness
Coal Tar Epoxy	15 mils
Epoxy	10 mils
Universal Primer	3 mils

2-6. ACCESSORIES. Requirements for extension stems and stem guides, position indicators, floor boxes, operating stands, and valve boxes shall be as indicated in the Eccentric Plug Valve Schedule and as specified herein and as specified in the Valve and Gate Actuators section.

2-7. TESTING. Except as modified herein, eccentric plug valves shall be tested in accordance with Section 5 of the governing standard. Each valve shall be performance tested in accordance with Section 5.2 of the governing standard. The leakage test shall be applied to the seating face of the plug (tending to unseat the plug) at the rated pressure of the valve.

Each valve shall be leaktight in both directions when closed by the actuator with the maximum differential pressure applied to the plug as specified herein and in the Eccentric Plug Valve Schedule.

PART 3 - EXECUTION

3-1. INSTALLATION. Valves shall be installed in accordance with Valve Installation section.

End of Section

Section 40 05 63.53

MISCELLANEOUS BALL VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of manually operated or remote activated two position (open-close) ball valves as specified herein.

Miscellaneous ball valves shall be provided where AWWA type ball valves are not required.

Piping, pipe supports, insulation, and accessories that are not an integral part of the valves or are not specified herein are covered in other sections.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If the requirements in this section are different from those in the General Equipment Stipulations, the requirements in the section shall take precedence.

1-2.02. Identification. Valves specified herein shall be tagged in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete drawings, details, and specifications covering the valves and their appurtenances shall be submitted in accordance with the Submittals Procedures section. Included in the submittal shall be drawings by the valve manufacturer to indicate the position of the valve actuator and valve shaft.

PART 2 - PRODUCTS

2-1. CONSTRUCTION. Ball valves shown on the drawing, but not specified herein, shall be selected to match piping material they are installed in.

2-1.01. Valves Type VB-1.

VB-1	Rating	500 psi nonshock cold WOG
Instrument air, heating water,	Code	MSS SP-110
	Type	In-line, two piece, end entry, full

chilled water, and condenser water systems with copper pipe, ball valves indicated on the plumbing drawings for water service in metallic piping systems. 2 inch and smaller		port
	Body/Bonnet	ASTM B584–C84400 bronze
	Trim	
	Seat	Reinforced Teflon
	Ball	Brass, or chrome plated brass
	Stem	Brass or bronze
	Thrust Washer	Reinforced Teflon
	Stem Seal	Teflon or Viton
	End Connection	Threaded End
	Temp. Limitations	-20 to 400°F
	Valve Operator	Lever
	Manufacturers	Conbraco Industries "Apollo 77-100 Series"; Powell "Fig 4210T"

2-1.02. Valves Type VB-2. Not used.

VB-2 Ball valves indicated on the plumbing drawings for water service for metallic piping systems 2-1/2 inch and 3 inch	Rating	500 psi nonshock cold WOG
	Code	MSS SP-110
	Type	In-line, three piece, end entry, full port
	Body/Bonnet	ASTM B584-C84400 Bronze
	Trim	
	Seat	Reinforced Teflon
	Ball	Brass or chrome plated
	Stem	Brass or Bronze
	Thrust Washer	Reinforced Teflon
	Stem Seal	Teflon or Viton
	End Connection	Threaded End
	Temp. Limitations	-20 to 400°F
	Valve Operator	Lever
	Manufacturers	Conbraco Industries "Apollo 82-100 Series"

2-1.03. Valves Type VB-3.

VB-3 Process air service	Rating	800 psi nonshock cold WOG
	Code	MSS SP-110
	Type	In-line, two piece, end entry,

		regular port
2 inch and smaller	Body/Bonnet	ASTM A351-CF8M, stainless steel
	Trim	
	Seat	Reinforced Teflon
	Ball	ASTM A276-316, stainless steel
	Stem	ASTM A276-316, stainless steel
	Thrust Washer	Reinforced Teflon
	Stem Seal	Teflon or Viton
	End Connection	Threaded End
	Temp. Limitations	-20 to 400°F
	Valve Operator	Lever
	Manufacturers	Conbraco Industries "Apollo 76-100 Series"; Neles-Jamesbury "Series 4000"

2-1.04. Valves Type VB-4.

VB-4	Rating	1000 psi nonshock cold WOG
Digester gas service	Code	MSS SP-110, NACE MR-01-75
	Type	In-line, three piece, bolted body, regular port
2 inch and smaller	Body/Bonnet	ASTM A351-CF8M, stainless steel
	Trim	
Socket weld	Seat	Reinforced Teflon
	Ball	ASTM A276-316 stainless steel
	Stem	ASTM A276-316 stainless steel
	Thrust Washer	Reinforced Teflon
	Stem Seal	Reinforced Teflon
	End Connection	Socket weld
	Temp. Limitations	-20 to 400°F
	Valve Operator	Lever
	Manufacturers	Conbraco Industries "Apollo 85-200 Series"; Neles-Jamesbury "Series 4000"

2-1.05. Valves Type VB-5.

VB-5	Rating	Class 150
	Code	
Compressed air, water	Type	In-line, split-body, full port
	Body/Bonnet	ASTM A216-WCB, cast steel

service	Trim	
	Seat	Reinforced Teflon
2-1/2 inch	Ball	ASTM A216-WCB, steel, chrome plated
	Stem	ASTM A108-CS
	Thrust Washer	Reinforced Teflon
	Stem Packing	Manufacturer's standard
	End Connection	Flanged, ASME B16.5, Class 150, raised face
	Temp. Limitations	-20 to 400°F
	Valve Operator	Lever
	Manufacturers	Conbraco Industries "Apollo 88A-200 Series"

2-1.06. Valves Type VB-6.

VB-6	Rating	Class 150
	Type	In-line, end entry, regular port
Compressed air, water service	Body/Bonnet	ASTM A216-WCB, cast steel
	Trim	
	Seat	Reinforced Teflon
3 inch and larger	Ball	ASTM A216-WCB, steel, chrome plated
	Stem	ASTM A108-CS
Flanged	Thrust Washer	Reinforced Teflon
	Body Seal	Reinforced Teflon
	Stem Seal	Manufacturer's standard
	End Connection	Flanged, ASME B16.5, Class 150, raised face
	Temp. Limitations	-20 to 400°F
	Valve Operator	Lever
	Manufacturers	Conbraco Industries "Apollo 88A-100 Series", Neles-Jamesbury "5000 Series", Powell "Fig 4224T"

2-1.07. Valves Type VB-7.

VB-7	Rating	800 psi nonshock cold WOG
Heating water, chilled water, and condenser	Code	ASME B16.34
	Type	In-line, three piece, bolted body, full port
	Body/Bonnet	ASTM A105, forged steel or

water systems with steel pipe, compressed air service 2 inch and smaller		ASTM A216-WCB, cast steel
	Trim	
	Seat	Reinforced Teflon
	Ball	ASTM A108-CS, chrome plated
	Stem	ASTM A108-CS
	Thrust Washer	Reinforced Teflon
	Stem Seal	Reinforced Teflon
	End Connection	Socket weld
	Temp. Limitations	-20 to 400°F
	Valve Operator	Lever or Electric
	Manufacturers	Contromatics "C-1122-BB-DL", Conbraco Industries "Apollo 83-200 Series", Neles-Jamesbury "4DX2200TT"
	Valve Operator Lever	Contromatics “C-1122-BB-DLConbraco Industries “Apollo 83R-200 Series”, Neles-Jamesbury “4DX2200TT”
	Valve Operator Electric	Conbraco Industries “Apollo 83R-242”

2-1.08. Valves Type VB-8.

VB-8 Compressed air, water service 2-1/2 inch through 4 inch Butt weld	Rating	800 psi nonshock cold WOG
	Code	ASME B16.34
	Type	In-line, three piece, bolted body, regular port
	Body/Bonnet	ASTM A105, forged steel or ASTM A216-WCB, cast steel
	Trim	
	Seat	Reinforced Teflon
	Ball	Nickel or hard chrome plates carbon steel
	Stem	Nickel or hard chrome plated carbon steel
	Thrust Washer	Reinforced Teflon
	Stem Seal	Reinforced Teflon
	End Connection	Butt weld
	Temp. Limitations	-20 to 400°F [-29 to 204°C]
	Valve Operator	Lever
	Manufacturers	Worcester Controls “4546TTBW4”

2-1.09. Valves Type VB-9.

VB-9 Diesel fuel, lubrication oil 2 inch and smaller	Rating	Class 600
	Code	ASME B16.34
	Type	In-line, three piece, bolted body, firesafe, full port
	Body/Bonnet	ASTM A105, forged steel
	Trim	
	Seat	Reinforced Teflon primary, metal secondary
	Ball	Stainless steel
	Stem	Stainless steel
	Thrust Washer	Reinforced Teflon
	Stem Seal	Reinforced Teflon
	End Connection	Threaded End (socket weld end for aqua ammonia)
	Temp. Limitations	-20 to 400°F
	Valve Operator	Lever
	Manufacturers	Neles-Jamesbury "4B2236XT-1"

2-1.10. Valves Type VB-10.

VB-10 Service as specified in Miscellaneous Plastic Pipe, Tubing, and Accessories section 4 inch and smaller Socket	Rating	150 psig nonshock cold WOG
	Type	In-line, true union, full port (Schedule 80)
	Body/Bonnet	PVC or CPVC to match piping system
	Trim	
	Seat	Teflon
	Ball	PVC or CPVC to match piping system
	Stem	PVC or CPVC to match piping system
	Thrust Washer	Teflon
	Stem Seal	Viton O-ring
	Body Seals	Viton O-rings
	End Connection	Socket
	Temp. Limitations	0 to 140°F
	Valve Operator	Lever
	Manufacturers	Hayward Plastic Products "True Union Ball Valve"; Nibco "Chemtrol TU Series Tru-Bloc Ball Valve"; Spears Manufacturing Co "True Union

		2000 Standard Series 3600 Ball Valve"

2-1.11. Valves Type VB-11.

VB-11 Service as specified in Miscellaneous Plastic Pipe, Tubing, and Accessories section 4 inch and smaller Flanged	Rating	150 psig nonshock cold WOG
	Type	In-line, true union, full port (Schedule 80)
	Body/Bonnet	PVC or CPVC to match piping system
	Trim	
	Seat	Teflon
	Ball	PVC or CPVC to match piping system
	Stem	PVC or CPVC to match piping system
	Thrust Washer	Teflon
	Stem Seal	Viton O-ring
	Body Seals	Viton O-rings
	End Connection	Flanged, ASME B16.5, Class 150, raised face
	Temp. Limitations	0 to 140°F
	Valve Operator	Lever
	Manufacturers	Hayward Plastic Products "True Union Ball Valve"; Nibco "Chemtrol TU Series Tru-Bloc Ball Valve"; Spears Manufacturing Co. "True Union 2000 Standard Series 3600 Ball Valve"

2-1.12. Valves Type VB-12.

VB-12 Distilled water, deionized water service 1 inch and smaller	Rating	150 psig at 73°F
	Type	In-line, Tru-union, end entry, regular port
	Body/Bonnet	Virgin unpigmented Type 1 Homopolymer Polypropylene
	Trim	Virgin unpigmented Type 1 Homopolymer Polypropylene
	End Connection	Socket weld
	Valve Operator	Lever
	Manufacturers	Orion "Whiteline Riontite"

2-1.13. Valves Type VB-13. Not used.

2-1.14. Valves Type VB-14.

VB-14 Pressurized chlorine service 1-1/2 inch and smaller	Rating Code Type Body/Bonnet Trim Seat Ball Stem Stem Seal End Connection Temp. Limitations Valve Operator Manufacturers	Class 600 ANSI B16.34 In-line, three piece, bolted body, full port Carbon steel PTFE Monel or Hastelloy C Monel or Hastelloy C PTFE Socket weld -20 to 400°F Lever Neles-Jamesbury "4DBC2271TT

2-1.15. Valves Type VB-15.

VB-15 Carbon dioxide, carbon dioxide solution (carbonic acid) service 2 inch and smaller	Rating Code Type Body Trim Seat Ball Stem Stem Seal End Connection Temp. Limitations Valve Operator Manufacturers	Class 600 ANSI B16.34 In-line, three piece, bolted body, full port Stainless steel Teflon Stainless steel Stainless steel Teflon Socket weld -100 to 400°F [-73 to 204°C] Lever Neles-Jamesbury "4D3636XT"

2-1.16. Valves Type VB-16.

VB-16 Diesel fuel, lubrication oil 2 inch and smaller	Rating Code Type Body/Bonnet Trim Seat	Class 800 ASME B16.34 FM (Factory Mutual) approved emergency shutoff Carbon Steel Stainless Steel Reinforced Teflon

	Ball	Stainless Steel
	Stem	Alloy 20
	Thrust Washer	Reinforced Teflon
	Stem Seal	Reinforced Teflon
	Fusible Link Temp. Rating	165°F
	End Connection	Threaded End
	Temp. Limitations	-20 to 100°F
	Valve Operator	Spring Handle
	Release Mode	Spring-to-Close
	Manufacturers	Neles-Jamesbury "Figure 1075"

2-1.17. Valves Type VB-17.

VB-17 Water service 2 inch and smaller	Rating	2000 psi nonshock cold WOG
	Type	In-line, two piece, end entry, full port
	Body/Bonnet	ASTM B548-C84400, bronze
	Trim	
	Seat	Reinforced Teflon
	Ball	ASTM A276-316, stainless Steel
	Stem	ASTM A276-316, stainless Steel
	Thrust Washer	Reinforced Teflon
	Stem Seal	Reinforced Teflon
	End Connection	Threaded End
	Temp. Limitations	-20 to 400°F
	Valve Operator	Electric Actuator
	Manufacturers	Conbraco Industries "Apollo 77-Arx-35-00 Series"

2-1.18. Length Tolerance. Unless otherwise specified, the actual length of valves shall be within plus or minus 1/16 inch of the specified or theoretical length.

2-1.19. Shop Coatings. All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop coated for corrosion protection. The valve manufacturer's standard coating will be acceptable, provided it is functionally equivalent to the specified coating.

Coating Materials

Coal Tar Epoxy	High-build coal tar epoxy; Ameron "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Epoxy Enamel (for liquid service)	Ameron "Amerlock 400 High-Solids Epoxy Coating", Carboline "Carboguard 891", or Tnemec "Series N140 Pota-Pox Plus".
Rust-Preventive Compound	As recommended by the manufacturer.

Surfaces To Be Coated

Unfinished Surfaces	
Interior Surfaces	
Liquid Service	Epoxy enamel.
Exterior Surfaces of Valves To Be Buried, Submerged, or Installed in Manholes or Valve Vaults	Coal tar epoxy.
Exterior Surfaces of all other valves	Universal primer.

2-2. VALVE ACTUATORS. Ball valve, except those which are equipped with power actuators or are designed for automatic operation, shall be provided with manual actuators. Unless otherwise specified or indicated on the drawings, each manual actuator shall be equipped with a lever operator. Ball valves with center lines more than 7’-6” above the floor shall be provided with chain levers.

Valves indicated to be electric motor operated on the drawings shall have reversible electric motor operators designed for 120 volt ac, single phase operation. Actuators shall include integral thermal overload protection and a declutchable manual override. Actuators shall be equipped with motor operation limit switches and two additional single-pole, double-throw limit switches for auxiliary open and closed indication. An internal heater and thermostat shall be provided in each actuator housing to prevent condensation. Actuators in Class I, Division 1 and Division 2, Group D hazardous areas indicated on the drawings shall have NEMA Type 7 housings. Actuators in other areas shall have NEMA Type 4X housings.

2-3. ACCESSORIES. If the drawings indicate the need for extension stems, stem guides; position indicator; floor boxes; valve boxes; or operating stands, refer to the Valve and Gate Actuator section.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section shall be installed in accordance with the Valve Installation section.

End of Section

Section 40 05 64.22

INDUSTRIAL BUTTERFLY VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of manual or remote operated industrial butterfly valves as specified herein, as indicated on the P&IDs, and as indicated in the Industrial Butterfly Valve Schedule.

Industrial type butterfly valves shall be provided where AWWA type butterfly valves are not required.

Piping, pipe supports, insulation, and accessories that are not an integral part of the valves or are not specified herein are covered in other sections. Powered actuators are covered in the Valve and Gate Actuators section.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Temporary Number Plates. Each industrial butterfly valve with an identifying number listed in the Industrial Butterfly Valve Schedule, shall be tagged or marked in the factory with the identifying number.

1-2.03. Identification. Valves specified herein shall be tagged in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete drawings, details, and specifications covering the valves and their appurtenances shall be submitted in accordance with the Submittals Procedures section. Included in the submittal shall be drawings by the valve manufacturer to indicate the position of the valve actuator and valve shaft.

Drawings shall include separate wiring diagrams for each electrically operated or controlled valve and the electrical control equipment. Each drawing shall be identified with the valve number or name as specified in this section.

PART 2 - PRODUCTS

2-1. CONSTRUCTION. Unless otherwise specified, industrial butterfly valves shall be the rubber-seat, tight-closing type. Valves specified with an electric, air, or hydraulic actuators shall be the lugged wafer style. Valve discs shall seat at 90 degrees with the pipe axis.

Industrial butterfly valves with center lines more than 7'-6" above the floor shall be provided with chain-wheels and operating chains as specified herein.

Flanged end valves shall be of the short-body type. Where mechanical joint ends are specified, in the valve schedule, either mechanical joint or push-on ends conforming to ANSI/AWWA C111/A21.11 will be acceptable. For buried or submerged service, shaft seals shall be O-ring type.

2-1.01. Valves VBF-1.

VBF-1 Heating water, chilled water, condenser water service Wafer	Rating	150 psi shutoff
	Body	ASTM A126, Class B, cast iron
	Trim	
	Seat	EPDM
	Disc	ASTM B148, Alloy 952, aluminum bronze, or Nylon 11 coated ductile iron
	Stem	ASTM A276, Grade 316 or 304, stainless steel
	Stem Seal	Synthetic O-rings
	Stem Packing	Buna-N
	Shaft Bearings	Upper and lower bearings or two upper bearings, bronze, reinforced Teflon, or acetal
	Shaft Seal	Synthetic rubber O-rings
	End Connection	Wafer
	Temperature Limitations	-20 to 250°F [-29 to 114°C]
	Manual Valve Operator	
	6" [150 mm] & smaller	Lever
	8" [200 mm] & larger	Geared Handwheel
	Manufacturer	Keystone "AR1", ABZ, Bray Series 30

2-1.02. Valves VBF-2.

VBF-2 Process air, heating water, chilled water,	Rating	150 psi shutoff
	Body	ASTM A126, Class B, cast iron
	Trim	
	Seat	EPDM
	Disc	ASTM B148, Alloy 952, aluminum bronze, or Nylon 11 coated

condenser water service Lugged Wafer		ductile iron
	Stem	ASTM A276, Grade 304, 316, or 416, stainless steel
	Stem Seal	Synthetic O-rings
	Stem Packing	Buna-N
	Shaft Bearings	Upper and lower bearings or two upper bearings, bronze, reinforced teflon, or acetal
	Shaft Seal	Synthetic rubber O-rings
	End Connection	Wafer
	Temperature Limitations	-20 to 250°F [-29 to 114°C]
	Manual Valve Operator	
	6" [150 mm] & smaller	Lever
	8" [200 mm] & larger	Geared Handwheel
	Manufacturer	Keystone “AR2”, ABZ, Bray Series 31

2-1.03. Valves VBF-3. Not used.

2-1.04. Valves VBF-4.

VBF-4 Odor control scrubber solution recirculation and drain	Rating	Class 150
	Body	PVC, molded
	Shaft	AISI Type 316 stainless steel
	Trim	
	Seat	FPM (Viton) or EPDM
	Disc	PVC or polypropylene
	Stem	316 stainless steel
	Stem Seal	Synthetic O-rings
	Shaft Bearings	Upper and lower bearings, reinforced Teflon
	End Connection	Flanged, ASME B16.5, Class 150 diameter and drilling
	Temperature Limitations	TBD
	Manual Valve Operator	Lever
	Manufacturer	Asahi American “Type 56”, Chemtrol “Model B”

2-1.05. Length Tolerance. Unless otherwise specified, the actual length of valves shall be within plus or minus 1/16 inch [1.6 mm] of the specified or theoretical length.

2-1.06. Shop Coatings. All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop coated for corrosion protection. The

valve manufacturer's standard coating will be acceptable, provided it is functionally equivalent to the specified coating.

Coating Materials	Specification Compliance
Coal Tar Epoxy	High-build coal tar epoxy; Ameron "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Rust-Preventive Compound	As recommended by the manufacturer.
Universal Primer	As recommended by the manufacturer.

Surfaces to Be Coated	Material
Unfinished Surfaces	
Exterior Surfaces of Valves To Be Buried, Submerged, or Installed in Manholes or Valve Vaults	Asphalt varnish or coal tar epoxy.
Exterior Surfaces of All Other Valves	Universal primer.
Polished or Machined Surfaces	Rust-preventive compound.
Actuators and Accessories	Universal primer.

2-2. VALVE ACTUATORS. Manual actuated valves 6 inches and smaller, unless chain-wheel actuators are required, shall be provided with levers as specified herein. Valves 8 inches and larger shall have enclosed, geared, hand-wheel or chain-wheel actuators with position indicators as specified herein. Requirements for automatic valve actuators shall be as specified herein, as indicated in the Industrial Butterfly Valves Schedule, and as specified in the Valve and Gate Actuator section.

2-2.01. Manual Actuators. Manual actuators of the types listed herein and in the Industrial Butterfly Valves Schedule shall be provided by the valve manufacturer.

Unless otherwise indicated or specified, each geared manual actuator shall be equipped with an operating hand-wheel.

The direction of rotation of the wheel, wrench nut, or lever to open the valve shall be to the left (counterclockwise). Each valve body or actuator shall have cast thereon the word "Open" and an arrow indicating the direction to open.

The housing of traveling-nut type actuators shall be fitted with a removable cover which shall permit inspection and maintenance of the operating mechanism without removing the actuator from the valve. Travel limiting devices shall be provided inside the actuator for the open and closed positions. Travel limiting stop nuts or collars installed on the reach rod of traveling-nut type operating mechanisms shall be field adjustable and shall be locked in position by means of a removable roll pin, cotter pin, or other positive locking device. The use of stop nuts or adjustable shaft collars which rely on clamping force or setscrews to prevent rotation of the nut or collar on the reach rod will not be acceptable.

Each actuator shall be designed so that shaft seal leakage cannot enter the actuator housing.

Valves for throttling service shall be equipped with an infinitely variable locking device or a totally enclosed gear actuator.

Actuators shall produce the required torque with a maximum pull of 80 lbs [356 N] on the lever, hand-wheel, or chain. Actuator components shall withstand, without damage, a pull of 200 lbs [890 N] on the hand-wheel or chain-wheel or an input of 300 foot-lbs [407 J] on the operating nut.

2-2.02. Handwheels. Handwheel diameters shall be as recommended by the valve manufacturer.

2-2.03. Levers. Levers shall be capable of being locked in at least five intermediate positions between fully open and fully closed.

2-2.04. Chain-wheels. All valves with center lines more than 7'-6" [2.3 m] above the floor shall be provided with chain-wheels and operating chains, unless otherwise specified in the Industrial Butterfly Valve Schedule. Each chain-wheel operated valve shall be equipped with a chain guide which will permit rapid handling of the operating chain without "gagging" of the wheel and will also permit reasonable side pull on the chain. Suitable extensions shall be provided, if necessary, to prevent interference of the chain with adjacent piping or equipment. Operating chains shall be hot-dip galvanized carbon steel and shall be looped to extend to within 4 feet [1.2 m] of the floor below the valve.

2-3. ACCESSORIES. Requirements for extension stems and stem guides, position indicators, floor boxes, operating stands, torque tubes, and valves boxes shall be as specified in Valve and Gate Actuator section, and as indicated in the Industrial Butterfly Valves Schedule.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section shall be installed in accordance with Valve Installation section.

End of Section

Section 40 05 68

CHECK VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of check valves as specified herein and as indicated on the P&IDs, and as indicated in the Check Valve Schedule.

Piping, pipe supports, insulation, and accessories that are not an integral part of the valves or are not specified herein are covered in other sections.

1-2. GENERAL. Equipment furnished under this section shall be fabricated and assembled in full conformity with Drawings, Specifications, engineering data, instructions, unless exceptions are noted by Design-Builder.

Valves shall be furnished with all necessary parts and accessories indicated on the Drawings, specified, otherwise required for a complete, properly operating installation and shall be the latest standard products of a manufacturer regularly engaged in the production of valves.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Temporary Number Plates. Each check valve with an identifying number listed in the Check Valve Schedule, shall be tagged or marked in the factory with the identifying number.

1-2.03. Identification. Valves specified herein shall be tagged in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete drawings, details, and specifications covering the valves and their appurtenances shall be submitted in accordance with the Submittals Procedures section. Included in the submittal shall be drawings by the valve manufacturer to indicate the position of the valve actuator and valve shaft.

PART 2 – PRODUCTS

2-1. CONSTRUCTION.

The valve types are coverd in the Check Valve Schedule and coordinated with the P&IDs. Note not all valve types listed here exist in within the Proejct.

2-1.01. Valves VC-1.

VC-1 Air or vacuum service 1-1/2 inch [38 mm] or smaller pipe	Type Body Trim Poppet O-ring Spring End Connection Temp. Limitations Manufacturers	Poppet Stainless steel Stainless steel Viton (EPDM for aqua ammonia system air supply) Stainless steel Threaded -20 to 375°F [-29 to 191°C] Circle Seal “Series 200” or Swagelok “Series C”

2-1.02. Valves VC-2.

VC-2 Water, sludge, liquid service, or sump pump discharge Threaded ends 2 inch [25 mm] or smaller pipe	Rating Code Type Body/Bonnet Trim Seat Disc Hinge Pins End Connection Temp. Limitations Manufacturers	Class 125 AWWA C508 Horizontal swing, threaded bonnet ASTM B62 bronze Bronze, regrinding Bronze Manufacturer’s standard Threaded -20 to 212°F [-29 to 100°C] Stockham “B-321”, Walworth “Fig 3406”

2-1.03. Valves VC-3.

VC-3 Water, sludge, or liquid service Socket ends 2 inch [50	Rating Code Type Body/Bonnet Trim Seat Disc Hinge Pins End Connection Temp. Limitations	Class 125 AWWA C508 Horizontal swing, threaded bonnet ASTM B62 bronze Bronze, regrinding Bronze Manufacturer’s standard Soldered -20°F to 212°F [-29°C to 100°C]

mm] or smaller pipe	Manufacturers	Nibco “S-413-B”, Walworth “Fig 3046SJ”

2-1.04. Valves VC-4.

VC-4 Air or vacuum service 2 inch [50 mm] or larger pipe	Rating Type Body Trim Seat Disc Hinge Hinge Pins Springs Bushings End Connection Temp. Limitations Manufacturers	Class 125 Dual disc wafer, full port Cast iron or carbon steel EPDM or Viton Aluminum Elastomeric Aluminum Stainless steel Manufacturer’s standard Plain, installed between ASME B16.1, Class 125, flat faced flanges -20 to 300°F [-29 to 149°C] “Silent Seatless Check Valves” 09 Series as manufactured by US Valve of Rutherford, New Jersey or Flexi-Hinge Valve Company “Flexi-Hinge”

2-1.05. Valves VC-5.

VC-5 Digester gas or ozonated water services 2 inch [50 mm] and larger pipe	Rating Type Body Trim Seat Disc Hinge Pins/Stops Springs Bushings End Connection Temp. Limitations Manufacturers	Class 150 Dual disc wafer A351-CF8M, 316 Stainless steel TFE A351-CF8M, 316 Stainless steel A351-CF8M, 316 Stainless steel A351-CF8M, 316 Stainless steel TFE Plain, installed between ASME B16.5, Class 150 diameter and drilling -20 to 212°F [-29 to 100°C] Mueller Steam Specialty, “Model 72”, Apco “Series 9000”, Val-Matic

2-1.06. Valves VC-6.

VC-6	Rating Code	Class 125 AWWA C508

Water, sludge, or liquid service 2-1/2 inch [68 mm] and larger pipe	Type	Horizontal swing, bolted bonnet
	Body/Bonnet	ASTM A126 Class B cast iron
	Trim	
	Seat Ring	Bronze
	Disc	Bronze
	Hinge Pins	Bronze or brass
	Bushings	Bronze
	Cover Gasket	Manufacturer's standard
	End Connection	Flanged, ASME B16.1 Class 125, flat faced
	Temp. Limitations	-20 to 212°F [-29 to 100°C]
	Manufacturers	Milwaukee "F-2974", Stockham "G-931"

2-1.07. Valves VC-7.

VC-7 Sump pump discharge service 3 inch [75 mm] and larger pipe	Rating	Class 125
	Code	AWWA C508
	Type	Horizontal swing, bolted bonnet
	Body/Bonnet	ASTM A126 Class B cast iron
	Trim	
	Seat Ring	ASTM B763 Alloy 84400 bronze
	Disc (3 inch)	ASTM B584 bronze
	(4 inch and larger)	ASTM A126 Class B cast iron
	Hinge Pins	Stainless steel
	Bearings	Bronze bushings
	Cover Gasket	Manufacturer's standard
	End Connection	Flanged, ASME B16.1 Class 125, flat faced
	Temp. Limitations	-20 to 212°F [-29 to 100°C]
	Valve Operator	Weighted lever
	Manufacturers	Mueller "A2604-6-01"

2-1.08. Valves VC-8.

VC-8 Low pressure clear water service 3 through 12 inch [75 through 300 mm] pipe	Rating	Class 125
	Type	Dual disc wafer
	Body	ASTM A126, Class B, cast iron
	Trim	
	Seat Ring	Buna-N
	Disc	ASTM B148 Alloy 952, aluminum bronze
	Springs/Hinge Pins/Stops	Stainless steel
	Bearings	Teflon

	End Connection	Plain, installed between ASME B16.1, Class 125, flat faced flanges
	Temp. Limitations	-20 to 225°F [-29 to 107°C] intermittent, 0 to 180°F [-18 to 82°C] continuous
	Manufacturers	Stockham “WG-970”, “Duo-Chek II 12HMP”, Apco Valve and Primer “9000AR1F”

2-1.09. Valves VC-9.

VC-9 High pressure clear water service 3 through 12 inch [75 through 300 mm] pipe	Rating	Class 250
	Type	Dual disc wafer
	Body/Bonnet	ASTM A126, Class B, cast iron
	Trim	
	Seat	Buna-N
	Disc	ASTM B148 Alloy 952, aluminum bronze
	Springs/Hinge Pins/Stops	AISI Type 316 stainless steel
	Bearings	Teflon
	End Connection	Plain, installed between ASME B16.1, Class 250, raised faced flanges
	Temp. Limitations	-20 to 225°F [-29 to 107°C] intermittent, 0 to 180°F [-18 to 82°C] continuous
	Manufacturers	Stockham “WG-970”, “Duo-Chek II Figure 30HMF”, Apco Valve and Primer “9200AR1R”

2-1.10. Valves VC-10.

VC -10 Wastewater pump discharge service 6 inch [150 mm] and larger pipe	Rating	Class 125
	Code	AWWA C508
	Type	Horizontal swing, bolted bonnet
	Body	ASTM A126 Class B cast iron
	Trim	
	Seat Ring	ASTM B763 Alloy 84400 bronze
	Disc	ASTM A126 Class B cast iron
	Hinge Pins	Stainless steel
	Bearings	Bronze bushings
	Cover Gasket	Manufacturer’s standard
	End Connection	Flanged, ASME B16.1, Class 125, flat faced

	Temp. Limitations	-20 to 212°F [-29 to 100°C]
	Valve Operator	External spring or weighted lever
	Manufacturers	American Flow Control “52 SC”, M&H “Style 259-02”, Mueller “A2600-6-01 or 6-02”

2-1.11. Valves VC-11.

VC-11 Low pressure clear water service 14 inch [350 mm] and larger pipe	Rating	Class 125
	Type	Dual disc wafer
	Body	ASTM A126, Class B, cast iron or ductile iron
	Trim	
	Seat Ring	Buna-N
	Disc	ASTM B148 Alloy 952, aluminum bronze
	Springs/Hinge Pins/Stops	Stainless steel
	Bearings	Teflon
	End Connection	Plain, installed between ASME B16.1, Class 125, flat faced flanges
	Temp. Limitations	--20 to 225°F [-29 to 107°C] intermittent, 0 to 180°F [-18 to 82°C] continuous
	Manufacturers	Marlin “Wafer Check 125HZNSF”, “Duo-Chek II Figure 12HMP”, Apco Valve and Primer “9000AR1F”

2-1.12. Valves VC-12.

VC-12 High pressure clear water service 14 inch [350 mm] and larger pipe lines	Rating	250 psig
	Type	Dual disc wafer
	Body	ASTM A126, Class B, cast iron
	Trim	
	Seat Ring	Buna-N
	Disc	ASTM B148 Alloy 952, aluminum bronze or ductile iron with bronze trim
	Springs/Hinge Pins/Stops	AISI Type 316 stainless steel
	Bearings	Teflon
	End Connection	Plain, installed between ASME B16.1, Class 250, raised faced flanges

	Temp. Limitations	-20 to 225°F [-29 to 107°C] intermittent, 0 to 180°F [-18 to 82°C] continuous
	Manufacturers	Marlin “Wafer Check 250HZNSR”, “Duo-Chek II Figure 25HMF”, Apco Valve and Primer “9000AR1R”

2-1.13. Valves VC-13.

VC-13 Service as specified in Miscellaneous Plastic Pipe, Tubing, and Accessories section Socket ends 3 inch and smaller PVC or CPVC pipe	Rating	150 psig [1 MPa] nonshock
	Type	Ball check, true union
	Body	PVC or CPVC, material shall match pipe material
	Trim	
	Ball	PVC or CPVC, material shall match pipe material
	Seat	Viton or EPDM
	Seals	Viton or EPDM
	End Connection	Socket
	Temp. Limitations	0 to 140°F [-18 to 60°C]
	Manufacturers	Hayward Plastics Products “Ball Check Valve”, Nibco “Chemtrol True Union Ball Check Valve”, Spears Manufacturing Co. “True Union 2000 Industrial Series 4500 Ball Check Valves”

2-1.14. Valves VC-14.

VC-14 Service as specified in Miscellaneous Plastic Pipe, Tubing, and Accessories Section Flanged ends 3 inch [75 mm] and smaller PVC or CPVC	Rating	150 psig [1 MPa] nonshock
	Type	Ball check, true union
	Body/Bonnet	PVC or CPVC, material shall match pipe material
	Trim	
	Ball	PVC or CPVC, material shall match pipe material
	Seat	Viton or EPDM
	Seals	Viton or EPDM
	End Connection	Flanged, ASME B16.5, Class 150, raised face
	Temp. Limitations	0 to 140°F [-18 to 60°C]
	Manufacturers	Hayward Plastics Products “Ball Check Valve”, Nibco “Chemtrol True Union Ball Check Valve”, Spears Manufacturing Co. “True

pipe		Union 2000 Industrial Series 4500 Ball Check Valves”

2-1.15. Valves VC-15.

VC-15 Chemical feed service 2 inch [50 mm] and smaller carbon steel pipe	Rating Type Body/Bonnet Trim Ball Seat Gasket Spring End Connection Temp. Limitations Manufacturers	Class 150 Spring loaded ball check with bolted removable cap Carbon steel Alloy steel A276 Stellite 6 316 Stainless Steel/Grafoil, Spiral Wound Stainless Steel Type 302 Socket welded 0 to 150°F [-18 to 66°C] Bonney Forge “HL51SW”

2-1.16. Valves VC-16.

VC-16 Chemical feed service 2 inch [50 mm] and smaller stainless steel pipe	Rating Type Body Trim Disc Seat Gasket End Connection Temp. Limitations Manufacturers	150 psig [1 MPa] nonshock Lift check (Disc) 316L Stainless Steel 316 Stainless Steel 316 Stainless Steel 316 Stainless Steel, Spiral Wound Threaded 1,200 F at 600 psig Conbraco “S90A”

2-1.17. Valves VC-17.

VC-17 Chemical piping vacuum relief service PVC or CPVC pipe	Rating Type Body Trim Diaphragm End Connection Temp. Limitations Manufacturers	100 psig [690 kPa] nonshock Diaphragm, two piece PVC Chemical resistant Threaded 0 to 140°F [-18 to 60°C] Plast-O-Matic “Series CKM Check Valves” or “Series VB Vacuum Breakers”

2-1.18. Valves VC-18.

VC-18 Chemical piping vacuum relief service 2 inch [50 mm] and smaller stainless steel pipe	Rating Type Body Trim Seat End Connection Temp. Limitations Manufacturers	3000 psig [20 MPa] Vacuum Breaker, Universal Low Pressure 316 Stainless Steel Chemically resistant Threaded 700°F [371°C] Check-All Valves “UN-3-100-SS-E” or equal

2-1.19. Valves VC-19.

VC-19 Chemical piping vacuum relief service Carpenter 20 pipe	Rating Type Body/Bonnet Trim Seat End Connection Temp. Limitations Manufacturers	3000 psig [20 MPa] nonshock Vacuum breaker, Universal low pressure check valve Carpenter 20 Cb-3 Teflon Threaded 0 to 140°F [-18 to 60°C] Check-All Valves “UN-3-XXX-A-20-T” or equal

2-1.20. Valves VC-20.

VC-20 Process Air Service for use with rotary positive displacement blowers	Max Pressure drop across valve Type End Connection Temp. Limitations Manufacturers	3 inch W.C. Full port, silent seatless type Flanged 0 to 300°F 09 Series US Valve

2-1.21. Shop Coatings. All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop coated for corrosion protection. The valve manufacturer’s standard coating will be acceptable, provided it is functionally equivalent to the specified coating.

Coating Materials

Coal Tar Epoxy — High-build coal tar epoxy; Ameron

	"Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Epoxy Enamel (for liquid service)	Ameron "Amerlock 400 High-Solids Epoxy Coating", Carboline "Carboguard°891", or Tnemec "Series N140 Pota-Pox Plus".
Rust-Preventive Compound	As recommended by the manufacturer.

Surfaces To Be Coated

Unfinished Surfaces

Interior Surfaces

Liquid Service	Epoxy enamel.
Exterior Surfaces of Valves To Be Buried, Submerged, or Installed in Manholes or Valve Vaults	Asphalt varnish or coal tar epoxy.
Exterior Surfaces of All Other Valves	Universal primer.
Polished or Machined Surfaces	Rust-preventive compound.
Actuators and Accessories	Universal primer.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section shall be installed in accordance with Valve Installation section.

End of Section

Section 40 05 86

AIR VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing air-release valves, combination air valves, air/vacuum valves and vacuum relief valves as required by the Work.

1-2. GENERAL. Equipment provided under this section shall be fabricated and assembled in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer.
Valves shall be furnished with all necessary parts and accessories indicated on the Drawings, specified, or otherwise required for a complete, properly operating installation and shall be the latest standard products of a manufacturer regularly engaged in the production of valves.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Governing Standard. Except as modified or supplemented herein, all valves furnished under this section shall conform to the applicable performance requirements of ANSI/AWWA C512.

1-2.03. Identification. Air valves shall be tagged in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete assembly drawings, together with detailed specifications and data covering materials used and accessories forming a part of the valves furnished, shall be submitted in accordance with the Submittals Procedures section.

PART 2 - PRODUCTS

2-1. CONSTRUCTION. Air release valves for clean water applications with operating pressures of 150 psi or less shall be Apco/Valve and Primer "No. 200", GA Industries "Figure 920m", Multiplex "Crispin Type PL", ARI “No. S-050”, or Val-Matic "No. 38". Air release valves for working pressures below 20 psi shall be provided with soft seats.

Air release valves for wastewater applications with operating pressures of 300 psi or less shall be Apco/Valve and Primer “No. 400 or 450”, Multiplex “Crispin S Series”, ARI “No. S-020”, or Val-Matic “VM-48A or 49A”.

Vacuum relief valves shall be globe body type designed for full vacuum relief protection. The valve shall be provided with a steel head to prevent entrance of debris, shall have brass plug and resilient seat, and shall normally be kept closed by a stainless steel spring. Valves shall be Apco/Valve and Primer “Series 1500”, GA Industries “Figure 990 High Capacity Vacuum Relief & Air Inlet Valve, or Val-Matic “High Flow Vacuum Relief Valve”. Vacuum relief valves shall be provided with a side mounted air release valve.

Three inch and smaller air release and vacuum relief valves for clean water applications shall be integral type, Apco/Valve Primer “Series 140”, Multiplex “Crispin AL Series”, or Val-Matic “Air/Vacuum Valves”.

Four inch and larger air release and vacuum relief valves for clean water applications shall be integral type, Apco/Valve Primer “Series 1900”, Multiplex “Crispin AL Series”, or Val-Matic “Air/Vacuum Valves”. Unless otherwise specified or indicated on the Drawings, valves shall be provided with surge check discs on the valve inlet to restrict the exhaust air flow rate.

Two inch and smaller combination air valves for clean water applications shall be of the integral type with a valve assembly which functions as both an air and vacuum valve and an air release valve. The valves shall be Apco/Valve and Primer "Single Body Combination Air Valves", Multiplex "Crispin Universal Air Release Valves", ARI “No. D-040”, or Val-Matic "Combination Air Valves".

Three inch and larger combination air valves for clean water applications shall consist of an air and vacuum valve with an externally mounted air release valve. The valves shall be Apco/Valve and Primer “Single Body Combination Air Valves” for 3 inch and "Custom Combination Air Valves" for 4 inch and larger, GA Industries "Figure 950 Kinetic Custom Combination Air Valves", Multiplex "Crispin Dual Air Valves", ARI “No. D-060-HF”, or Val-Matic "Dual Body Combination Air Valves". Unless otherwise specified or indicated on the Drawings, valves shall be provided with surge check discs on the valve inlet to restrict the exhaust air flow rate.

Combination air valves for wastewater applications shall be of the integral type with a valve assembly which functions as both an air and vacuum valve and an air release valve. The valves shall be Apco/Valve and Primer “No. 440”, GA Industries “Figure 942”, Multiplex “Crispin US Series”, ARI “No. D-020”, or Val-Matic “VM-801A or VM-804”

Two inch and smaller air release and vacuum relief valves for vertical diffusion vane pumps shall be of the kinetic energy type with a valve assembly which

functions as both an air release and a vacuum relief valve. The exhaust from the valve shall be provided with a throttling device for field adjusting the air flow rate. The valves shall be Apco/Valve and Primer "Series 140DAT Air Valves for Vertical Turbine Pumps", GA Industries "Figure 933 Kinetic Air/Vacuum Valve", ARI “No. D-040”, or Multiplex "Crispin Deep Well Air Valve". The discharge from the valve shall be provided with a threaded NPT connection.

Three inch and larger air release and vacuum relief valves for vertical diffusion vane pumps shall be of the kinetic energy type with a valve assembly which functions as both an air release and a vacuum relief valve. The valve shall be provided with a surge check valve on the valve inlet or outlet. The valves shall be Apco/Valve and Primer “Series 140DAT Air Valves for Vertical Turbine Pumps” for 3 inch and "Series 1900 Air Valves for Vertical Turbine Pumps" for 4 inch and larger, GA Industries "Figure 931 Slow-Closing Kinetic Air/Vacuum Valve", ARI “No. D-060-HF-NS”, or Multiplex "Crispin Air & Vacuum Valve with Surge Check Valve". The discharge from the valve shall be provided with a flanged connection.

2-2. MATERIALS. Except as modified or supplemented herein, materials of construction shall comply with the governing standard.

Valve Trim	Bronze or austenitic stainless steel or polymer materials. Valve trim for valves in wastewater service shall be austenitic stainless steel.
Float	Austenitic stainless steel, polycarbonate, or foamed polypropylene.
Shop Coatings	
Epoxy (NSF-61 Certified)	PPG Amercoat “Amerlock 400 High Solids Epoxy”, Carboline “Carboguard 891”, Sherwin-Williams "Macropoxy 646NSF" or Tnemec “Series N140 Pota-Pox Plus”.
Epoxy	PPG Amercoat “Amercoat 385 Epoxy”, Carboline “Carboguard 890”, Sherwin-Williams "Macropoxy 646" or Tnemec “Series N69 Hi-Build Epoxoline II”.
Rust-Preventive Compound	As recommended by manufacturer.

2-3. SHOP PAINTING. All interior and exterior ferrous metal surfaces, except stainless steel components, shall be shop painted for corrosion protection. The valve manufacturer's standard coating will be acceptable, provided it is functionally equivalent to the specified coating and is compatible with the specified field coating.

Surfaces shall be painted as indicated:

Interior Surfaces of Valves in Clean Water Applications (Raw or Treated Water in Potable Water Facilities)	NSF-61 Certified Epoxy.
Interior Surfaces of Valves in Wastewater Applications	Epoxy
Exterior Surfaces of All Other Valves	Universal primer.
Polished or Machined Surfaces	Rust-preventive compound.

Interior epoxy coatings for clean water valves shall comply with ANSI/AWWA C550/NSF 61. Interior coatings for all valves shall be free of holidays. The total dry film thickness of shop-applied coatings shall be not less than:

Type of Coating	Minimum Dry Film Thickness
Epoxy	10 mils
Universal Primer	3 mils

2-4. SHUTOFF VALVES. A shutoff valve shall be provided in the piping leading to each air valve. Shutoff valves 2 inches and smaller shall be ball valves as specified in the Miscellaneous Ball Valves section. Shutoff valves 3 inches and larger for wastewater service shall be eccentric plug valves as specified in the Eccentric Plug Valve section.

Each 4 inch and larger combination air valve shall be provided with a shutoff valve between the air and vacuum valve and the air release valve.

PART 3 - EXECUTION

3-1. INSTALLATION. Air release and combination air valves shall be installed in accordance with the Valve Installation section.

End of Section

Section 40 05 88.11

SOLENOID VALVES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of manually operated or remote activated two position (open-close) solenoid operated valves.

Piping, pipe supports, insulation, and accessories that are not an integral part of the valves or are not specified herein are covered in other sections.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Identification. Valves specified herein shall be tagged in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS. Complete drawings, details, and specifications covering the valves and their appurtenances shall be submitted in accordance with the Submittals Procedures section.

PART 2 - PRODUCTS

2-1. CONSTRUCTION. Solenoid valves shall have packless construction without packing box or sliding seal.

Solenoid coils for DC service shall be 125 volts, Class H, for continuous duty at rated voltage ± 10 percent and 40°C ambient, in a NEMA Type 4 enclosure, with a conduit knockout.

Valves shall be normally closed unless otherwise specified or indicated on the drawings. Normally open solenoid valves shall close when energized and normally closed solenoid valves shall open when energized.

2-1.01. Valves Type VSOL-1.

VSOL-1	Type	2-Way, pilot operated
	Body/Bonnet	Brass or bronze
	Trim	
	Seals	Buna-N or Teflon
	Disc	Buna-N or Teflon
	Stem	Manufacturer's standard
	Bonnet Gasket	Manufacturer's standard
	Spring	Manufacturer's standard
	End Connection	Threaded
	Temp. Limitations	32 to 104°F [0 to 40°C]
	Valve Operator	Integral
	Manufacturers	ASCO "8210 Series"

2-1.02. Valves Type VSOL-2. Not used.

2-1.03. Length Tolerance. Unless otherwise specified, the actual length of valves shall be within ± 1/16 inch of the specified or theoretical length.

2-1.04. Shop Coatings. All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop coated for corrosion protection. The valve manufacturer's standard coating will be acceptable, provided it is functionally equivalent to the specified coating.

Coating Materials

Asphalt Varnish	Fed Spec TT-C-494.
Coal Tar Epoxy	High-build coal tar epoxy; Ameron "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".
Epoxy Enamel (for liquid service)	Ameron "Amerlock 400 High-Solids Epoxy Coating", Carboline "Carboguard 891", or Tnemec "Series N140 Pota-Pox Plus".
Rust-Preventive Compound	As recommended by the manufacturer.

Surfaces To Be Coated

Unfinished Surfaces

Interior Surfaces	None

Exterior Surfaces of Valves To Be Buried, Submerged, or Installed in Manholes or Valve Vaults	Asphalt varnish or coal tar epoxy.
Exterior Surfaces of All Other Valves	Universal primer.
Polished or Machined Surfaces	Rust-preventive compound.

2-2. ACCESSORIES.

2-2.01. Manual Operators. Valves shall be furnished with manual operators to allow valve operation when electrical power is off.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section shall be installed in accordance with the Valve Installation section.

End of Section

Section 40 05 93

COMMON MOTOR REQUIREMENTS FOR PROCESS EQUIPMENT

PART 1 – GENERAL

1-1. SCOPE. This section covers single and three-phase, small (fractional) and medium (integral) horsepower, alternating current motors rated 500 horsepower and less (NEMA MG1).

Motors shall be designated and coordinated with the driven equipment and shall be located as indicated on the Drawings.

1-2. GENERAL. Motors furnished under driven equipment Specification sections shall be fabricated and assembled in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the Design-Builder.

Where applicable, individual motor data sheets have been developed which specify additional requirements for specific motors.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations section shall apply to all motors, unless otherwise specified. If requirements in this section differ from those in the General Equipment Stipulations section, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Governing Standards. Motors furnished under this section shall be designed, constructed, and tested in accordance with the latest version of NEMA MG 1, NEMA MG 10, and IEEE 112, Test Method B.

1-2.04. Nameplates. All motor nameplate data shall conform to NEMA MG 1 requirements.

1-3. SUBMITTALS. Complete assembly, foundation, and installation drawings, together with complete engineering data covering the materials used, parts, devices, and accessories forming a part of the motor shall be submitted in accordance with the Submittals Procedures section. The drawings and data shall include, but shall not be limited to, the following:

Motors

Name of manufacturer.
Type and model.

Type of bearing and method of lubrication.
Rated size of motor, hp [kW], and service factor.
Temperature rise and insulation rating.
Full load rotative speed.
Net weight.
Efficiency at full, 3/4, and 1/2 load.
Full load current.
Locked rotor current.
Space heater wattage, where applicable.
Motor temperature switch data, where applicable.
Motor Shaft Grounding Ring data, where applicable.
RTD data, where applicable.

Seismic Design Requirements

Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-4. OPERATION AND MAINTENANCE DATA AND MANUALS. Adequate operation and maintenance information shall be supplied. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section.

Operation and maintenance manuals shall include the following:

a. Assembly, installation, alignment, adjustment, and checking instructions.

b. Lubrication and maintenance instructions.

c. Guide to troubleshooting.

d. Parts lists and predicted life of parts subject to wear.

e. Outline, cross-section, and assembly drawings; engineering data; and wiring diagrams.

f. Test data and performance curves, where applicable.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. Service conditions for motors shall be as specified in the driven equipment Specification sections. Motors shall be designed for special conditions such as area classification, altitude, frequent starting, intermittent overload, high inertia, mounting configuration, or service environment. The motors shall be designed for the site elevation and ambient temperatures indicated in the Meteorological and Seismic Design Criteria section.

Unless specified otherwise, all motors shall be designed for full voltage starting and to operate from an electrical system that may have a maximum of 5 percent voltage distortion according to IEEE 519.

Motors utilizing a reduced-voltage, autotransformer starter shall be capable of reduced-voltage starting at a 65 percent tap setting.

Motors utilizing a reduced voltage solid state starter shall be capable of starting at 50% of the specified voltage.

When powered from a variable frequency drive (VFD), motors shall be inverter duty and specifically selected for service with an adjustable frequency type speed controller and shall be derated as required to compensate for harmonic heating effects and reduced self-cooling capability at low speed operation. Each motor shall not exceed a Class B temperature rise when operating in the installed condition at load with power received from the adjustable frequency drive. All motors driven by AFDs shall be supplied with full phase insulation on the end turns and shall meet the requirements of NEMA MG 1, Part 31. In addition to the requirements of NEMA MG 1, Part 31, motors shall be designed to be continually pulsed at the motor terminals with a voltage of 1600 volts ac.

The number of starts per hour for motors shall be rated for the load cycling requirements of NEMA MG 10.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Unless otherwise specified in the attached motor data sheet(s), design and construction of each general-purpose motor shall be as specified herein. Motor voltage, frequency, speed, service factor, and insulation class shall be as follows.

Motor voltage.	460, 3 phase for ½ horsepower and larger, 120, single phase for smaller than ½ horsepower
Frequency.	60 Hz
Speed.	Constant speed
Service factor.	1.0 , except for VFD driven motors which shall be 1.15
Insulation class and temperature rise above 40^{o} C design ambient (by resistance method.	Class F with 90^{o} C rise at 1.15 SF
Enclosure.	Totally enclosed fan cooled
Main conduit box sized to include.	Main motor leads and space heater leads where space heaters are specified

2-2.01. Nameplate Horsepower. Motor nameplate horsepower [kW] shall be equal to or greater than the maximum load imposed by the driven equipment.

2-2.02. Enclosures. All motors shall be self-ventilated. All self-ventilated open type motors, including those with dripproof, splashproof, and weather protected enclosures, and the fan covers of totally enclosed fan cooled motors shall meet NEMA MG 1 requirements for a fully guarded machine.

2-2.02.01. Totally Enclosed Motors. Totally enclosed motors shall be furnished with drain holes and rotating shaft seals. Frames, bearing brackets, external terminal housings, and fan covers for fan cooled motors shall be cast iron. External cooling fans for fan cooled motors shall be fabricated of brass, bronze, aluminum alloy containing not more than 0.2 percent copper, malleable iron, or plastic. All plastic fans shall be fabricated of a reinforced thermosetting plastic and shall be UL approved.

2-2.02.02. Outdoor Motors. Outdoor motors shall have NEMA weather protected enclosures. All exposed metal surfaces shall be protected, where practical, with a corrosion resistant polyester coating. Exposed uncoated surfaces shall be of a corrosion resistant metal. Enclosure exterior and interior surfaces, air gap surfaces, and windings shall be protected with a corrosion resistant polyester, polyurethane or epoxy coating.

2-2.02.03. Motors for Hazardous Locations. Motors for hazardous locations shall be in accordance with the NEC and of the correct type enclosures for the particular service as specified in NEMA MG 1. Motors shall meet the requirements of UL 674.

2-2.02.04. Encapsulated Windings. Where specified in the motor data sheet(s), motors shall be provided with encapsulated windings meeting the requirements of NEMA MG1-1.27.2.

2-2.02.05. Severe Duty Chemical Service Motors. Where specified in the motor data sheet(s), motors shall be provided with special corrosion-resistant finish and encapsulated windings meeting the requirements of NEMA MG1-1.27.2 and IEEE 841.

2-2.03. Main Conduit Boxes. The main conduit box shall be in accordance with NEMA MG 1. The main conduit boxes shall be diagonally split for easy access to the motor leads, and designed for rotation in 90-degree increments. A gasket shall be furnished between the halves of the box. Conduit openings in the main conduit box shall match the size and quantity of conduits indicated on the one line Drawings.

The main conduit box shall be sized for all indicated accessory leads.

Motors furnished in NEMA 320 frame series and larger shall have conduit boxes designed and constructed to permit motor removal after installation without disconnecting raceways.

2-2.04. Leads. Motor power leads shall be wired into the main conduit box. Unless otherwise specified, space heater leads shall be wired into the main conduit box. All motor leads and their terminals shall be permanently marked in accordance with the requirements of NEMA MG 1, Part 2. Each lead marking shall be visible after taping of the terminals.

All motors rated 100 horsepower [74 kW] and larger, and all vertical motors shall have the direction of rotation marked by an arrow mounted visibly on the stator frame near the terminal housing, or on the nameplate, and the leads marked for phase sequence T1, T2, T3, to correspond to the direction of rotation and supply voltage sequence.

Leads for dual-voltage rated or for multispeed motors shall be easily connected or reconnected in the main conduit box for the operating voltage or for the specified speeds. Permanent instructions for making these connections shall be furnished inside the main conduit box or on the motor frame or nameplate.

2-2.05. Terminals. Cable type leads shall be provided with compression type connectors.

2-2.06. Grounding Connections. All motors shall be furnished with a ground connection.

2-2.07. Bearings. All bearings shall be self-lubricating, shall have provisions for relubrication, and shall be designed to operate in any position or at any angle.

All bearing mountings shall be designed to prevent the entrance of lubricant into the motor enclosure or dirt into the bearings, and shall be fitted with pipes, drain plugs, and fittings arranged for safe, easy relubrication from the outside of the motor while the motor is in service, as necessary.

2-2.07.01. Insulated Bearings. Motors over 100 horsepower controlled by an adjustable frequency drive shall be furnished with one insulated bearing. The insulated bearing shall be installed on the non-drive end of the motor.

2-2.08. Rotors. All induction motors shall have squirrel-cage rotors adequately sized to avoid overheating during acceleration of the motor and driven equipment. Rotors shall be dynamically balanced to 0.08 in./sec [2.03 mm/s] or less.

2-2.09. Shafts. Shafts shall be furnished with corrosion resistant treatment or shall be of a corrosion resistant material.

2-2.10. Torque Characteristics. Motors rated 200 horsepower [149 kW] and less shall have torques and locked-rotor current in accordance with NEMA MG 1, Part 12.

2-2.11. Motor Space Heaters. Outdoor motors 1 horsepower and larger shall be provided with a space heater element sized to prevent condensation on the core and windings. The space heaters shall be isolated or so located as to prevent heat damage to adjacent painted surfaces and shall be suitable for 120 volt, 60 Hz, single phase power supply.

2-2.12. Temperature Sensing Devices. Each motor controlled by an adjustable frequency drive shall be furnished with at least one automatic reset winding temperature switch per phase. Temperature switch contacts shall be normally closed and rated 5 amps at 120 volts ac. The contacts shall be wired in series with the end leads brought out to the motor terminal box.

Motors shall be furnished with a pair of resistive temperature devices (RTDs) placed in each phase winding to sense winding temperature. Bearing RTDs complete with detector head and holder assemblies shall be furnished in accordance with the applicable requirements of ISA MC96.1 and IEEE 119. All RTDs shall be 100 ohm, platinum type, and shall be connected with a twisted shielded triad to the motor protection relay.

An auxiliary conduit box shall be provided for termination of RTD or temperature switch wiring.

2-2.13. Motor Shaft Grounding Ring. Each motor controlled by an adjustable frequency drive shall be furnished with a maintenance free, conductive micro fiber, shaft grounding ring with circumferential micro fibers to discharge electrical shaft currents within the motor. Motor shaft grounding ring shall be installed on the drive end on the motor shaft. Shaft grounding ring shall be installed by the motor's manufacturer in accordance with grounding ring manufacturer's recommendations.

2-2.14. Assembly. All motors shall be completely assembled with the driven equipment, lubricated, and ready for operation.

2-2.15. Efficiency. Unless otherwise specified in the attached motor data sheet(s), motors shall be premium efficiency type and shall have a NEMA nominal efficiency nameplate value equal to or greater than values indicated in the following table. Efficiency shall be determined in accordance with IEEE 112, Test Method B.

Vertical motors shall have efficiency values equal to or greater than those indicated in the following table minus 0.50.

Motor		Nominal Efficiency Values	Nominal Efficiency Values
kW	hp	Open Drip Enclosure	TEFC Enclosure

		3600 rpm	1800 rpm	1200 rpm	900 rpm	3600 rpm	1800 rpm	1200 rpm	900 rpm
0.7	1	84.0	85.5	82.5	75.0	77.0	85.5	82.5	75.5
1.1	1.5	84.0	86.5	86.5	78.0	84.0	86.5	87.5	80.0
1.5	2	85.5	86.5	87.5	86.5	85.5	86.5	88.5	85.5
2.2	3	85.5	89.5	88.5	89.5	87.0	89.5	89.5	86.5
3.7	5	86.5	89.5	89.5	89.5	88.5	89.5	89.5	85.5
5.6	7.5	88.5	91.0	90.2	88.5	90.0	91.7	91.0	86.5
7.5	10	89.5	91.7	91.7	91.0	91.0	91.7	91.0	91.0
11.2	15	90.2	93.0	91.7	91.0	91.0	92.4	92.0	91.0
14.9	20	91.7	93.0	92.4	92.0	92.0	93.0	92.0	91.0
18.7	25	92.4	93.6	93.0	92.0	92.0	93.6	93.0	91.0
22.4	30	93.0	94.1	93.6	93.0	92.4	93.6	93.0	93.0
29.8	40	93.0	94.1	94.1	93.0	92.4	94.1	94.1	93.0
37.3	50	93.0	94.5	94.1	93.0	93.0	94.5	94.1	93.0
44.8	60	93.6	95.0	94.5	94.0	93.6	95.0	94.5	93.0
56	75	94.0	95.0	95.0	94.0	93.6	95.4	95.0	94.0
74.6	100	94.5	95.4	95.0	95.0	94.1	95.4	95.0	94.0
93.2	125	95.0	95.4	95.0	95.0	95.0	95.4	95.0	94.0
112	150	95.0	95.8	95.4	95.0	95.0	95.8	95.8	94.0
149	200	95.4	95.8	95.4	95.0	95.4	96.2	95.8	94.1
186	250	95.0	95.8	95.4	95.0	95.8	96.2	95.8	94.5
224	300	95.4	95.8	95.4		95.8	96.2	95.8	
261	350	95.4	95.8	95.4		95.8	96.2	95.8	
298	400	95.8	95.8	95.8		95.8	96.2	95.8	
336	450	95.8	96.2	96.2		95.8	96.2	95.8	
373	500	95.8	96.2	96.2		95.8	96.2	95.8	

2-3. ACCESSORIES.

2-3.01. Special Tools and Accessories. Motors requiring periodic repair and adjustment shall be furnished complete with all special tools, instruments, and accessories required for proper maintenance. Each motor shall be provided with lifting eyebolts or lugs and appropriate fittings for adding bearing lubricant. Grease lubricated units shall be provided with a means of venting the casing. Oil lubricated units shall be provided with constant level oilers or with sight glasses arranged to indicate operating and static oil levels.

2-4. ANCHORS. Contractor shall furnish suitable anchors for each item of equipment as required for driven equipment.

2-5. BALANCE. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the unfiltered vibration displacement (peak-to-peak), as measured at any point on the machine, shall not exceed the limits as required by NEMA MG 1. At any operating speed, the ratio of rotative speed to the critical speed of a unit or its components shall be less than 0.8 or more than 1.3.

PART 3 - EXECUTION

3-1. INSTALLATION. Each motor shall be installed in accordance with the Equipment Installation section.

End of Section

Section 40 06 20

SCHEDULES FOR LIQUIDS PROCESS PIPING

1. SCOPE. This section consists of a schedule of 4 inch [100 mm] and larger pipelines indicating the type of pipe to be used. Pipe materials, installation, testing, and disinfection, when specified, are covered in other sections.

Piping smaller than 4 inches [100 mm] is covered in the various miscellaneous piping sections. Piping for plumbing, heating and air conditioning systems is covered in other sections. Piping to be furnished with equipment is covered in the applicable equipment section.

2. ALTERNATIVE PIPE TYPES. Where more than one type of pipe is indicated in the schedule, the type of pipe material to be installed may be selected by Contractor. The details on the drawings cover only one type of pipe for each line. If a different material is selected by Contractor, all details of connections, jointing, wall fittings, support, anchorage, and harnesses shall be modified as necessary to produce an equivalent design acceptable to ✓ Engineer ✓ Consulting Engineer ✓ .

3. WALL FITTINGS. A wall pipe or sleeve will be required for all pipe passing through concrete or masonry block walls. Wall fittings and sleeves shall be as indicated on the drawings and as specified in the applicable piping section.

4. SCHEDULE INDEX. Pipe material abbreviations and their applicable specification section number are as indicated:

Abbreviation	Pipe Material	Section No.
BR	Brass	40 05 41
CBCP	Concrete bar-wrapped steel cylinder pipe	40 05 39.16
CCFP	Centrifugally cast fiberglass pipe	40 05 36.11
CCP	Concrete culvert pipe	33 42 16
CI	Cast iron soil pipe	22 13 16
CPVC	CPVC	40 05 32
CS	Miscellaneous steel pipe	40 05 24.43
CSG	Galvanized steel pipe	40 05 24.43

Abbreviation	Pipe Material	Section No.
CU	Copper tubing	40 05 17
DIP	Ductile iron pipe	40 05 19
HDPE	HDPE pressure pipe	40 05 33.11
HS	Hose	40 05 41
PE	Polyethylene	40 05 32
PP	Polypropylene	40 05 32
PVC	PVC	40 05 32
PVCFJ	PVC fused joint pipe	40 05 31.13
PVCPP	PVC pressure pipe	40 05 31.12
PVCSP	PVC sewer pipe	40 05 31.16
PVDF	PVDF	40 05 32
RPT	Reinforced plastic tubing	40 05 32
SP	Steel pipe	40 05 24
SS	Stainless steel pipe	40 05 23

5. SCHEDULE. Pipe materials shall conform to Schedule 40 06 20 -S01. All pipelines indicated on the drawings and all pipelines required for proper operation of the equipment furnished shall be provided whether listed in the schedule or not.

End of Section

Section 40 06 20-S01
PIPE SCHEDULE

System	Size	Material(s)	Name/Function	From	To	Exposure
AA	6	SS-02	Air-Aeration Process Air	Dry Screw Process Air Blowers	BNR Train No. 1, 2 Zone 1,2	O
			Air-Aeration Sludge Tanks	Rotary Lobe Sludge Holding Tank Blowers	Sludge Holding Tanks No. 1,2	O
	8	SS-02	Air-Aeration Process Air	Dry Screw Process Air Blowers	BNR Train No. 1, 2 Zone 1,2	O
	10	SS-02	Air-Aeration Process Air	Dry Screw Process Air Blowers	BNR Train No. 1, 2 Zone 1,2	O
ANTI	0.5	PE	Anticalin -RO Influent Feed Point	Anticalin Metering Pump	RO Influent Feed Point	B
	1	CPVC-02	Anticalin -RO Feed Conditioning System	Anticalin Storage Tote	Anticalin Metering Pump	I
		PE-06	Anticalin -RO Influent Feed Point	Anticalin Metering Pump	Common RO Header	I
		PVC-02	Anticalin -RO Influent Feed Point	Anticalin Metering Pump	Common RO Header	I
AS	3	SS-02	Air-Scour - Membrane Basins	MBR Scour Air Blowers	Cassette A-1,A-2,B-1,B-2 Mem	O
	6	SS-02	Air-Scour - Membrane Basins	MBR Scour Air Blowers	Cassette A-1,A-2,B-1,B-2 Mem	O
	8	SS-02	Air-Scour - Membrane Basins	MBR Scour Air Blowers	Cassette A-1,A-2,B-1,B-2 Mem	O
AWS	4	DIP	Aerated WAS - Sludge Holding Tanks	Sludge Holding Tank No. 1,2	Dewatering Sludge Feed Pumps	O
	6	DIP	Aerated WAS - Dewatering Sludge Feed Pumps	Dewatering Sludge Feed Pumps	Belt Filter Press	O
				Sludge Holding Tank No. 1,2	Dewatering Sludge Feed Pumps	O
CA	0.5	PE	Citric Acid - RO CIP Feed Point	Citric Acid Metering Pump	RO CIP Feed Point	B
	0.75	PE	Citric Acid - MBR Cleaning Feed Point	Citric Acid Metering Pump	MBR CIP Feed Point	B
	1-2	CPVC-02, DB-01, DB-02, PE-06, PVC-	Citric Acid - Miscellaneous		MBR Area	I
CAKE	8	DIP	Cake	Belt Filter Press	Screw Conveyor	O
Carrier	2	CPVC	Chemical Bank		Chemical Facility	B
CIP	3	CPVC-02	Neutralization Tank Drain	Neutralization Tank	Plant Sewer	I
CIPR	4	CPVC-02	CIP Solution Return	RO Membranes	RO Cleaning Return	I
	6	CPVC-02	CIP Solution Return	RO Membranes	RO Cleaning Return	I
		CPVC-01	CIP Solution Return	RO Membranes	RO Cleaning Return	I
		SS-05	CIP Solution Return	RO Membranes	RO Cleaning Return	I
CIPS	2	CPVC-01	CIP Solution Supply	CIP Pumps	RO Membranes	I
	3	CPVC-02	CIP Solution Supply	CIP Pumps	RO Membranes	I
	4	CPVC-02	CIP Solution Supply	CIP Pumps	RO Membranes	I
	6	CPVC-02	CIP Solution Supply	CIP Pumps	RO Membranes	I
		CPVC-01	CIP Solution Supply	CIP Pumps	RO Membranes	I
		SS-05	CIP Solution Supply	CIP Pumps	RO Membranes	I
D	3	DIP	Process Drain	Multiple	Multiple	I or O
		PVC-02	Process Drain	Multiple	Multiple	I or O
DRN	1	CPVC-02	Process Drain	Multiple	Multiple	I or O
	2	CPVC-02	Process Drain	Multiple	Multiple	I or O
	3	DIP	Process Drain	Multiple	Multiple	I or O
	4	DIP	Process Drain	Multiple	Multiple	I or O
	6	DIP	Process Drain	Multiple	Multiple	I or O
	8	DIP	Process Drain	Multiple	Multiple	I or O
FA	2	PVC-01	Foul Air	Headworks	Headworks	O
	8	PVC-01	Foul Air	Headworks	Headworks	O

PIPE SCHEDULE

System	Size	Material(s)	Name/Function	From	To	Exposure
FA	10	PVC-01	Foul Air	Headworks	Headworks	O
	14	PVC-01	Foul Air	Headworks	Headworks	O
FBW	2	PVC-02	Filtered Backwash - FBW	FBW Pipe	Plant Sewer	O
	3	DIP	Filtered Backwash - FBW	SAFE Filter	SAFE Backwash Pumps	O
	4	DIP	Filtered Backwash - FBW	SAFE Filter	SAFE Backwash Pumps	O
	6	DIP	Filtered Backwash - FBW	SAFE Filter	Sludge Holding Tanks No. 1,2	O
		PVC-C900	Filtered Backwash - FBW	SAFE Filter	Sludge Holding Tanks No. 1,2	B
FF	4	CPVC-02	RO Forward Flush	RO Flush Pump	RO Membranes	I
		SS-05	RO Forward Flush	RO Flush Pump	RO Membranes	I
FIW	6	DIP	Filter Inlet Water	FIW Pipe	Plant Sewer	B
	18	DIP	Filter Inlet Water	SAFE Settle Tank	SAFE Filter	O/B
	24	DIP	Filter Inlet Water	SAFE Filter Gate	SAFE Filter	O
FOW	18	DIP	Filtered Outfall Water - FOW	SAFE Filter	Outfall Balancing Tank	O
		PVC-C900	Filtered Outfall Water - FOW	SAFE Filter	Outfall Balancing Tank	B
	24	DIP	Filtered Outfall Water - FOW	SAFE Filter	Outfall Balancing Tank	O
FPW	24	C900	Water - Fire - FPW	Property Line	Throughout site	B
FSCM	8	DIP	Filter Scum	Filter Scum Collection Trough	Plant Sewer	O
FSW	4	DIP	Filter Solids Waste	Filter Solids Pump	Filter Solids Pump	O
	6	DIP	Filter Solids Waste	Filter Solids Pipe	Filter Solids Pipe	O
GEN	1	DF	Generator Diesel Fuel	Generator Area	Generator Area	O
IA	1	CU-XX	Instrument Air	MBR	MBR	O
IPR	4	DIP	Indirect Potable Reuse Water - IPR	IPR Pumps	IPR Pumps	O
	6	DIP	Indirect Potable Reuse Water - IPR	IPR Pumps	IPR Pumps	O
	8	DIP	Indirect Potable Reuse Water - IPR	IPR Pumps	IPR Pumps	O
	10	DIP	Indirect Potable Reuse Water - IPR	IPR Pumps	IPR Pumps	O
		C900	Indirect Potable Reuse Water - IPR	IPR Pump Station	Property Line	B
MFF	1	PVC-02	Microfiltration Filtrate - MFF	MFF Pipe	Turbidimeter	O
		SS-04	Microfiltration Filtrate - MFF	MFF Pipe	Turbidimeter	O
	4	PVC-02	Microfiltration Filtrate - MFF	RO Feed Tanks	Recycled Water Pump	O
	6	SS-04	Microfiltration Filtrate - MFF	Filtrate Piping	Filtrate Piping	O
	8	PVC-02	Microfiltration Filtrate - MFF	Filtrate Pumps	RO Feed Tanks	B
		SS-04	Microfiltration Filtrate - MFF	Filtrate Piping	Filtrate Piping	O
	10	SS-04	Microfiltration Filtrate - MFF	Filtrate Piping	Filtrate Piping	O
	12	DIP	Microfiltration Filtrate - MFF	RO Feed Tanks	Outfall Balancing Tank	O
		PVC-02	Microfiltration Filtrate - MFF	RO Feed Tanks	Outfall Balancing Tank	B
	16	PVC-01	Microfiltration Filtrate - MFF	RO Feed Tanks	RO System	B
ML	24	SP	Mixed Liquor	BNR	MBR	O
	36	SP	Mixed Liquor	BNR	MBR	O/B

Section 40 06 20-S01
PIPE SCHEDULE

System	Size	Material(s)	Name/Function	From	To	Exposure
NACL	0.5	TEFL	Sodium Hypochlorite - IPR Pump Discharge		Chemical Facility	B
			Sodium Hypochlorite - Plant Water Feed Point		Chemical Facility	B
			Sodium Hypochlorite - RO Concentrate Feed Pc		Chemical Facility	B
			Sodium Hypochlorite - RO Influent Feed Point		Chemical Facility	B
			Sodium Hypochlorite - UV AOP Feed Point		Chemical Facility	B
	0.75	TEFL	Sodium Hypochlorite - MBR Cleaning Feed Poir		Chemical Facility	B
			Sodium Hypochlorite - Ocean Outfall Feed Poin		Chemical Facility	B
	1-3	CPVC-01, DB-02, TEFL-01	Sodium Hypochlorite		MBR Area/Chemical Facility	I or B
NAOH	0.5	PE	Sodium Hydroxide -BNR Feed Point		Chemical Facility	B
			Sodium Hydroxide -Product Water Feed point		Chemical Facility	B
	0.75	PE	Sodium Hydroxide -RO CIP Feed Point		Chemical Facility	B
	1-3	CS-02, CS-03, DB-01, PE-06	Sodium Hydroxide -Feed		Chemical Facility	I or B
NHS	0.5	PE	Sodium Bisulfate - NHS- Dichlorination Station		Chemical Facility	B
	1	CPVC-02, PE-06	Sodium Bisulfate		Chemical Facility	I
NOCL	1-3	CPVC-02, PVC-02	Sodium Hypochlorite		Chemical Facility	I
OF	4	CPVC-02	Overflow	RO Flush Tank	Trench Drain	I
	6	CPVC-02	Overflow	CIP and Neutralization Tanks	Trench Drain	I
	20	DIP	Overflow	Outfall Balancing Tank	Drain	O
PCR	4	CPVC-02	Reverse Osmosis Permeate	ROT Train CIP Permeate Return	ROT Train CIP Permeate Return	I
POLY	1	PVC-02	Polymer	Polymer Feed Pump	Belt Filter Press	O
	3	PVC-02	Polymer	Polymer Feed Pump	Belt Filter Press	O
POW	12	DIP	Plant Outfall Water - POW	Outfall Pump Station	Dechlorination Station	O
	18	DIP	Plant Outfall Water - POW	Outfall Pump Station	Dechlorination Station	O
	20	DIP	Plant Outfall Water - POW	Outfall Pump Station	Dechlorination Station	B
		C900	Plant Outfall Water - POW	Dichlorination Station	Property Line	B
		SP (epoxy lined and coated)	Plant Outfall Water - POW	Dechlorination Station	Composite Sampler	O
	48	SP (epoxy lined and coated)	Plant Outfall Water - POW	Outfall Pump Station	Dechlorination Station	B
	78	SP (epoxy lined and coated)	Plant Outfall Water - POW	Outfall Pump Station	Dechlorination Station	B
PRW	1	PVC-02	Plant Recycled Water	Throughout Plant	Throughout Plant	O
	2	PVC-02	Plant Recycled Water	Throughout Plant	Throughout Plant	O
	3	DIP	Plant Recycled Water	Recycled Water Pump	Recycled Water Pump	O
		PVC-02	Plant Recycled Water	Throughout Plant	Throughout Plant	O
	4	DIP	Plant Recycled Water	Recycled Water Pump	Recycled Water Pump	O
PW	2.5	PVC-02	Water Potable Water - PW	Throughout Plant	Throughout Plant	B
	3	PVC-C900	Water Potable Water - PW	Throughout Plant	Throughout Plant	B
	4	PVC-C900	Water Potable Water - PW	West of Maintenance Building	Headworks	B
	6	C900	Water Potable Water - PW	Throughout Plant	Throughout Plant	B
		PVC-C900	Water Potable Water - PW	Throughout Plant	Throughout Plant	B
	8	C900	Water Potable Water - PW	Property Line	West of Maintenance Building	B
RAS	14	SP	Return Activated Sludge	RAS Collection Channel	RAS Deox Pipe	O
	30	SP	Return Activated Sludge	RAS Deox Pipe	Deox Box	B

Section 40 06 20-S01
PIPE SCHEDULE

System	Size	Material(s)	Name/Function	From	To	Exposure
RCW	1	PVC-02	Reclaimed Water - RCW	Near all Units	Near all Units	B
	2	PVC-02	Reclaimed Water - RCW	Near all Units	Near all Units	B
	4	PVC-C900	Reclaimed Water - RCW	Yard Pipes	Yard Pipes	B
ROC	3	SS-05	Reverse Osmosis Concentrate- ROC	RO Vessel	Outfall System	B
		SS-12	Reverse Osmosis Concentrate- ROC	RO Vessel	Outfall System	I
	4	PVC-02	Reverse Osmosis Concentrate - ROC	RO/UV Building	Outfall Area	B
		SS-05	Reverse Osmosis Concentrate- ROC	RO Membranes	RO Booster Pump	I
	6	SS-05	Reverse Osmosis Concentrate- ROC	RO Membranes	RO Booster Pump	I
	10	CPVC-02	Reverse Osmosis Concentrate- ROC	RO Concentrate	Chemical Injection	B
		PVC-02	Reverse Osmosis Concentrate- ROC	RO Concentrate	Outfall	I
	12	PVC-02	Reverse Osmosis Concentrate- ROC	RO Concentrate	Outfall	B
		PVC-C900	Reverse Osmosis Concentrate Chlorine Contact	OutFall Pumping Station	Dechlorination Station	B
ROF	4	SS-05	Reverse Osmosis Feed- ROF	RO Feed	RO Membrane Stage 2	I
	6	CPVC-02	Reverse Osmosis Feed- ROF		RO Feed Pump Piping	I
		SS-05	Reverse Osmosis Feed- ROF	RO Feed	RO Membrane Stage 1	I
	8	CPVC-02	Reverse Osmosis Feed- ROF	RO Water Pump	Outfall Tank	I
		PVC-02	Reverse Osmosis Feed- ROF		RO /UV building	B
				RO Water Pump	Outfall Tank	I
	10	CPVC-02	Reverse Osmosis Feed- ROF	Sodium Hypochlorite Injection	Antiscalent Injection	I
	12	CPVC-02	Reverse Osmosis Feed- ROF	MBR	RO Feed Area	I or B
ROP	1	CPVC-02	Reverse Osmosis Permeate- ROP	Upstream of Sulfuric Acid and Sodium Hypo	UV Analyzer Panel	I
		CS-02	Reverse Osmosis Permeate- ROP	Upstream of Sulfuric Acid and Sodium Hypo	UV Analyzer Panel	I
	2	CPVC-02	Reverse Osmosis Permeate- ROP	RO Permeate Vessels	Outfall Balancing Tank	I
	3	CPVC-02	Reverse Osmosis Permeate- ROP	RO Permeate Makeup	CIP Makeup Tank	I
	4	CPVC-02	Reverse Osmosis Permeate- ROP	RO Feed Pumps	RO Permeate Vessels	I
	8	CPVC-02	Reverse Osmosis Permeate- ROP	RO Permeate Vessels	Outfall Balancing Tank	I
		PVC-02	Reverse Osmosis Permeate- ROP off spec wate	RO /UV building	Outfall Balancing Tank	B
			Reverse Osmosis Permeate- ROP	RO Permeate Vessels	Outfall Balancing Tank	I
SA	0.5	TEFL	Sulfuric Acid -RO Influent Feed Point		Chemical Facility	B
			Sulfuric Acid -UV AOP Influent Feed Point		Chemical Facility	B
	1	CPVC-02	Sulfuric Acid -UV AOP Influent Feed Point	Sulfuric Acid Storage	Static Mixer	I
		CRP-01	Sulfuric Acid -Sulfuric Acid Storage	Sulfuric Acid Storage	UV/AOP System or RO Feed Tank Outlet	I
		CS-12	Sulfuric Acid -Sulfuric Acid Storage	Sulfuric Acid Storage	UV/AOP System or RO Feed Tank Outlet	I
SAN	4	PVC Sewer Pipe	Sanitary Sewers - SAN		Near all Units	B
	6	PVC Sewer Pipe	Sanitary Sewers - SAN		Near all Units	B
	8	PVC Sewer Pipe	Sanitary Sewers - SAN		Near all Units	B
UVE	8	CPVC-02	Ultraviolet Treatment Effluent - UVE	UV Disinfection Units	Calcite Filters	B
		PVC-02	Off Spec Ultraviolet Effluent - UVE	RO /UV building	Outfall Balancing Tank	B
			Ultraviolet Treatment Effluent - UVE	RO /UV building	Calcite Contactor	B
				UV Disinfection Units	Calcite Filters	B
	10	PVC-02	Ultraviolet Treatment Effluent - UVE	Calcite Filters	Backwash Waste Holding Tank	O

PIPE SCHEDULE

System	Size	Material(s)	Name/Function	From	To	Exposure
WAS	3	DIP	Waste Activated Sludge -WAS	BNR RAS	Sludge Holding Tanks	O
		PVC-02	Waste Activated Sludge -WAS	MBR WAS	Sludge Holding Tanks	B
				BNR RAS	Sludge Holding Tanks	B
	6	DIP	Waste Activated Sludge -WAS	BNR Scum Collection Box	BNR Scum/WAS Wetwell	B
		PVC-02	Waste Activated Sludge -WAS	BNR Scum Collection Box	BNR Scum/WAS Wetwell	B
WWR	4	DIP	Wastewater - Raw	Plant Sewer Duplex Pumps	Plant WWR Influent Lines	O or B
	8	DIP	Wastewater - Raw	Plant Influent Flowmeter Isolation Valve	Plant Influent Flowmeter Isolation Valve	O
	12	DIP	Wastewater - Raw	Plant Influent Flowmeter Isolation Valve	Headworks Combined Influent Header	O
		C900	Wastewater - WWR	Property Line	Headworks	B
		HDPE or PVC-C900	Wastewater - Raw	Teresa Road	Headworks Flow Meter Area	B
	16	DIP	Wastewater - Raw	Headworks Combined Influent Header	Headworks Flow Control Valve	O
				Plant Influent Flowmeter Isolation Valve	Headworks Combined Influent Header	O
		C900	Wastewater - WWR	Property Line	Headworks	B
		HDPE or PVC-C900	Wastewater - Raw	Teresa Road	Headworks Flow Meter Area	B
	24	DIP	Wastewater - Raw	Headworks Flow Control Valve	Headworks Influent	O
WWS	3	DIP	Wastewater - Screened	Grit Classifiers	Grit Collector	O
	4	DIP	Wastewater - Screened		Headworks Drain & Grit Pump Piping	O
	6	DIP	Wastewater - Screened	Dewatering Sludge Feed Pumps	Safe Diversion Box	O or B
	8	DIP	Wastewater - Screened	Fine Screen Flow Control Valves	Fine Screens Influent	O
	12	DIP	Wastewater - Screened	Fine Screens Effluent Combined Header	BNR Tanks	O or B
	14	DIP	Wastewater - Screened	Fine Screens Effluent	Fine Screens Effluent Combined Header	O or B
	18	DIP	Wastewater - Screened	Headworks Isolation Valve	Safe Diversion Box	O
	20	PVC-C900	Wastewater - Screened		SAFE Diversion Box to SAFE Settle Tank	B
	24	DIP	Wastewater - Screened	SAFE Diversion Box	SAFE Settle Tank	B
				Headworks Effluent	Headworks Isolation Valve	O

Section 40 06 20-S01
PIPE SCHEDULE

System	Size	Material(s)	Name/Function	From	To	Exposure

Section 40 61 11

INSTRUMENTATION AND CONTROL SYSTEM

PART 1 – GENERAL

1-1. SCOPE. This section covers the furnishing and installation of an instrumentation and control system designated as the Plant Control System (PCS).

The system shall be furnished as specified, complete with all software, human machine interface (HMI) hardware, input/output hardware, instrumentation, and all devices, accessories, appurtenances, testing, and training necessary for proper operation. The PCS is comprised of the Supervisory System (Servers and workstation computers and the Process System (redundant programmable logic controllers (PLCs), Remote I/O (RIO) and packaged systems' PLCs). The PCS will be integrated into the City-wide Supervisory Control and Data Acquisition (SCADA) System.

1-1.01. Associated Sections. This section also includes the equipment and services specified in the following sections. Not every section listed below is provided with the supplier request for proposal package as they are not all applicable.

Section 40 62 00	COMPUTER SYSTEM HARDWARE
Section 40 64 00	PROGRAMMABLE LOGIC CONTROLLERS
Section 40 64 01	VENDOR STANDARD PROGRAMMABLE LOGIC CONTROLLERS
Section 40 66 11	NETWORK SYSTEMS
Section 40 66 33	METALLIC AND FIBER OPTIC COMMUNICATION CABLE AND CONNECTORS
Section 40 67 11	PANELS, CONSOLES, AND APPURTENANCES
Section 40 68 16	COMPUTER SYSTEM SOFTWARE
Section 40 68 83	SOFTWARE CONTROL BLOCK DESCRIPTIONS
Section 40 69 13	UNINTERRUPTIBLE POWER SUPPLY
Section 40 71 00	FLOW INSTRUMENTS
Section 40 72 00	PRESSURE AND LEVEL INSTRUMENTS
Section 40 74 00	TEMPERATURE INSTRUMENTS
Section 40 75 00	PROCESS ANALYTICAL INSTRUMENTS

Section 40 78 00 PANEL MOUNTED INSTRUMENTS

Section 40 79 11 MISCELLANEOUS INSTRUMENTS

1-2. GENERAL. Equipment furnished and installed 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, unless exceptions are noted by System Supplier.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Drawings. The Drawings indicate locations and arrangements of equipment and may include installation details and block and one-line diagrams showing connections and interfaces with other equipment. The input/output (I/O) lists are attached as an appendix to the Programmable Logic Controllers section and are also indicated on the P&I Drawings.

Principal components of the instrumentation systems shall be as indicated on the P&ID drawings and instrument device schedule attached this section.

1-2.03. Codes, Permits and Agency Approvals. All work performed and all materials used shall be in accordance with the National Electrical Code, and with applicable local regulations and ordinances. Where mandated by codes, panels, assemblies, materials, and equipment shall be listed by Underwriters' Laboratories (UL) or if UL is not available another nationally recognized test laboratory (NRTL). Design-Builder shall, as part of their work, arrange for and obtain all necessary permits, inspections, and approvals by the authorities having local jurisdiction of such work. This shall include any third-party inspections and testing of panels and equipment.

1-2.04. Supplier's Qualifications. Equipment and software furnished under this section and under other related sections listed in the Scope paragraph above shall be designed, coordinated, and supplied by a single manufacturer or supplier, hereinafter referred to as the System Supplier. The System Supplier shall be regularly engaged in the business of supplying computer-based monitoring, control, and data acquisition systems. The Design-Builder shall utilize the services of the System Supplier to coordinate all control system related items, to check-out and calibrate instruments, and to perform all testing, training, and startup activities specified to be provided.

The System Supplier shall have the following minimum qualifications:

- The supplier shall maintain a design office staffed with qualified technical design personnel.
- The supplier shall maintain competent and experienced service personnel to service the hardware and software furnished for this project.
- The supplier shall have as a minimum 5 years of experience in the design, coordination and supply of computer-based monitoring, control, and data acquisition systems.

1-2.05. Coordination. Systems supplied under this section shall be designed and coordinated by System Supplier for proper operation with related equipment and materials furnished by other suppliers under other sections of these specifications, under other contracts, and, where applicable, with related existing equipment. All equipment shall be designed and installed in full conformity with the Drawings, specifications, engineering data, instructions, and recommendations of the manufacturer, and the manufacturer of the related equipment.

1-2.06. Related Equipment and Materials. Related equipment and materials may include, but will not be limited to, instrumentation, motor controllers, valve actuators, chemical feeders, analytical measuring devices, conduit, cable, and piping as described in other sections or furnished under other contracts.

1-2.07. Device Tag Numbering System. All devices shall be provided with permanent identification tags. The tag numbers shall agree with System Supplier's equipment drawings and shall match the tag numbers used on the Drawings and device schedules. All field-mounted transmitters and devices shall have stamped stainless steel identification tags. Panel, subpanel, and rack-mounted devices shall have laminated phenolic identification tags securely fastened to the device. Hand-lettered or tape labels will not be acceptable.

1-3. GENERAL REQUIREMENTS. The drawings and specifications indicate the extent and general arrangement of the systems. If any departures from the Drawings or Specifications are deemed necessary by System Supplier, details of such departures and the reasons shall be submitted to Design-Builder for review with or before the first stage submittal. No departures shall be made without prior written acceptance.

The specifications describe the minimum requirements for hardware and software. Where System Supplier's standard configuration includes additional items of equipment or software features not specifically described herein, such equipment or features shall be furnished as a part of the system and shall be warranted as specified herein.

1-3.01. Governing Standards. Equipment furnished under this section shall be designed, constructed, and tested in accordance with IEEE 519, ANSI C37.90, FCC Part 15 - Class A, and NEMA ICS-1-109.60.

1-3.02. Dimensional Restrictions. Layout dimensions will vary between manufacturers and the layout area indicated on the Drawings is based on typical values. The System Supplier shall review the Drawings, the manufacturer's layout drawings and installation requirements, and make any modifications requisite for proper installation subject to acceptance by Design-Builder. At least three feet of clear access space shall be provided in front of all instrumentation and control system components.

1-3.03. Workmanship and Materials. System Supplier shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except for testing.

1-3.04. Corrosive Fluids. All parts which are exposed to corrosive conditions shall be made from corrosion resistant materials. System Supplier shall submit certification that the instrument manufacturer approves the selection of materials of primary elements that are in contact with the specified process fluid to be inert to the effects of the process fluid.

1-3.05. Appurtenances. Signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, and isolation devices shall be furnished as needed for proper performance of the equipment.

1-3.06. Programming Devices. A programming or system-configuring device shall be provided for systems that contain any equipment that requires such a device for routine calibration, maintenance, and troubleshooting. The programming device shall be complete, newly purchased for this project, and shall be in like-new condition when turned over to Owner at completion of start-up.

1-3.07. Instrument Cleaning. Instruments to be utilized in oxygen, ozone, or similar service shall be cleaned for oxygen service, labeled appropriately, and bagged or packaged as necessary to ensure the instrument will remain suitable for insertion in the process during installation. Any special mounting or installation requirements associated with such instruments shall be detailed on tags attached to the instrument.

1-4. SUBMITTALS. Complete dimensional, assembly, and installation drawings, wiring and schematic diagrams; and details, specifications, and data covering the materials used and the parts, devices and accessories forming a part of the system furnished, shall be submitted in accordance with the Submittal Procedures section and the Schedule of Submittals. Submittal data shall be grouped and submitted in three separate stages as indicated in the Schedule of Submittals and herein. The submittal for each stage shall be substantially complete. Individual drawings and data sheets submitted at random intervals will not be accepted for review. Equipment tag numbers or identifications used on the Drawings shall be referenced where applicable.

1-4.01. First Stage Submittal. The first stage submittal shall include the following items.

a. A detailed list of any exceptions, functional differences, or discrepancies between the system proposed by System Supplier and this specification.

b. Product catalog cut sheets on all hardware and software items, clearly marked to show the model number, optional features, and intended service of each device.

c. A brief, concise description of the proposed system, including major hardware and software components and personnel training.

d. A block diagram or schematic drawing showing the principal items of equipment furnished, including model numbers, and their interrelationships.

e. Drawings showing floor and wall space or desktop area requirements for all equipment items, including allowances for door swings and maintenance access.

f. Environmental and power requirements, including heat release information for each equipment item.

g. Standard field termination drawings for all process input/output equipment, showing typical terminations for each type of point available in the system.

h. A copy of the proposed software licenses for all software associated with the system.

i, Outline for training classes.

j. Additional Requirements identified in other sections.

1-4.02. Second Stage Submittal. Before any equipment is released for shipment to the site and before factory testing is scheduled, the following data shall be submitted.

a. Detailed functional descriptions and control philosophy of all software modules specified and furnished as part of System Supplier's standard system. The descriptions shall indicate available modes of control, permissive to be met before auto sequences commence or continue, description of automatic startup and shutdown, operator adjustable set points with ranges and defaults, alarm and shutdown conditions. The descriptions shall be identified with the applicable specification paragraph.

b. Complete panel fabrication drawings and details of panel wiring, piping, and painting. Panel and subpanel drawings shall be to scale and shall include overall dimensions, metal thickness, door swing, mounting details, weight, and front of panel arrangement to show general appearance, with spacing and mounting height of instruments and control devices.

c. Wiring and installation drawings for all interconnecting wiring between components of the system and between related equipment and the equipment furnished under this section. Wiring diagrams shall show complete circuits and indicate all connections. If panel terminal designations, inter-device connections, device features and options, or other features are modified during the fabrication or factory testing, revised drawings shall be submitted before shipment of the equipment to the site.

d. Fiber termination diagrams to show all fiber terminations at fiber patch panels and final termination at equipment. Fiber termination diagrams shall show individual fiber type (single or multimode), fiber core/cladding dimensions, fiber colors, circuit identifications, and type of terminator.

e. Review of drawings submitted prior to the final determination of related equipment shall not relieve System Supplier from supplying systems in full compliance with the specific requirements of the related equipment.

f. Input/output listings showing point names, numbers, and addresses. Input/output identification numbers from the contract documents shall be cross-referenced in this submittal.

g. Proposed lesson plans or outlines for all training courses specified herein, including schedule, instructors' qualifications and experience, and recommended prerequisites.

h. Standard system engineering and user manuals describing the use of the system and application programming techniques for creating reports, graphics, database, historical records, and adding new process I/O nodes to the system.

i. Additional Requirements identified in other sections.

1-4.03. Third Stage Submittal. Complete system documentation, in the form of Operation and Maintenance Manuals, shall be submitted before the commencement of field acceptance testing. Operation and Maintenance Manuals shall include complete instruction books for each item of equipment and software furnished. Where instruction booklets cover more than one specific model or range of device, product data sheets shall be included which indicate the device model number and other special features. A complete set of "as-built" wiring, fabrication, and interconnection drawings shall be included with the manuals. If field-wiring modifications are made after these drawings are submitted, the affected drawings shall be revised and resubmitted. Additional requirements are identified in other specification sections.

1-5. PREPARATION FOR SHIPMENT. All electronic equipment and instruments shall be suitably packaged to facilitate handling and to protect against damage during transit and storage. All equipment shall be boxed, crated, or otherwise completely enclosed and protected during shipment, handling, and storage. All equipment shall be protected from exposure to the elements, shall be kept dry at all times, and shall not be exposed to adverse ambient conditions.

Painted surfaces shall be protected against impact, abrasion, discoloration, and other damage. Painted surfaces that are damaged prior to acceptance of equipment shall be repainted to the satisfaction of Design-Builder.

Each shipment shall include an appropriate shipping list that indicates the contents of the package, including the specific instrument tags. The shipping list shall be accessible without exposing the instruments to the atmosphere. The shipping list shall also contain any cautionary notes regarding storage of the instruments, including requirements to protect the instrument from static discharge, desensitizing chemicals (solvents, paints, etc.), or ambient atmospheric conditions.

Individual instruments shall be appropriately tagged or labeled to positively identify the device. All identification shall be visible without the need to unpack the instrument from its protective packaging.

Instrument shipment and storage requirements shall be coordinated with Design-Builder prior to shipment. Design-Builder shall provide adequate storage and be ready to accept the shipment before shipping any equipment to the site. Additional shipping and storage requirements shall be as detailed in the individual instrument specifications.

Components which are shipped loose due to transportation limitations shall be assembled and disassembled by the manufacturer prior to shipment to assure that all components fit together and are adequately supported.

1-6. DELIVERY, STORAGE, AND SHIPPING. The System Supplier shall coordinate with the Design-Builder and shall deliver equipment for installation in accordance with the general Terms and Conditions of this procurement package.

1-7. SPARE PARTS. Spare parts and consumable items are specified in other sections. The System Supplier shall provide spare parts per the general Terms and Conditions.

1-7.01. Packaging. All spare parts shall be delivered to Owner before final acceptance of the system. Packaging of spare parts shall provide protection against dust and moisture and shall be suitable for storage. Circuit boards and other electronic parts shall be enclosed in anti-static material. All packages shall be clearly marked with the manufacturer's name, part number or other identification, date of manufacture, and approximate shelf life.

1-7.02. Replacement. Design-Builder may utilize spare parts and supplies during system installation, de-bugging, startup, or training, but shall restore all such materials and supplies to the specified quantities before final acceptance of the systems.

PART 2 - PRODUCTS

2-1. GENERAL REQUIREMENTS. All equipment furnished under each section referenced in SCOPE is a part of this section and shall be selected by System Supplier for its superior quality and intended performance. Equipment and materials used shall be subject to review.

2-1.01. Standard Products. The systems furnished shall be standard products. Where two or more units of the same type of equipment are supplied, they shall be the products of the same manufacturer; however, all components of the systems furnished hereunder need not be the products of one manufacturer unless specified herein.

To the extent possible, instruments used for similar types of functions and services shall be of the same brand and model line. Similar components of different instruments shall be the products of the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. The design of the systems furnished hereunder shall utilize concepts, techniques and features that provide maximum reliability and ease of maintenance and repair. The systems shall include board-level devices such as light emitting diodes or other indicators to facilitate quick diagnosis and repair. Diagnostic software shall be furnished to facilitate system-level troubleshooting.

Where redundant hardware is provided, the system shall be capable of performing all specified functions, without reconfiguring hardware or software, with only one device of each category in service.

2-2.01. Factory Assembly. Equipment shall be shipped completely factory assembled, except where its physical size, arrangement, configuration, or shipping and handling limitations make the shipment of completely assembled units impracticable.

2-3. POWER SUPPLY AND INSTRUMENT SIGNAL. Power supply to all control system equipment shall be 120 volts, 60 Hz, single phase. System Supplier shall be responsible for distribution of power among enclosures, consoles, peripherals, and other components of the system from the power supply receptacles and junction boxes indicated on the Drawings. Power distribution hardware shall include cables and branch circuit overcurrent protection installed in accordance with the electrical section.

Unless otherwise indicated, power supply to the instrumentation shall be 24 volts dc to the greatest extent possible. For instruments not capable of 24 volts dc power; unregulated 120 volts, 60 Hz, single phase power shall be utilized. Unless otherwise indicated, all transmitted electronic analog instrument signals shall be 4-20 mA dc and shall be linear with the measured variable.

2-3.01. Facility Distribution System. Equipment not indicated to be powered from an uninterruptible power source shall be suitable for being supplied from the facility distribution system and shall be capable of withstanding voltage variations of $\pm$10 percent and harmonics up to the limits of IEEE 519 without affecting operation. System Supplier shall provide voltage conditioning or filtering equipment if necessary to meet the requirements specified.

2-3.02. Power Supplies. Power supplies for voltages other than those listed above shall be an integral part of the equipment furnished. Internal power supplies shall be regulated, current limiting, and self-protected.

2-3.03. Surge Withstand. All equipment shall meet all surge withstand capability tests as defined in ANSI C37.90 without damage to the equipment.

2-3.04. Uninterruptible Power Supply. An uninterruptible power supply (UPS) shall be furnished hereunder to power the equipment indicated on the Drawings or will be furnished under another section. System Supplier shall be responsible for coordinating the size of the UPS unit with the equipment furnished hereunder, and shall advise Design-Builder if a unit of higher capacity is necessary.

2-4. SERVICE CONDITIONS AND ENVIRONMENTAL REQUIREMENTS. The equipment provided for the instrumentation and control system shall be suitable for the service conditions specified in the attached equipment sections.

All equipment shall be designed and selected to operate without degradation in performance throughout the environmental extremes specified. Equipment shall be designed to prevent the generation of electromagnetic and radio frequency interference and shall be in compliance with FCC Rules and Regulations, Part 15, for Class A computing devices.

2-4.01. Ambient Temperature and Elevation. All system equipment located in air conditioned rooms shall be suitable for operation in ambient temperatures from 10°C to 35°C and a relative humidity of 10 to 80 percent, noncondensing. All equipment located in non-air conditioned indoor areas shall be suitable for an ambient temperature range of 0°C to 50°C and a relative humidity of 10 to 95 percent, noncondensing. All equipment located outdoors shall be suitable for operation in an ambient temperature range -20°C to 60°C and a relative humidity of 5 to 100 percent. Heaters and air conditioning/cooling equipment shall be provided where essential to maintain equipment within its manufacturer-recommended operating ranges.

All equipment and instruments shall be designed to operate at the site elevation as defined in the Seismic and Meteorological Design Criteria section.

2-4.02. Deleterious Effects. All system equipment will be installed in areas without anti-static floor construction and without any provisions for control of particulates or corrosive gases other than ordinary office-type HVAC filtering. System Supplier shall furnish any additional air cleaning equipment, anti-static chair pads, or other protective measures necessary for proper operation of the system.

All input/output hardware shall meet or exceed, without false operation, all requirements of NEMA ICS-1-109.60, Electrical Noise Tests.

2-4.03. Noise Level. The equivalent "A" weighted sound level for any system equipment located in the control room, except printers, shall not exceed 35 dBA. The sound level for printers shall not exceed 65 dBA. Sound reduction enclosures shall be provided where necessary to comply with these limits.

2-4.04. Lightning Protection. In addition to other environmental protection specified herein, the entire system shall be provided with lightning protection. Lightning protection measures shall include the following.

2-4.04.01. Grounding. All major components of the system shall have a low resistance ground connection. Grounding system provisions indicated on the Drawings shall be modified as recommended by System Supplier.

2-4.04.02. Surge Suppressors. Surge and lightning suppressors shall be non-faulting, non-interrupting, and shall protect against line-to-line and line-to-ground surges. Devices shall be solid-state metal oxide varistor (MOV) or silicon junction type, with a response time of less than 50 nanoseconds. Surge protective devices shall be applied for the following:

a. All 120 VAC power connections to RTUs, PLCs, DCUs, instruments and control room equipment. Surge arresters shall be Transtector "ACP-100-HW Series", Power Integrity Corporation “ZTA Series”, Phoenix Contact “Mains PlugTrab”, or MCG Surge Protection “400 Series”.

b. All connections to coaxial-based networked equipment (including CCTV, CATV, Ethernet, Arcnet, and satellite) where any part of the circuit is outside of the building envelope. Surge arresters shall be Telematic “VP08”, Transtector CCTV-PTZ Series”, Phoenix Contact “CoaxTrab Series”, or Northern Technologies “TCS-CP3 Series”.

c. All analog signal circuits where any part of the circuit is outside of the building envelope. Circuits shall be protected at both the transmitter and the control system end of the circuit. Surge protection devices shall not impede or interfere with the use of smart transmitter calibration/communication. Protection devices located near the transmitter shall be Telematic “TP48.” Protection devices in control panels shall be Transtector “PDS Series or FSP Series”, Telematic “SD Series”, Phoenix Contact “PipeTrab Series”, or Citel “BP1-24.”

d. All metallic pair (twisted and untwisted) conductor local area network and data highway termination points, where any part of the data highway cable is routed outside of the building envelope. Single-port protective devices shall be Phoenix Contact “PlugTrab Series”, Transtector “FSP” Series”, or Telematic “NP Series.”

e. All serial, PLC data highway, and remote I/O network termination points where any part of the circuit is routed outside of the building envelope. Surge protection devices shall be Transtector “DRDC Series” (RS-232); Transtector “FSP Series” (RS-422), Phoenix Contact “PlugTrab Series” or Citel “E280 Series”.

f. All telephone lines at points of connection to the system. Protection devices for dial-up circuits shall be Transtector “TSJ Series”, Telebyte “Model 22PX”, Citel “BP1-T”, or equal. Protection devices for full period circuits shall be Transtector “LMP Series”, Northern Technologies “DLP-S Series”, Phoenix Contact “TeleTrab Series”, or Circuit Components, Inc. “SPR-TM Series.”

2-5. SOFTWARE DOCUMENTATION. System Supplier shall furnish complete documentation on all software supplied with the systems specified herein.

Operating systems, compilers, assemblers, and utility and diagnostic programs that are standard commercial products of third parties need not be included in the optical media backup. Software documentation shall consist of the following principal items.

a. One backup set of any integrated circuit or solid-state memory-based plug-in firmware used.

b. Two complete back-up copies of system and application software in executable format on optical media compatible with the system furnished.

c. Three sets of user reference manuals for all standard system and application software.

d. One set of user reference manuals for all operating system software.

e. Three sets of printed as-built reference documentation for any special software provided specifically for this contract.

f. For each licensed software product, all documentation provided by the product manufacturer shall be provided. This includes all reference manuals and any other documents that were provided by the manufacturer. One set of this documentation shall be supplied for each and every piece of equipment provided. Multiple pieces of similar equipment or software require multiple copies of this documentation.

2-6. SOFTWARE LICENSE. All software programs supplied as a standard part of System Supplier's products for this project shall be licensed to Owner for use on the system specified herein. Such license shall not restrict Owner from using the software on the system provided hereunder or its replacement. Owner shall have the right to make copies of the software for use on the system provided. Specific requirements of System Supplier's software license are subject to review and approval by Owner and Design-Builder.

2-7. INSTALLATION TEST EQUIPMENT. All necessary testing equipment for calibration and checking of system components shall be provided by System Supplier. System Supplier shall also furnish calibration and maintenance records for all testing and calibration equipment used on the site if requested by Design-Builder.

2-8. PROGRAMMING DEVICES. The following programming devices shall be provided for the instruments specified in other sections:

Instruments Requiring Programming Devices	Quantity of Programming Devices
Panel mounted instruments	1
Flow instruments	1

Pressure and level instruments	1
Analytical instruments	1
Miscellaneous instruments	1

2-9. PROGRAMMING SOFTWARE. The following programming software shall be provided for the instruments specified in other sections:

Instruments Requiring Programming Software	Number of Copies of Programming Software
Panel mounted instruments	1
Flow instruments	1
Pressure and level instruments	1
Analytical instruments	1
Miscellaneous instruments	1

PART 3 – EXECUTION

3-1. INSTALLATION REQUIREMENTS. The installation of equipment furnished hereunder for installation at the site shall be by the Design-Builder or their assigned subcontractors.

3-1.01. Field Wiring. Field wiring materials and installation shall be in accordance with the electrical section.

3-1.02. Instrument Installation. Instruments shall be mounted so that they can be easily read and serviced and so that all appurtenant devices can be easily operated. Installation details for some instruments are indicated on the Drawings.

All outdoor instrumentation shall be protected from direct sun exposure. Instruments shall be placed in locations to limit south and west sun exposure. Sunshades shall be provided on instruments that are subject to the direct sun exposure. Sunshades shall be located so the opening faces north or east where possible. Sunshades shall be provided as shown on the Drawings.

3-1.03. Salvage of Existing Equipment. Not used.

3-2. SYSTEM SOFTWARE CONFIGURATION. System software shall be configured by the System Supplier. Configuration services shall consist of the creation of the system database, report formats, operator interface graphic and tabular display screen formats, password and security implementation, and programming of control units to provide a fully functioning system. The System

Supplier shall fully configure the system using data provided herein or supplied by the Design-Builder and/or the Owner after award of the contract.

The system that is delivered to the field for installation, checkout, and startup shall have all files, or databases, that are configurable in size, sized in a manner in which there will be 50% space available for future work after the completion of this project. This sizing should include the addition of memory modules, disk drives, or any other device to insure the 50% spare space availability. All "tuning" of software that is dependent on space requirements shall be done prior to the completion of this project.

Tuning of software programs shall be accomplished in such a manner that the program operates at its highest performance level. These programs include, but are not limited to Microsoft SQL Server, all PLC ladder logic, and others.

3-2.01. Control System Database. The control system database shall be developed and configured by the System Supplier. The System Supplier shall enter information obtainable from the Contract Documents into the database prior to soliciting input from the Design-Builder and the Owner. The System Supplier shall determine the need for any "pseudo" database points and shall ascertain and enter all information needed to define these points. The System Supplier is responsible for entering all information associated with each point. This includes but is not limited to, descriptions, engineering units, associated displays, areas, security, etc. All fields associated with each database point must be completely filled out accurately.

3-2.02. Graphic Screen Displays. The System Supplier shall be responsible for developing and configuring the custom graphic displays. Each piece of major process equipment that is monitored by the control system shall be displayed on one or more graphic screen. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. These items must be done in accordance to the Configuration Standards and Conventions as described later in this section. Alarm and/or event displays shall also be provided and proven functional prior to acceptance of the system. A means of capturing and printing of all graphic screens shall also be included. The software program provided must be capable of printing the screen in a black and white (using gray scale) or color format. This program must be accessible from all terminals provided under this contract. The black and white printing shall be done in a manner in which the use of the black background is not represented in the printout. This is done to keep the utilization of ink cartridge and toner cartridge to a minimum.

All graphic screens shall be animated to indicate the current state of the piece of equipment. The following graphic screens shall be provided, as a minimum.

- System Overview

- Alarm Summary
- Event Summary
- Overview of each major process area (with vectoring to sub-areas)
- Summary screen to vector to all process trends

A minimum of 300 custom graphic displays shall be provided by the System Supplier.

3-2.03. Report Formats. Report formats shall be developed and programmed by the System Supplier using tag names defined in the database creation. Reports shall be provided as summarized below. All reports will be provided with a header on each page to indicate the contents of each column of information. Each page shall be numbered and indicate the name of the report, the date the report was printed, and the time of the printout. The printout shall also include the time span of the information shown on the report.

- Daily Operating Report. A daily report, listing the major system variables (up to 30 variables) shall be provided. The report shall include hourly values and minimum/maximum/average values where appropriate. A minimum of 6 separate daily reports shall be provided by the System Supplier.
- Monthly Operating Report. A monthly operating report, which averages the values from the above daily reports, shall be provided. The report shall include monthly minimum/maximum/average values where appropriate.

3-2.04. Configuration Standards and Conventions. A “Software Configuration Standards and Conventions” document will be prepared and submitted by the Design-Builder. The document shall be submitted for review and approval before software configuration commences. The document shall describe and define such items as proposed graphic display process line colors/representations; symbology; color standards for “on”, “off”, “opened”, “closed”, and “alarm” conditions; alarm handling conventions; how items will be selected for control; methods for navigation between displays; address usage/naming conventions; and security setup. Before submitting the initial draft document, the System Supplier shall meet with the Design-Builder and/or Owner to review any of the Owner’s existing standards and conventions. All copies of this submittal shall be provided in color to insure the accuracy of each item. No black and white copies will be accepted. The colors used in the printed submittal shall accurately depict the colors and shapes proposed for use on the final system.

In addition to submitting the document for review, an updated version of the document shall be submitted as part of the O&M Manuals. The document shall be revised to document any additional standards that are established throughout the configuration process.

3-2.05. Configuration Review Meetings. Proposed graphic screens and report formats shall be reviewed with the Owner and Design-Builder throughout the configuration process. The System Supplier's programming personnel shall attend all meetings. A second review meeting shall be held at approximately 50 percent completion. Both meetings shall be held at the Owner's facilities.

3-2.06. Software Functional Requirements. General functional requirements for system configuration are indicated on the Drawings and described in the specifications. The information presented herein and indicated on the Drawings illustrates the general functional intent of the system, and may not be sufficient to fully configure the system. The System Supplier shall be responsible for determining what additional information may be required to complete the configuration tasks, and for obtaining this information from the Design-Builder or the Owner.

3-3. SYSTEMS CHECK. System Supplier shall provide the services of a field manager and a trained and experienced field supervisor to assist the installation contractor during installation, and to calibrate, test, and advise others of the procedures for installation, adjustment, and operation.

3-3.01. Field Manager. System Supplier shall appoint a field services manager who shall be responsible for the coordination of all system check-out and startup activities, and who shall be immediately available to Design-Builder and Owner by phone or on site for the duration of this project.

3-3.02. Field Inspection at Delivery. The field supervisor shall inspect major equipment items within five working days of delivery, to assure that the equipment was not damaged during shipment and shall supervise or assist with unpacking, initial placement, and initial wiring of the system.

3-3.03. Field Calibration of Instruments. After each instrument has been installed, a technical representative of System Supplier shall calibrate each instrument and shall provide a written calibration report for each instrument, indicating the results and final settings. The adjustments of calibrated instruments shall be sealed or marked, insofar as possible, to discourage tampering. Instrument calibration shall be done before checkout of the system operation. A typical instrument calibration report is attached to the end of this section.

3-3.04. Training for Installation Personnel. The field supervisor shall train the installation personnel in reading and understanding submittal drawings, and in the correct installation and wiring procedures for the equipment.

3-3.05. Field Inspection Prior to Start Up. After installation and wiring connections are complete, the field supervisor, with additional System Supplier's

personnel shall verify that each external connection to the system is correctly wired and field process components and devices are functioning as intended.

3-3.05.01. Analog Signals. Analog input signals shall be simulated at the transmitting source, and verified to be received at the proper register address in the control system. Analog outputs shall be generated at the control system, and verified to be received with the correct polarity, at the respective receiving device.

3-3.05.02. Discrete Signals. Discrete input and output signals shall be simulated and verified that they are received at the respective receiving device, and at the proper voltage.

3-3.05.03. Devices by Other Suppliers. If interrelated devices furnished by other suppliers or under other contracts, such as valve actuators, motor controls, chemical feeders, and instruments, do not perform properly at the time of system checkout, the field supervisor shall use suitable test equipment to introduce simulated signals to and/or measure signals from these devices to locate the sources of trouble or malfunction.

3-3.05.04. System Check Out Report. The System Supplier shall submit a written report on the results of such tests to Design-Builder. Additional documentation shall be furnished as requested by Design-Builder to establish responsibility for corrective measures. System Supplier shall verify, in writing, to Design-Builder or Owner that System Supplier has successfully completed the external connection check before beginning system startup or field acceptance testing.

3-3.06. Start Up Assistance. After the field supervisor has completed the system check and submitted his report, System Supplier shall supply a factory-trained engineer and programmer to provide on-site start up assistance. During the startup period, these personnel shall thoroughly check all equipment, correct any deficiencies, and verify the proper operation of all components. Three (3) working days shall be included for this task.

3-4. TESTING. The system shall be acceptance tested at the factory and on site.

System Supplier shall prepare a testing procedure to be approved by Owner and Design-Builder that shall demonstrate that the system conforms to the specifications. The testing procedure shall be submitted at least 30 days in advance of testing. The testing shall be conducted by System Supplier and witnessed by Owner and/or Design-Builder.

System Supplier shall notify Design-Builder and Owner in writing at least 14 days before the proposed testing date. If the factory acceptance test is concluded unsuccessfully, the test shall be repeated. System Supplier shall reimburse

Owner and Design-Builder for all expenses incurred in connection with attending repeated factory or site testing necessitated by system failure or inadequate preparation.

3-4.01. Factory Acceptance Testing. After system assembly and debugging at System Supplier's facility, the system shall be tested before the system is shipped to the site. The factory test shall be conducted on complete system, including all field I/O devices, communications and network equipment, and peripherals.

The entire system, including all peripherals and associated software, shall be factory tested under simulated operating conditions. Both normal operating sequences and fault conditions shall be simulated. The results shall be noted in the HMI alarm/event log. The testing procedures for hardware and software are described below.

All basic functions shall be demonstrated, including I/O processing, communications, alarm handling, HMI display functions, alarm logging, report generation, and historical data storage, as well as the specific functions listed herein. The system shall operate continuously for at least a 72 hours without faults. This operational test may run concurrently with the demonstration of hardware and software functions. The test procedure shall also include at a least four-hour period for discretionary tests to be conducted by Design-Builder or Owner.

3-4.01.01. Hardware Test. Processors, processor modules, and peripheral devices associated with the system shall be assembled together as they will be installed in the field and shall be tested. The test shall demonstrate proper operation of each hardware device and communications among devices, and shall include verification of selected analog and discrete inputs and outputs.

3-4.01.02. Software Test. All system software modules specified herein shall be demonstrated. Software tests shall include running all diagnostics, debugging routines, and system test routines. The operating system, advanced process control language compiler, and all associated drivers shall be fully tested and operable for the system test. Software "patches" or changes to bypass failed or flawed modules during the test will not be acceptable.

3-4.02. Site Acceptance Testing. After installation and checkout by System Supplier's personnel, the system shall be subjected to an acceptance test.

Site acceptance testing shall be scheduled after receipt of the System Check Out Report and System Supplier shall verify that all field signal changes are reflected in the proper address locations in the system database.

The site acceptance testing shall follow the same procedure as the factory testing and shall operate without loss of basic functions. The number of working days of continuous operation for the test shall be 30. The operational demonstration shall confirm that the status, alarm, and process variable signals are valid and are being updated appropriately, and that the discrete and analog output signals from the control system are being correctly transmitted and implemented. Any errors or abnormal occurrences shall be recorded by System Supplier's field representative. System Supplier's field representative need not be continuously present during the site acceptance testing, but shall be available to respond to the site within one hour of notification. The representative shall inspect the system for faults at least once every 24 hours and shall log or record any noted problems. The log shall include a description of the problem, its apparent cause, and any corrective action taken.

3-4.02.01. Failure of Redundant Equipment. Failure of redundant equipment shall not be considered downtime provided that automatic failover occurs as specified and, in the opinion of Design-Builder, the failure was not caused by deficiency in design or installation. In the event of repeated failure of any hardware component or software module, the acceptance test shall be terminated and re-started.

3-4.02.02. Completion of Test. Successful completion of the site acceptance test, including the operational demonstration, is prerequisite to Substantial Completion as specified in the Supplementary Conditions.

3-5. TRAINING. System Supplier shall conduct training courses for personnel selected by Owner. Training shall be provided in the following categories: instrument, control system maintenance, operator (pre-installation), operator (post-installation), programmer (HMI software), programmer (PLC software), networking, and supplemental shall be provided. Training shall be conducted by experienced instructors who are familiar with the specific system supplied.

3-5.01. General Training Requirements. Training requirements shall be in accordance with the Demonstration and Training section.

3-5.01.01. Training Costs. All costs associated with the training program; excluding travel, lodging, and per diem expenses for Owner's and Design-Builder's personnel to attend off-site training programs; shall be the responsibility of System Supplier and shall be included in the contract price.

3-5.02. Instrument Training. Training on the calibration, maintenance, troubleshooting, and repair for the instrument devices provided under this project shall be provided. Training shall also be provided for any hand-held or computer-based calibration devices and their associated software.

3-5.03. Control System Maintenance Training. System maintenance training shall be provided to enable Owner's personnel to perform routine and preventive maintenance, troubleshoot, and repair all hardware furnished with the system, except equipment provided by the HMI computer manufacturer. Maintenance and repair instruction shall assume that Owner's personnel will repair equipment by replacing circuit boards and modules, and shall not include instruction on circuit board level repair.

3-5.04. Operator Training. Owner's personnel will utilize the system for day-to-day monitoring and/or control of the facilities. The training program shall provide operators with sufficient knowledge to move from screen to screen within the system, understand the contents of group and detailed point displays, react to and acknowledge alarms, adjust control setpoints and alarm limits, configure and print shift reports, print preconfigured reports on demand, control equipment connected to the system, and react to and resolve minor system errors.

3-5.04.01. Classes. Operator training shall include sessions as specified below.

3-5.04.01.01. Pre-installation Session. Each pre-installation training session shall consist of 8 hours of training for 10 students at the System Supplier's facility 8 hours training for 10 students at the Owner's facility.

3-5.04.01.02. Post-installation Session. The post-installation training shall include three separate, but identical, sessions for three shifts of personnel and shall be conducted at Owner's facilities. Each class shall consist of 8 hours of instruction using the lesson plan submitted and approved for use. The post-installation sessions may have to be conducted outside normal working hours to accommodate the working schedule of Owner's personnel. The post-installation training sessions shall be conducted for 10 of the Owner's operating personnel .

3-5.04.02. Content of Classes. Each session shall cover at least the following topics.

a. Power-up, "bootstrapping", and shutdown of all hardware devices.
b. Logging on and off the system and the use of passwords.
c. Access and interpretation of standard displays and diagnostics.
d. Use and care of operator workstations, servers, video displays, printers, and other control room hardware, including replenishment of supplies and replacement of ribbons and ink cartridges.
e. Moving from screen to screen within the graphic display environment.
f. Interpretation of preconfigured group and detailed point or database displays.
g. Response to and acknowledgment of alarms.

h. Adjustment of control set points and alarm limits.

i. Configuration and printing of shift and other reports by schedule or on demand.

j. Control of field equipment and devices connected to the system.

k. Manual entries to database points.

l. Generation of current (real-time) and historical custom and predefined reports and trend displays.

m. Appropriate responses to software and hardware errors.

n. Enabling and disabling individual inputs and outputs.

The operator-training program shall be developed for personnel with no prior experience with the hardware and software provided as part of the project.

3-5.05. Programmer Training (HMI Software). Programmer training shall be furnished as described in this section.

System programming training shall be provided to enable Owner's and Design-Builder's personnel to initially configure and later reconfigure the system. Programming tasks shall include addition or modification to the system database; modification or creation of graphic and tabular display and report formats; and creation and modification of historical archiving groups and data reduction algorithms.

3-5.05.01. Classes. Programmer training shall be conducted in two sessions. The first session shall consist of 8 hours of instruction for 4 students and shall be conducted at Owner's facilities within 30 days of delivery of the configuration hardware and software. The second session shall consist of 8 hours of instruction for 4 students and shall be conducted at Owner's facility.

3-5.05.02. Content of Classes. Programmer training shall include, but shall not be limited to the following topics:

a. Loading of any supplied software into the system.

b. Use of basic operating system commands for file management, system startup, and creation and editing of batch files.

c. Creation and editing of database.

d. Configuration of printed report formats.

e. Creation and editing of tabular and graphic HMI interface display screens.

f. Diagnostic routines.

g. Creation and modification of control algorithms.

h. Addition of new I/O points and new PLCs to the system.

i. Historical record retrieval, data reduction, archiving, and disk housekeeping.

j. System backup procedures and reloading from backup.

Programmer training shall be designed for personnel who have a general familiarity with control system operation and high-level application programs, but not necessarily with the specific hardware or software furnished for this project.

3-5.05.03. Hardware and Software. The first session of training shall be conducted using hardware and software of the same versions as provided for the system specified. Programmer training for the second session shall be conducted using equipment and software installed at the site.

3-5.06. Programmer Training (PLC Software). Programmer training shall be provided for the PLC software furnished. Programmer training shall be provided on at least the following topics:

a. File management and backup procedures.

b. Documentation printing options.

c. Entering I/O and database points.

d. Logic function programming.

e. PID (Proportional-Integral-Derivative) loop programming and tuning.

f. Error recovery and interpretation of errors.

g. Communication protocol set-up and diagnostics.

PLC software programmer training shall be conducted at the Owner's facilities within 30 days of delivery of PLCs.

3-5.06.01. Programmer Training (OIT Software). Programmer training shall be provided for the OIT software furnished. Programmer training shall be provided on at least the following topics:

a. Loading of any supplied software into the system.

b. Use of basic operating system commands for file management and OIT startup.

c. Creation and editing of database.

d. Creation and editing of tabular and graphic OIT display screens.

e. Alarm creation, annunciation, reset and logging.

f. Addition of new I/O points to the system.

g. Diagnostic routines.

h. Communication protocol set-up.

i. System backup procedures and reloading from backup.

3-5.07. Network Training. System Supplier shall provide training on network equipment provided. Network training shall be conducted in one session at Owner's facilities using the hardware and software installed for this project.

a. Course shall provide an overall description of the network and how it operates.

b. A one hour course (for each make/model of switch, router, and firewall) on configuration shall be provided for up to five people. This instruction shall be aimed at a network administrator's level of understanding, and shall be provided by the individual that configured the devices. The course shall review the configuration settings. Course training material shall be vendor provided equipment manuals.

c. A one hour course on the use of the management software shall be provided for up to five people. This instruction shall be aimed at a network administrator's level of understanding, and shall be provided by the individual that configured the software. Course training material shall be vendor provided software manuals.

d. Training shall be provided on the use of any Network Test Equipment provided. Course training material shall be vendor provided equipment manuals.

e. Training on network diagnostics of PLCs, HMIs and Ethernet switches.

The training shall provide instruction for up to 5 Owner-selected students.

3-5.08. Supplemental Training. Not used.

End of Section

INSTRUMENT NAME & SERVICE:		
BRAND & MODEL NO.:		
TAG OR LOOP NO.:		
INPUT/OUTPUT RANGE:		
INPUT	ACTUAL OUTPUT	DESIRED OUTPUT
PROPORTIONAL BAND:		
RESET:		
POSITION OF SWITCHES, JUMPERS, ETC.		
COMMENTS:		
DATE OF CALIBRATION: CALIBRATED BY:		
Black & Veatch	INSTRUMENT CALIBRATION REPORT	Figure 1-40 61 11

INSTRUMENT DEVICE SCHEDULE - MORRO BAY WRF

Instrument Device Schedule - Legend/Description Sheet

Item. This is an arbitrary sequential number which is for reference only.
Area Code. This relates to the area of the plant the equipment is located
System Code. This is the abbrevation for each system
Tag. This is the ISA (or similar) alpha tag representing the function of the instrument.
Service Description. This is the description of the instrument service.
Device Type & Size. This is the instrument device type and should match the description as listed in the specification. Where appropriate, the size of the device (such as diameter of flowmeters) will be listed.
Output Type. This generally will be '4-20 mA' or "Dry Contact'. It could also be a serial output for smart devices (such as HART or FLD-BUS) but only if the serial output is the primary I/O interface.
Output Range. This is the calibrated range for analog devices or the trip point(s) for discrete devices.
Power Type. This will typically be either '2-wire' for loop powered devices or '4-wire' for 120 volt powered devices.
Install Detail. This is a reference to the installation detail on the drawings if applicable.
P&ID Drawing. This is the drawing number of the P&ID where the device is shown.
Spec. This column may include a cross reference to another specification section where applicable or to a note which provides additional information. Notes are appended to the end of the device schedule listings.

Item	Tag	Service Description	Device Type	Size	Output Type	Output Range	Power Type	P&ID Drawing	Specification	Remarks
1	21-SCR-FIT-0101	INFLUENT MAIN 1 FLOW	FLOW INDICATING TRANSMITTER	12"	4-20 mA DC		24VDC	21-I-001	40 71 00	
2	21-SCR-FIT-0201	INFLUENT MAIN 2 FLOW	FLOW INDICATING TRANSMITTER	8"	4-20 mA DC		24VDC	21-I-001	40 71 00	
3	21-SCR-FIT-0301	PLANT DRAIN SYSTEM DUPLEX PUMPS	FLOW INDICATING TRANSMITTER	4"	4-20 mA DC		24VDC	21-I-001	40 71 00	
4	21-SCR-LDIT-1001	COARSE SCREEN NO 1 DIFFERENTIAL LEVEL TRANSMITTER	DIFFERENTIAL LEVEL TRANSMITTER	N/A	4-20 mA DC		24VDC	21-I-001	40 72 00	VENDOR SUPPLY
5	21-SCR-LDSH-1001	COARSE SCREEN NO 1 DIFFERENTIAL LEVEL SWITCH	DIFFERENTIAL LEVEL SWITCH	N/A	DRY CONTACT		N/A	21-I-001	40 72 00	VENDOR SUPPLY
6	21-SCR-LE-1001	COARSE SCREEN NO 1 US LEVEL SENSOR A	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	21-I-001	40 72 00	VENDOR SUPPLY
7	21-SCR-LE-1001	COARSE SCREEN NO 1 US LEVEL SENSOR B	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	21-I-001	40 72 00	VENDOR SUPPLY
8	21-SCR-LSHH-1001	COARSE SCREEN NO 1 HIGH HIGH LEVEL SWITCH	LEVEL SWITCH HIGH-HIGH	N/A	DRY CONTACT		N/A	21-I-001	40 72 00	VENDOR SUPPLY
9	21-GRT-PG-1001	TRAIN 1 GRIT PUMP DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	21-I-001	40 73 12	VENDOR SUPPLY
10	21-NPW-PSL-1001	TRAIN 1 PLANT WATER SYSTEM HEADER LOW PRESSURE	PRESSURE SWITCH		DRY CONTACT		N/A	21-I-001	40 72 00	VENDOR SUPPLY
11	21-SCR-PSL-1001		PRESSURE SWITCH		DRY CONTACT		N/A	21-I-001	40 72 00	
12	21-SCR-WSH-1001	COARSE SCREEN NO 1 TORQUE SWITCH	TORQUE SWITCH	N/A	DRY CONTACT		N/A	21-I-001		VENDOR SUPPLY
13	21-SCR-LDIT-2001	COARSE SCREEN NO 2 DIFFERENTIAL LEVEL TRANSMITTER	DIFFERENTIAL LEVEL TRANSMITTER	N/A	4-20 mA DC		24VDC	21-I-002	40 72 00	VENDOR SUPPLY
14	21-SCR-LDSH-2001	COARSE SCREEN NO 2 DIFFERENTIAL LEVEL SWITCH	DIFFERENTIAL LEVEL SWITCH	N/A	DRY CONTACT		N/A	21-I-002	40 72 00	VENDOR SUPPLY
15	21-SCR-LE-2001	COARSE SCREEN NO 1 US LEVEL SENSOR A	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	21-I-002	40 72 00	VENDOR SUPPLY
16	21-SCR-LE-2001	COARSE SCREEN NO 1 US LEVEL SENSOR B	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	21-I-002	40 72 00	VENDOR SUPPLY
17	21-SCR-LSHH-2001	COARSE SCREEN NO 2 HIGH HIGH LEVEL SWITCH	LEVEL SWITCH HIGH-HIGH	N/A	DRY CONTACT		N/A	21-I-002	40 72 00	VENDOR SUPPLY
18	21-GRT-PG-2001	TRAIN 2 GRIT PUMP DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	21-I-002	40 73 12	VENDOR SUPPLY
19	21-NPW-PSL-2001	TRAIN 2 PLANT WATER SYSTEM HEADER LOW PRESSURE	PRESSURE SWITCH		DRY CONTACT		N/A	21-I-002	40 72 00	VENDOR SUPPLY
20	21-SCR-PSL-2001		PRESSURE SWITCH		DRY CONTACT		N/A	21-I-002	40 72 00	
21	21-SCR-WSH-2001	COARSE SCREEN NO 2 TORQUE SWITCH	TORQUE SWITCH	N/A	DRY CONTACT		N/A	21-I-002		VENDOR SUPPLY
22	22-SCR-FIT-1001	FINE SCREEN INLET HEADER FLOW	FLOW INDICATING TRANSMITTER	8"	4-20 mA DC		24VDC	22-I-001	40 71 00	
23	22-SCR-LDIT-1001	FINE SCREEN NO 1 DIFFERENTIAL LEVEL TRANSMITTER	DIFFERENTIAL LEVEL TRANSMITTER	N/A	4-20 mA DC		24VDC	22-I-001	40 72 00	VENDOR SUPPLY
24	22-SCR-LDIT-2001	FINE SCREEN NO 2 DIFFERENTIAL LEVEL TRANSMITTER	DIFFERENTIAL LEVEL TRANSMITTER	N/A	4-20 mA DC		24VDC	22-I-001	40 72 00	VENDOR SUPPLY
25	22-SCR-LE-0001	SAFE DIVERSION BOX US LEVEL SENSOR	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	22-I-001	40 72 00	
26	22-SCR-LE-1001A	FINE SCREEN NO 1 US LEVEL SENSOR A	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	22-I-001	40 72 00	VENDOR SUPPLY
27	22-SCR-LE-1001B	FINE SCREEN NO 1 US LEVEL SENSOR B	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	22-I-001	40 72 00	VENDOR SUPPLY
28	22-SCR-LE-2001A	FINE SCREEN NO 2 US LEVEL SENSOR A	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	22-I-001	40 72 00	VENDOR SUPPLY
29	22-SCR-LE-2001B	FINE SCREEN NO 2 US LEVEL SENSOR B	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	22-I-001	40 72 00	VENDOR SUPPLY
30	22-SCR-LIT-0001	SAFE DIVERSION BOX LEVEL TRANSMITTER	LEVEL INDICATING TRANSMITTER	N/A	4-20 mA DC		24VDC	22-I-001	40 72 00	
31	22-PRW-PSL-1001	FINE SCREEN 1 PLANT WATER SYSTEM HEADER LOW PRESSURE	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	22-I-001	40 72 00	VENDOR SUPPLY
32	22-PRW-PSL-2001	FINE SCREEN 2 PLANT WATER SYSTEM HEADER LOW PRESSURE	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	22-I-001	40 72 00	VENDOR SUPPLY
33	23-ODC-PDIT-0001	ODOR CONTROL PRE-FILTER DIFFERENTIAL PRESSURE	DIFFERENTIAL PRESSURE INDICATING TRANSMITTER	N/A	4-20 mA DC		2-WIRE	23-I-001	40 72 00	VENDOR SUPPLY
34	23-ODC-PDIT-0002	ODOR CONTROL UNIT DIFFERENTIAL PRESSURE	DIFFERENTIAL PRESSURE INDICATING TRANSMITTER	N/A	4-20 mA DC		2-WIRE	23-I-001	40 72 00	VENDOR SUPPLY
35	31-BNR-AE-0001	BNR SPLITTER BOX pH LEVEL	pH SENSOR	N/A	mV	SEE AIT	N/A	31-I-001	40 75 00	
36	31-BNR-AE-1001	BASIN 1 ANOXIC AREA OXYGEN REDUCTION POTENTIAL	OXYGEN REDUCTION POTENTIAL SENSOR	N/A	mV	SEE AIT	N/A	31-I-001	40 75 00	
37	31-BNR-AE-1002	AERATION BASIN 1 MLSS CONTENT	MIXED LIQUOR SUSPENDED SOLIDS SENSOR	N/A	mV	SEE AIT	N/A	31-I-001	40 75 00	
38	31-BNR-AE-1003	AERATION BASIN 1 AMMONIA/AMMONIUM CONTENT	AMMONIA/AMMONIUM SENSOR	N/A	mV	SEE AIT	N/A	31-I-001	40 75 00	
39	31-BNR-AE-1101	AERATION BASIN 1 DISSOLVED OXYGEN CONTENT	DISSOLVED OXYGEN SENSOR	N/A	mV	SEE AIT	N/A	31-I-001	40 75 00	VENDOR SUPPLY
40	31-BNR-AE-1101		CONDUCTIVITY SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
41	31-BNR-AE-1101		TOTAL CHLORINE SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
42	31-BNR-AE-1101		pH SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
43	31-BNR-AE-1101		ULTRAVIOLET TRANSMITTANCE		mV	SEE AIT	N/A	31-I-001	40 75 00	
44	31-BNR-AE-1101		MONO-CHLORIMINE/AMMONIA SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
45	31-BNR-AE-1101		AMMONIA SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
46	31-BNR-AE-1101		AMMONIA/AMMONIUM SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
47	31-BNR-AE-1101		DISSOLVED OXYGEN SENSOR	N/A	mV	SEE AIT	N/A	31-I-001	40 75 00	VENDOR SUPPLY
48	31-BNR-AE-1101		TURBIDITY SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
49	31-BNR-AE-1101		OXYGEN REDUCTION POTENTIAL SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
50	31-BNR-AE-1101		FREE CHLORINE SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
51	31-BNR-AE-1101		TOTAL SUSPENDED SOLIDS SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
52	31-BNR-AE-1101		MIXED LIQUOR SUSPENDED SOLIDS SENSOR		mV	SEE AIT	N/A	31-I-001	40 75 00	
53	31-BNR-AE-1201	AERATION BASIN 1 DISSOLVED OXYGEN CONTENT	DISSOLVED OXYGEN SENSOR	N/A	mV	SEE AIT	N/A	31-I-001	40 75 00	VENDOR SUPPLY
54	31-BNR-AE-2001	BASIN 2 ANOXIC AREA OXYGEN REDUCTION POTENTIAL	OXYGEN REDUCTION POTENTIAL SENSOR	N/A	mV	SEE AIT	N/A	31-I-002	40 75 00	
55	31-BNR-AE-2002	AERATION BASIN 2 MLSS CONTENT	MIXED LIQUOR SUSPENDED SOLIDS SENSOR	N/A	mV	SEE AIT	N/A	31-I-002	40 75 00	
56	31-BNR-AE-2003	AERATION BASIN 2 AMMONIA/AMMONIUM CONTENT	AMMONIA/AMMONIUM SENSOR	N/A	mV	SEE AIT	N/A	31-I-002	40 75 00	
57	31-BNR-AE-2101	AERATION BASIN 2 DISSOLVED OXYGEN CONTENT	DISSOLVED OXYGEN SENSOR	N/A	mV	SEE AIT	N/A	31-I-002	40 75 00	VENDOR SUPPLY
58	31-BNR-AE-2201	AERATION BASIN 2 DISSOLVED OXYGEN CONTENT	DISSOLVED OXYGEN SENSOR	N/A	mV	SEE AIT	N/A	31-I-002	40 75 00	VENDOR SUPPLY
59	31-RAS-AE-0001	RAS DEOX AREA TOTAL SUSPENDED SOLIDS CONTENT	TOTAL SUSPENDED SOLIDS SENSOR	N/A	mV	SEE AIT	N/A	31-I-001	40 75 00	
60	31-BNR-AIT-0001	BNR SPLITTER BOX pH LEVEL	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 75 00	
61	31-BNR-AIT-1001	BASIN 1 ANOXIC AREA OXYGEN REDUCTION POTENTIAL	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 75 00	
62	31-BNR-AIT-1002	AERATION BASIN 1 MLSS CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 75 00	
63	31-BNR-AIT-1003	AERATION BASIN 1 AMMONIA/AMMONIUM CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 75 00	
64	31-BNR-AIT-1101	AERATION BASIN 1 DISSOLVED OXYGEN CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 75 00	VENDOR SUPPLY
65	31-BNR-AIT-1201	AERATION BASIN 1 DISSOLVED OXYGEN CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 75 00	VENDOR SUPPLY
66	31-BNR-AIT-2001	BASIN 2 ANOXIC AREA OXYGEN REDUCTION POTENTIAL	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-002	40 75 00	
67	31-BNR-AIT-2002	AERATION BASIN 2 MLSS CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-002	40 75 00	
68	31-BNR-AIT-2003	AERATION BASIN 2 AMMONIA/AMMONIUM CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-002	40 75 00	
69	31-BNR-AIT-2101	AERATION BASIN 2 DISSOLVED OXYGEN CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-002	40 75 00	VENDOR SUPPLY
70	31-BNR-AIT-2201	AERATION BASIN 2 DISSOLVED OXYGEN CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-002	40 75 00	VENDOR SUPPLY
71	31-RAS-AIT-0001	RAS DEOX AREA TOTAL SUSPENDED SOLIDS CONTENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 75 00	
72	31-AER-FIT-1101	BLOWERS TO AERATION BASIN 1 DIFFUSERS AIR FLOW (THERMAL DISPERSI	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 71 00	VENDOR SUPPLY
73	31-AER-FIT-1201	BLOWERS TO AERATION BASIN 1 DIFFUSERS AIR FLOW (THERMAL DISPERSI	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 71 00	VENDOR SUPPLY
74	31-AER-FIT-2101	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR FLOW (THERMAL DISPERSI	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-002	40 71 00	VENDOR SUPPLY
75	31-AER-FIT-2201	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR FLOW (THERMAL DISPERSI	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-002	40 71 00	VENDOR SUPPLY
76	31-WAS-FIT-0001	MBR RAS TO SCUM/WAS PUMPS HEADER FLOW (MAGNETIC TYPE)	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-003	40 71 00	

INSTRUMENT DEVICE SCHEDULE - MORRO BAY WRF

Item	Tag	Service Description	Device Type	Size	Output Type	Output Range	Power Type	P&ID Drawing	Specification	Remarks
77	31-WAS-LE-0001	SCUM/WAS WETWELL LEVEL (RADAR TYPE)	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	31-I-003	40 72 00	
78	31-BNR-MSH-1001	BASIN 1 MBR FEED PUMP MOTOR LEAK DETECTION	MOISTURE DETECTION SWITCH	N/A	DRY CONTACT	N/A	N/A	31-I-001		
79	31-BNR-TSH-1001	BASIN 1 MBR FEED PUMP MOTOR WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	31-I-001	40 74 00	
80	31-BNR-MSH-2001	BASIN 2 ANOXIC MIXER MOTOR LEAK DETECTION	MOISTURE DETECTION SWITCH	N/A	DRY CONTACT	N/A	N/A	31-I-002		
81	31-BNR-MSH-2001	BASIN 2 MBR FEED PUMP MOTOR LEAK DETECTION	MOISTURE DETECTION SWITCH	N/A	DRY CONTACT	SEE AIT	N/A	31-I-002		
82	31-BNR-TSH-2001	BASIN 2 ANOXIC MIXER MOTOR WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	31-I-002	40 74 00	
83	31-WAS-LIT-0001	SCUM/WAS WETWELL LEVEL (RADAR TYPE)	LEVEL INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-003	40 72 00	
84	31-BNR-TSH-2001	BASIN 2 MBR FEED PUMP MOTOR WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT	SEE AIT	N/A	31-I-002	40 74 00	
85	31-WAS-LSHH-0001	SCUM/WAS WETWELL LEVEL HIGH HIGH	LEVEL SWITCH HIGH-HIGH	N/A	DRY CONTACT		N/A	31-I-003	40 72 00	
86	31-WAS-LSLL-0001	SCUM/WAS WETWELL LEVEL LOW LOW	LEVEL SWITCH LOW-LOW	N/A	DRY CONTACT		N/A	31-I-003	40 72 00	
87	31-SCM-PG-0001	SCUM PUMP SUCTION PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-003	40 73 12	
88	31-BNR-MSH-0001	BASIN 1 ANOXIC MIXER MOTOR LEAK DETECTION	MOISTURE DETECTION SWITCH	N/A	DRY CONTACT	SEE AIT	N/A	31-I-001		
89	31-RAS-MSH-0001	RAS DEOX MIXER MOTOR LEAK DETECTION	MOISTURE DETECTION SWITCH	N/A	DRY CONTACT	SEE AIT	N/A	31-I-001		
90	31-BNR-ZSC-1001	BASIN 1 MBR FEED PUMP OUTLET VALVE CLOSED	LIMIT SWITCH	N/A	DRY CONTACT	N/A	N/A	31-I-001	40 05 57	
91	31-AER-PDI-0101	DRY SCREW PROCESS AIR BLOWER NO. 1 INLET DIFFERENTIAL PRESSURE	DIFFERENTIAL PRESSURE INDICATOR	N/A	?			31-I-004		VENDOR SUPPLY
92	31-AER-PDI-0201	DRY SCREW PROCESS AIR BLOWER NO. 2 INLET DIFFERENTIAL PRESSURE	DIFFERENTIAL PRESSURE INDICATOR	N/A	?			31-I-004		VENDOR SUPPLY
93	31-AER-PDI-0301	DRY SCREW PROCESS AIR BLOWER NO. 2 INLET DIFFERENTIAL PRESSURE	DIFFERENTIAL PRESSURE INDICATOR	N/A	?			31-I-004		VENDOR SUPPLY
94	31-AER-PDSH-0101	DRY SCREW PROCESS AIR BLOWER NO. 1 INLET DIFFERENTIAL PRESSURE H	DIFFERENTIAL PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	31-I-004	40 72 00	VENDOR SUPPLY
95	31-AER-PDSH-0201	DRY SCREW PROCESS AIR BLOWER NO. 2 INLET DIFFERENTIAL PRESSURE H	DIFFERENTIAL PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	31-I-004	40 72 00	VENDOR SUPPLY
96	31-AER-PDSH-0301	DRY SCREW PROCESS AIR BLOWER NO. 3 INLET DIFFERENTIAL PRESSURE H	DIFFERENTIAL PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	31-I-004	40 72 00	VENDOR SUPPLY
97	31-AER-PG-0101	DRY SCREW PROCESS AIR BLOWER NO. 1 OUTLET PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-004	40 73 12	VENDOR SUPPLY
98	31-AER-PG-201	DRY SCREW PROCESS AIR BLOWER NO. 2 OUTLET PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-004	40 73 12	VENDOR SUPPLY
99	31-AER-PG-0302	DRY SCREW PROCESS AIR BLOWER NO. 3 OUTLET PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-004	40 73 12	VENDOR SUPPLY
100	31-WAS-PG-0001	WAS PUMP SUCTION PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-003	40 73 12	
101	31-SCM-PSL-0001	SCUM PUMP SUCTION PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	31-I-003	40 72 00	
102	31-WAS-PSL-0001	WAS PUMP SUCTION PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	31-I-003	40 72 00	
103	31-WAS-FIT-0002	SCUM/WAS PUMPS OUTLET HEADER FLOW (MAGNETIC TYPE)	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-003	40 71 00	
104	31-AER-PIT-0001	DRY SCREW PROCESS AIR BLOWERS COMMON HEADER LINE PRESSURE	PRESSURE INDICATING TRANSMITTER	N/A	4-20 mA DC		2-WIRE	31-I-004	40 72 00	VENDOR SUPPLY
105	31-AER-PSH-0101	DRY SCREW PROCESS AIR BLOWER NO. 1 OUTLET PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	31-I-004	40 72 00	VENDOR SUPPLY
106	31-AER-PSH-201	DRY SCREW PROCESS AIR BLOWER NO. 2 OUTLET PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	31-I-004	40 72 00	VENDOR SUPPLY
107	31-AER-PSH-0302	DRY SCREW PROCESS AIR BLOWER NO. 3 OUTLET PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	31-I-004	40 72 00	VENDOR SUPPLY
108	31-WAS-PG-0002	SCUM PUMP DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-003	40 73 12	
109	31-WAS-PG-0002	WAS PUMP DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-003	40 73 12	
110	31-WAS-PSH-0002	SCUM PUMP DISCHARGE PRESSURE HIGH	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	31-I-003	40 72 00	
111	31-WAS-PSH-0002	WAS PUMP DISCHARGE PRESSURE HIGH	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	31-I-003	40 72 00	
112	31-AER-TG-0101	DRY SCREW PROCESS AIR BLOWER NO. 1 OUTLET TEMP	TEMPERATURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-004	40 74 00	VENDOR SUPPLY
113	31-AER-TG-0201	DRY SCREW PROCESS AIR BLOWER NO. 2 OUTLET TEMP	TEMPERATURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-004	40 74 00	VENDOR SUPPLY
114	31-AER-TG-0301	DRY SCREW PROCESS AIR BLOWER NO. 3 OUTLET TEMP	TEMPERATURE GAUGE	4-1/2"	N/A	N/A	N/A	31-I-004	40 74 00	VENDOR SUPPLY
115	31-AER-TSH-0101	DRY SCREW PROCESS AIR BLOWER NO. 1 OUTLET TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	31-I-004	40 74 00	VENDOR SUPPLY
116	31-AER-TSH-0201	DRY SCREW PROCESS AIR BLOWER NO. 2 OUTLET TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	31-I-004	40 74 00	VENDOR SUPPLY
117	31-AER-TSH-0301	DRY SCREW PROCESS AIR BLOWER NO. 3 OUTLET TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	31-I-004	40 74 00	VENDOR SUPPLY
118	31-BNR-TSH-0001	BASIN 1 ANOXIC MIXER MOTOR WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT	SEE AIT	N/A	31-I-001	40 74 00	
119	31-RAS-TSH-0001	RAS DEOX MIXER MOTOR WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT	SEE AIT	N/A	31-I-001	40 74 00	
120	31-MEM-LE-1001	BASIN 1 MIXED LIQUOR COLLECTION CHANNEL LEVEL (ULTRASONIC TYPE)	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	31-I-001	40 72 00	
121	31-MEM-LIT-1001	BASIN 1 MIXED LIQUOR COLLECTION CHANNEL LEVEL (ULTRASONIC TYPE)	LEVEL INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-001	40 72 00	
122	31-MEM-LE-2001	BASIN 2 MIXED LIQUOR COLLECTION CHANNEL LEVEL (ULTRASONIC TYPE)	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	31-I-002	40 72 00	
123	31-MEM-LIT-2001	BASIN 2 MIXED LIQUOR COLLECTION CHANNEL LEVEL (ULTRASONIC TYPE)	LEVEL INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	31-I-002	40 72 00	
124	32-MEM-AE-0001	RO FEED TANK INLET HEADER NH3 MEASUREMENT	NH3 SENSOR	N/A	mV	SEE AIT	N/A	32-I-005	40 75 00	VENDOR SUPPLY
125	32-MEM-AE-0002	RO FEED TANK INLET HEADER TURBIDITY MEASUREMENT	TURBIDITY SENSOR	N/A	mV	SEE AIT	N/A	32-I-005	40 75 00	VENDOR SUPPLY
126	32-MEM-AE-1001	FILTRATE PUMP NO. 1 OUTLET TURBIDITY MEASUREMENT	TURBIDITY SENSOR	N/A	mV	SEE AIT	N/A	32-I-003	40 75 00	VENDOR SUPPLY
127	32-MEM-AIT-1001	FILTRATE PUMP NO. 1 OUTLET TURBIDITY MEASUREMENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-003	40 75 00	VENDOR SUPPLY
128	32-MEM-AIT-0001	RO FEED TANK INLET HEADER NH3 MEASUREMENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-005	40 75 00	VENDOR SUPPLY
129	32-MEM-AIT-0002	RO FEED TANK INLET HEADER TURBIDITY MEASUREMENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-005	40 75 00	VENDOR SUPPLY
130	32-MEM-FIT-1001	FILTRATE PUMP NO. 1 OUTLET FLOW (MAGNETIC TYPE)	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-003	40 71 00	VENDOR SUPPLY
131	32-MEM-PG-1001	FILTRATE PUMP NO. 1 SUCTION PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-003	40 73 12	VENDOR SUPPLY
132	32-AIR-FIT-0001	ROTARY LOBE MEMBRANE SCOUR BLOWERS COMMON OUTLET HEADER F	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-006	40 71 00	
133	32-DRN-FIT-0001	DRAIN PUMP OUTLET FLOW (MAGNETIC TYPE)	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-007	40 71 00	VENDOR SUPPLY
134	32-MEM-PIT-1001	FILTRATE PUMP NO. 1 INLET HEADER PRESSURE	PRESSURE INDICATING TRANSMITTER	N/A	4-20 mA DC		2-WIRE	32-I-003	40 72 00	VENDOR SUPPLY
135	32-MEM-PSH-1001	FILTRATE PUMP NO. 1 SUCTION PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-003	40 72 00	VENDOR SUPPLY
136	32-RAS-FIT-1001	RAS COLLECTION CHANNEL NO. 1 TO RAS DEOX FLOW (MAGNETIC TYPE TY	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-001	40 71 00	
137	32-AIR-FSL-0101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 OUTLET FLOW LOW	FLOW SWITCH LOW	N/A	DRY CONTACT	N/A	N/A	32-I-006	40 71 00	VENDOR SUPPLY
138	32-AIR-PDI-0101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 INLET DIFFERENTIAL PRS	DIFFERENTIAL PRESSURE INDICATOR	N/A	?		N/A	32-I-006		VENDOR SUPPLY
139	32-MEM-PSL-1001	FILTRATE PUMP NO. 1 SUCTION PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	32-I-003	40 72 00	VENDOR SUPPLY
140	32-MEM-TSH-1001	FILTRATE PUMP NO. 1 MORO WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	32-I-003	40 74 00	VENDOR SUPPLY
141	32-MEM-PG-1002	FILTRATE PUMP NO. 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-003	40 73 12	VENDOR SUPPLY
142	32-MEM-PSH-1002	FILTRATE PUMP NO. 1 DISCHARGE PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-003	40 72 00	VENDOR SUPPLY
143	32-MEM-LE-1001	MEMBRANE BASIN 1 LEVEL (ULTRASONIC TYPE)	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	32-I-001	40 72 00	VENDOR SUPPLY
144	32-MEM-LE-1001		PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	32-I-001	40 72 00	
145	32-MEM-LE-1001		PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	32-I-001	40 72 00	
146	32-MEM-LIT-1001	MEMBRANE BASIN 1 LEVEL (ULTRASONIC TYPE)	LEVEL INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-001	40 72 00	VENDOR SUPPLY
147	32-MEM-LSHH-1001	MEMBRANE BASIN 1 LEVEL HIGH HIGH	LEVEL SWITCH HIGH-HIGH	N/A	DRY CONTACT		N/A	32-I-001	40 72 00	VENDOR SUPPLY
148	32-MEM-LSLL-1001	MEMBRANE BASIN 1 LEVEL LOW LOW	LEVEL SWITCH LOW-LOW	N/A	DRY CONTACT		N/A	32-I-001	40 72 00	VENDOR SUPPLY
149	32-MEM-LE-1002	RAS COLLECTION CHANNEL NO. 1 LEVEL (ULTRASONIC TYPE)	PRIMARY LEVEL ELEMENT/SENSOR	N/A	mV	SEE LIT	N/A	32-I-001	40 72 00	
150	32-MEM-LIT-1002	RAS COLLECTION CHANNEL NO. 1 LEVEL (ULTRASONIC TYPE)	LEVEL INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-001	40 72 00	
151	32-MEM-LSHH-1002	MEMBRANE BASIN 1 LEVEL HIGH HIGH	LEVEL SWITCH HIGH-HIGH	N/A	DRY CONTACT		N/A	32-I-001	40 72 00	VENDOR SUPPLY
152	32-MEM-LE-2001	MEMBRANE BASIN 2 LEVEL (ULTRASONIC TYPE)	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	32-I-002	40 72 00	VENDOR SUPPLY
153	32-MEM-LE-2001		PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	32-I-002	40 72 00	
154	32-MEM-LE-2001		PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	32-I-002	40 72 00	
155	32-MEM-LIT-2001	MEMBRANE BASIN 2 LEVEL (ULTRASONIC TYPE)	LEVEL INDICATING TRANSMITTER		4-20 mA DC		4-WIRE	32-I-002	40 72 00	VENDOR SUPPLY
156	32-MEM-LSHH-2001	MEMBRANE BASIN 2 LEVEL HIGH HIGH	LEVEL SWITCH HIGH-HIGH		DRY CONTACT		N/A	32-I-002	40 72 00	VENDOR SUPPLY
157	32-MEM-LSLL-2001	MEMBRANE BASIN 2 LEVEL LOW LOW	LEVEL SWITCH LOW-LOW		DRY CONTACT		N/A	32-I-002	40 72 00	VENDOR SUPPLY
158	32-MEM-LE-2002	RAS COLLECTION CHANNEL NO. 2 LEVEL (ULTRASONIC TYPE)	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	32-I-002	40 72 00	VENDOR SUPPLY
159	32-MEM-LIT-2002	RAS COLLECTION CHANNEL NO. 2 LEVEL (ULTRASONIC TYPE)	LEVEL INDICATING TRANSMITTER		4-20 mA DC		4-WIRE	32-I-002	40 72 00	VENDOR SUPPLY
160	32-MEM-LSHH-2002	MEMBRANE BASIN 2 LEVEL HIGH HIGH	LEVEL SWITCH HIGH-HIGH		DRY CONTACT		N/A	32-I-002	40 72 00	VENDOR SUPPLY
161	32-AIR-PDSH-0101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 INLET DIFFERENTIAL PRS	DIFFERENTIAL PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-006	40 72 00	VENDOR SUPPLY
162	32-AIR-PG-0101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 SUCTION PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-006	40 73 12	VENDOR SUPPLY
163	32-AIR-TG-0101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 OUTLET TEMP	TEMPERATURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-006	40 74 00	VENDOR SUPPLY
164	32-AIR-TSH-0101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 OUTLET TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	32-I-006	40 74 00	VENDOR SUPPLY
165	32-AIR-PG-0102	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-006	40 73 12	VENDOR SUPPLY
166	32-AIR-PSH-0102	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 DISCHARGE PRESSURE H	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-006	40 72 00	VENDOR SUPPLY

Schedule 40 61 11A

INSTRUMENT DEVICE SCHEDULE - MORRO BAY WRF

Item	Tag	Service Description	Device Type	Size	Output Type	Output Range	Power Type	P&ID Drawing	Specification	Remarks
167	32-AIR-FSL-0201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 OUTLET FLOW LOW	FLOW SWITCH LOW	N/A	DRY CONTACT	N/A	N/A	32-I-006	40 71 00	VENDOR SUPPLY
168	32-AIR-PDI-0201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 INLET DIFFERENTIAL PRE	DIFFERENTIAL PRESSURE INDICATOR	N/A	?		N/A	32-I-006		VENDOR SUPPLY
169	32-DRN-PG-0001	DRAIN PUMP SUCTION PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-007	40 73 12	VENDOR SUPPLY
170	32-DRN-PG-0002	DRAIN PUMP DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-007	40 73 12	VENDOR SUPPLY
171	32-MEM-PSL-1002	FILTRATE PUMP NO. 1 DISCHARGE PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	32-I-003	40 72 00	VENDOR SUPPLY
172	32-AIR-PIT-0001	ROTARY LOBE MEMBRANE SCOUR BLOWERS COMMON OUTLET HEADER P	PRESSURE INDICATING TRANSMITTER		4-20 mA DC		2-WIRE	32-I-006	40 72 00	
173	32-AIR-PDSH-0201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 INLET DIFFERENTIAL PRE	DIFFERENTIAL PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-006	40 72 00	VENDOR SUPPLY
174	32-AIR-PG-0201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 SUCTION PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-006	40 73 12	VENDOR SUPPLY
175	32-DRN-PSH-0002	DRAIN PUMP DISCHARGE PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-007	40 72 00	VENDOR SUPPLY
176	32-MEM-AE-2001	FILTRATE PUMP NO. 2 OUTLET TURBIDITY MEASUREMENT	TURBIDITY SENSOR	N/A	mV	SEE AIT	N/A	32-I-004	40 75 00	VENDOR SUPPLY
177	32-MEM-AIT-2001	FILTRATE PUMP NO. 2 OUTLET TURBIDITY MEASUREMENT	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-004	40 75 00	VENDOR SUPPLY
178	32-MEM-FIT-2001	FILTRATE PUMP NO. 2 OUTLET FLOW (MAGNETIC TYPE)	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-004	40 71 00	VENDOR SUPPLY
179	32-DRN-PSL-0001	DRAIN PUMP SUCTION PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	32-I-007	40 72 00	VENDOR SUPPLY
180	32-MEM-PI-2001	FILTRATE PUMP NO. 2 SUCTION PRESSURE	PRESSURE INDICATOR	4-1/2"	N/A	N/A	N/A	32-I-004	40 78 00	VENDOR SUPPLY
181	32-MEM-PIT-2001	FILTRATE PUMP NO. 2 INLET HEADER PRESSURE	PRESSURE INDICATING TRANSMITTER	N/A	4-20 mA DC		2-WIRE	32-I-004	40 72 00	VENDOR SUPPLY
182	32-MEM-PSH-2001	FILTRATE PUMP NO. 2 SUCTION PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-004	40 72 00	VENDOR SUPPLY
183	32-MEM-PSL-2001	FILTRATE PUMP NO. 2 SUCTION PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	32-I-004	40 72 00	VENDOR SUPPLY
184	32-AIR-TG-0201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 OUTLET TEMP	TEMPERATURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-006	40 74 00	VENDOR SUPPLY
185	32-AIR-TSH-0201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 OUTLET TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	32-I-006	40 74 00	VENDOR SUPPLY
186	32-MEM-TIT-0001	RO FEED TANK INLET HEADER TEMPERATURE MEASUREMENT	RESISTANCE TEMPERATURE TRANSMITTER	N/A	4-20 mA DC		2-WIRE	32-I-005	40 74 00	VENDOR SUPPLY
187	32-AIR-PG-0202	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	32-I-006	40 73 12	VENDOR SUPPLY
188	32-AIR-PSH-0202	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 DISCHARGE PRESSURE H	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-006	40 72 00	VENDOR SUPPLY
189	32-MEM-TSH-2001	FILTRATE PUMP NO. 2 MOROR WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	32-I-004	40 74 00	VENDOR SUPPLY
190	32-MEM-PI-2002	FILTRATE PUMP NO. 2 DISCHARGE PRESSURE	PRESSURE INDICATOR	4-1/2"	N/A	N/A	N/A	32-I-004	40 78 00	VENDOR SUPPLY
191	32-RAS-FIT-2001	RAS COLLECTION CHANNEL NO. 2 TO RAS DEOX FLOW (MAGNETIC TYPE TY	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	32-I-002	40 71 00	
192	32-MEM-PSH-2002	FILTRATE PUMP NO. 2 DISCHARGE PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	32-I-004	40 72 00	VENDOR SUPPLY
193	32-MEM-PSL-2002	FILTRATE PUMP NO. 2 DISCHARGE PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	32-I-004	40 72 00	VENDOR SUPPLY
194	33-RO-LIT-0101	RO FEED TANK 1 LEVEL (DP TYPE)	LEVEL INDICATING TRANSMITTER	N/A	4-20 mA DC		2-WIRE	33-I-001	40 72 00	
195	33-RO-LIT-0201	RO FEED TANK 2 LEVEL (DP TYPE)	LEVEL INDICATING TRANSMITTER	N/A	4-20 mA DC		2-WIRE	33-I-001	40 72 00	
196	33-RO-LSHH-0101	RO FEED TANK 1 LEVEL HIGH HIGH	LEVEL SWITCH HIGH-HIGH	N/A	DRY CONTACT		N/A	33-I-001	40 72 00	
197	33-RO-LSHH-0201	RO FEED TANK 2 LEVEL HIGH HIGH	LEVEL SWITCH HIGH-HIGH	N/A	DRY CONTACT		N/A	33-I-001	40 72 00	
198	33-RO-LSLL-0101	RO FEED TANK 1 LEVEL LOW LOW	LEVEL SWITCH LOW-LOW	N/A	DRY CONTACT		N/A	33-I-001	40 72 00	
199	33-RO-LSLL-0201	RO FEED TANK 2 LEVEL LOW LOW	LEVEL SWITCH LOW-LOW	N/A	DRY CONTACT		N/A	33-I-001	40 72 00	
200	34-TW-FIT-0001	RECYCLED WATER PUMP COMMON OUTLET HEADER FLOW (MAGNETIC TY	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	34-I-001	40 71 00	
201	34-TW-PG-0001	AIR BLADDER STORAGE TANK PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	34-I-001	40 73 12	
202	34-TW-PG-0101	RECYCLED WATER PUMP NO. 1 SUCTION PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	34-I-001	40 73 12	
203	34-TW-PG-0102	RECYCLED WATER PUMP NO. 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	34-I-001	40 73 12	
204	34-TW-PG-0201	RECYCLED WATER PUMP NO. 2 SUCTION PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	34-I-001	40 73 12	
205	34-TW-PG-0202	RECYCLED WATER PUMP NO. 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	34-I-001	40 73 12	
206	34-TW-PSH-0002	RECYCLED WATER PUMP NO. 2 DISCHARGE PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	34-I-001	40 72 00	
207	34-TW-PSH-0102	RECYCLED WATER PUMP NO. 1 DISCHARGE PRESSURE HIGH	PRESSURE SWITCH HIGH	N/A	DRY CONTACT		N/A	34-I-001	40 72 00	
208	34-TW-PSL-0101	RECYCLED WATER PUMP NO. 1 SUCTION PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	34-I-001	40 72 00	
209	34-TW-PSL-0201	RECYCLED WATER PUMP NO. 2 SUCTION PRESSURE LOW	PRESSURE SWITCH	N/A	DRY CONTACT		N/A	34-I-001	40 72 00	
210	34-TW-TSH-0101	RECYCLED WATER PUMP NO. 1 MOTOR WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	34-I-001	40 74 00	
211	34-TW-TSH-0201	RECYCLED WATER PUMP NO. 2 MOTOR WINDING TEMP HIGH	TEMPERATURE SWITCH	N/A	DRY CONTACT		N/A	34-I-001	40 74 00	
212	51-RO-AE-0001	RO FEED PUMPS COMMON HEADER INLET CONDUCTIVITY	CONDUCTIVITY SENSOR	N/A	mV		N/A	51-I-001	40 75 00	
213	51-RO-AE-0002	RO FEED PUMPS COMMON HEADER INLET TURBIDITY	TURBIDITY SENSOR	N/A	mV		N/A	51-I-001	40 75 00	
214	51-RO-AE-0003	RO FEED PUMPS COMMON HEADER INLET ORP	OXYGEN REDUCTION POTENTIAL SENSOR	N/A	mV		N/A	51-I-001	40 75 00	
215	51-RO-AE-0004	RO FEED PUMPS COMMON HEADER INLET FREE CHLORINE	FREE CHLORINE SENSOR	N/A	mV		N/A	51-I-001	40 75 00	
216	51-RO-AE-0005	RO FEED PUMPS COMMON HEADER INLET MONO-CHLORIMINE/AMMONI	MONO-CHLORIMINE/AMMONIA SENSOR	N/A	mV		N/A	51-I-001	40 75 00	
217	51-RO-AE-0006	RO FEED PUMPS COMMON HEADER INLET pH	SENSOR	N/A	mV		N/A	51-I-001	40 75 00	
218	51-RO-FIT-0001	RO FEED PUMPS COMMON HEADER INLET FLOW (MAGNETIC TYPE)	FLOW INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	51-I-001	40 71 00	
219	51-RO-AIT-0001	RO FEED PUMPS COMMON HEADER INLET CONDUCTIVITY	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	51-I-001	40 75 00	
220	51-RO-AIT-0002	RO FEED PUMPS COMMON HEADER INLET TURBIDITY	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	51-I-001	40 75 00	
221	51-RO-AIT-0003	RO FEED PUMPS COMMON HEADER INLET ORP	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	51-I-001	40 75 00	
222	51-RO-AIT-0004	RO FEED PUMPS COMMON HEADER INLET FREE CHLORINE	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	51-I-001	40 75 00	
223	51-RO-AIT-0005	RO FEED PUMPS COMMON HEADER INLET MONO-CHLORIMINE/AMMONI	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	51-I-001	40 75 00	
224	51-RO-AIT-0006	RO FEED PUMPS COMMON HEADER INLET pH	ANALYZER INDICATING TRANSMITTER	N/A	4-20 mA DC		4-WIRE	51-I-001	40 75 00	
225	61-CAL-FIT-0001	SEWER OR STORM DRAIN FLOW	FLOW INDICATING TRANSMITTER	3"	4-20 mA DC		4 -WIRE	61-I-001	40 71 00	
226	61-CAL-LE-0001	BACKWASH WASTE HOLDING TANK ULTRASONIC SENSOR	PRIMARY LEVEL ELEMENT/SENSOR		mV		N/A	61-I-001	40 72 00	
227	61-CAL-LIT-0001	BACKWASH WASTE HOLDING TANK ULTRASONIC TRANSMITTER	LEVEL INDICATING TRANSMITTER		4-20 mA DC			61-I-001	40 72 00	
228	61-CAL-PDS-0101	CALCITE VESSEL 1 DIFFERENTIAL PRESSURE	DIFFERENTIAL PRESSURE SWITCH		DRY CONTACT		N/A	61-I-001	40 72 00	
229	61-CAL-PDS-0201	CALCITE VESSEL 2 DIFFERENTIAL PRESSURE	DIFFERENTIAL PRESSURE SWITCH		DRY CONTACT		N/A	61-I-001	40 72 00	
230	61-CAL-PG-0001	CALCITE VESSEL 1 INLET PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	61-I-001	40 73 12	
231	61-CAL-PG-0002	CALCITE VESSEL 2 PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	61-I-001	40 73 12	
232	61-CAL-PG-0003	CALCITE SYSTEM FLUSH PUMP DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	61-I-001	40 73 12	
233	62-TW-AE-0001	STORAGE TANK DISCHARGE TOTAL CHLORINE	TOTAL CHLORINE SENSOR		mV	SEE AIT	N/A	62-I-001	40 75 00	
234	62-TW-AE-0002	STORAGE TANK DISCHARGE CONDUCTIVITY	CONDUCTIVITY SENSOR		mV	SEE AIT	N/A	62-I-001	40 75 00	
235	62-TW-AE-0003	STORAGE TANK DISCHARGE pH	pH SENSOR		mV	SEE AIT	N/A	62-I-001	40 75 00	
236	62-TW-AIT-0001	STORAGE TANK DISCHARGE TOTAL CHLORINE	ANALYZER INDICATING TRANSMITTER		4-20 mA DC		4 -WIRE	62-I-001	40 75 00	
237	62-TW-AIT-0002	STORAGE TANK DISCHARGE CONDUCTIVITY	ANALYZER INDICATING TRANSMITTER		4-20 mA DC		4 -WIRE	62-I-001	40 75 00	
238	62-TW-AIT-0003	STORAGE TANK DISCHARGE pH	ANALYZER INDICATING TRANSMITTER		4-20 mA DC	0-14	4 -WIRE	62-I-001	40 75 00	
239	62-TW-LG-0001	STORAGE TANK LEVEL SIGHT GLASS	LEVEL INDICATOR		N/A	N/A	N/A	62-I-001	40 72 00	
240	62-TW-LIT-0001	STORAGE TANK PRESSURE SENSING TYPE LEVEL	LEVEL INDICATING TRANSMITTER		4-20 mA DC		2 -WIRE	62-I-001	40 72 00	
241	62-TW-LSHH-0001	STORAGE TANK PRESSURE SENSING TYPE LEVEL SWITCH	LEVEL SWITCH HIGH-HIGH		DRY CONTACT		N/A	62-I-001	40 72 00	
242	62-TW-LSLL-0001	STORAGE TANK PRESSURE SENSING TYPE LEVEL SWITCH	LEVEL SWITCH LOW-LOW		DRY CONTACT		N/A	62-I-001	40 72 00	
243	63-TW-AE-0008	IPR PUMP STATION DISCHARGE HEADER pH	pH SENSOR		mV	SEE AIT	N/A	63-I-001	40 75 00	
244	63-TW-AIT-0008	IPR PUMP STATION DISCHARGE HEADER pH	ANALYZER INDICATING TRANSMITTER		4-20 mA DC	0-14	4 -WIRE	63-I-001	40 75 00	
245	63-TW-FIT-0001	IPR PUMP STATION DISCHARGE HEADER FLOW	FLOW INDICATING TRANSMITTER		4-20 mA DC		4 -WIRE	63-I-001	40 71 00	
246	63-TW-PG-0101	IPR PUMP NO.1 DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	63-I-001	40 73 12	
247	63-TW-PG-0201	IPR PUMP NO.2 DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	63-I-001	40 73 12	
248	63-TW-PG-0301	IPR PUMP NO.3 DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	63-I-001	40 73 12	
249	63-TW-PIT-0001	IPR PUMP STATION DISCHARGE HEADER PRESSURE	PRESSURE INDICATING TRANSMITTER		4-20 mA DC		2-WIRE	63-I-001	40 72 00	
250	63-TW-PSH-0101	IPR PUMP NO.1 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	63-I-001	40 72 00	
251	63-TW-PSH-0201	IPR PUMP NO.2 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	63-I-001	40 72 00	
252	63-TW-PSH-0301	IPR PUMP NO.3 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	63-I-001	40 72 00	
253	64-TW-FIT-0001	OUTFALL PUMP STATION DISCHARGE HEADER FLOW	FLOW INDICATING TRANSMITTER		4-20 mA DC		4 -WIRE	64-I-001	40 71 00	
254	64-TW-LG-0001	OUTFALL BALANCING TANK SIGHT LEVEL	LEVEL GAUGE		N/A	N/A	N/A	64-I-001	40 72 00	
255	64-TW-LIT-0001	OUTFALL BALANCING TANK PRESSURE SENSING TYPE LEVEL	LEVEL INDICATING TRANSMITTER		4-20 mA DC			64-I-001	40 72 00	
256	64-TW-LSHH-0001	OUTFALL BALANCING TANK PRESSURE SENSING TYPE LEVEL	LEVEL SWITCH HIGH-HIGH		DRY CONTACT		N/A	64-I-001	40 72 00	

INSTRUMENT DEVICE SCHEDULE - MORRO BAY WRF

Item	Tag	Service Description	Device Type	Size	Output Type	Output Range	Power Type	P&ID Drawing	Specification	Remarks
257	64-TW-LSL-0001	OUTFALL BALANCING TANK PRESSURE SENSING TYPE LEVEL	LEVEL SWITCH LOW		DRY CONTACT			64-I-001	40 72 00	
258	64-TW-PG-0101	OUTFALL PUMP NO.1 DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	64-I-001	40 73 12	
259	64-TW-PG-0201	OUTFALL PUMP NO.2 DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	64-I-001	40 73 12	
260	64-TW-PG-0301	OUTFALL PUMP NO.3 DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	64-I-001	40 73 12	
261	64-TW-PG-0401	OUTFALL PUMP NO.4 DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	64-I-001	40 73 12	
262	65-TW-AE-0001	OUTFALL PUMP STATION DISCHARGE HEADER FREE CHLORINE	FREE CHLORINE SENSOR		mV	SEE AIT	N/A	65-I-001	40 75 00	
263	65-TW-AIT-0001	OUTFALL PUMP STATION DISCHARGE HEADER FREE CHLORINE	ANALYZER INDICATING TRANSMITTER		4-20 mA DC			65-I-001	40 75 00	
264	71-WAS-AE-0101	SLUDGE HOLDING TANK NO.1 DISSOLVED OXEGEN SENSOR	DISSOLVED OXYGEN SENSOR		mV	SEE AIT	N/A	71-I-001	40 75 00	
265	71-WAS-AE-0201	SLUDGE HOLDING TANK NO.2 DISSOLVED OXEGEN SENSOR	DISSOLVED OXYGEN SENSOR		mV	SEE AIT	N/A	71-I-001	40 75 00	
266	71-WAS-AIT-0101	SLUDGE HOLDING TANK NO.1 DISSOLVED OXEGEN ANALYZER	ANALYZER INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	71-I-001	40 75 00	
267	71-WAS-AIT-0201	SLUDGE HOLDING TANK NO.2 DISSOLVED OXEGEN ANALYZER	ANALYZER INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	71-I-001	40 75 00	
268	71-WAS-LE-0101	SLUDGE HOLDING TANK NO.1 RADAR LEVEL SENSOR	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	71-I-001	40 72 00	
269	71-WAS-LE-0201	SLUDGE HOLDING TANK NO.2 RADAR LEVEL SENSOR	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	71-I-001	40 72 00	
270	71-WAS-LIT-0101	SLUDGE HOLDING TANK NO.1 RADAR LEVEL TRANSMITTER	LEVEL INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	71-I-001	40 72 00	
271	71-WAS-LIT-0201	SLUDGE HOLDING TANK NO.2 RADAR LEVEL TRANSMITTER	LEVEL INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	71-I-001	40 72 00	
272	71-WAS-MSH-0002	SLUDGE HOLDING TANK NO.2 MIXER MOISTURE DETECTION SWITCH	MOISTURE DETECTION SWITCH		DRY CONTACT	SEE LIT	N/A	71-I-001		
273	71-WAS-MSH-0101	SLUDGE HOLDING TANK NO.1 MIXER MOISTURE DETECTION SWITCH	MOISTURE DETECTION SWITCH		DRY CONTACT	SEE LIT	N/A	71-I-001		
274	71-WAS-TSH-0002	SLUDGE HOLDING TANK NO.2 MIXER TEMPERATURE SWITCH	DIFFERENTIAL TEMPERATURE SWITCH		DRY CONTACT	SEE LIT	N/A	71-I-001	40 74 00	
275	71-WAS-TSH-0101	SLUDGE HOLDING TANK NO.1 MIXER TEMPERATURE SWITCH	DIFFERENTIAL TEMPERATURE SWITCH		DRY CONTACT	SEE LIT	N/A	71-I-001	40 74 00	
276	71-WAS-LE-0001	SAFE DIVERSION BOX ULTRASONIC LEVEL SENSOR	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	71-I-002	40 72 00	
277	71-WAS-LE-0001	SAFE DIVERSION BOX ULTRASONIC LEVEL SENSOR	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	71-I-002	40 72 00	
278	71-WAS-LIT-0001	SAFE DIVERSION BOX ULTRASONIC LEVEL TRANSMITTER	LEVEL INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	71-I-002	40 72 00	
279	71-WAS-LSHH-0001	SAFE DIVERSION BOX ULTRASONIC LEVEL SWITCH	LEVEL SWITCH HIGH-HIGH		DRY CONTACT		N/A	71-I-002	40 72 00	
280	71-AIR-PDI-0101	SHT BLOWER NO 1 INLET DIFFERENTIAL PRESSURE INDICATOR	DIFFERENTIAL PRESSURE INDICATOR		N/A		N/A	71-I-003	40 72 00	VENDOR SUPPLY
281	71-AIR-PDI-0201	SHT BLOWER NO 2 INLET DIFFERENTIAL PRESSURE INDICATOR	DIFFERENTIAL PRESSURE INDICATOR		N/A		N/A	71-I-003	40 72 00	VENDOR SUPPLY
282	71-AIR-PDSH-0101	SHT BLOWER NO 2 INLET DIFFERENTIAL PRESSURE SWITCH	DIFFERENTIAL PRESSURE SWITCH HIGH		DRY CONTACT		N/A	71-I-003	40 72 00	VENDOR SUPPLY
283	71-AIR-PDSH-0201	SHT BLOWER NO 2 INLET DIFFERENTIAL PRESSURE SWITCH	DIFFERENTIAL PRESSURE SWITCH HIGH		DRY CONTACT		N/A	71-I-003	40 72 00	VENDOR SUPPLY
284	71-AIR-PG-0101	SHT BLOWER NO 1 INLET PRESSURE INDICATOR	PRESSURE GAUGE		N/A	N/A	N/A	71-I-003	40 73 12	VENDOR SUPPLY
285	71-AIR-PG-0102	SHT BLOWER NO 1 OUTLET PRESSURE INDICATOR	PRESSURE GAUGE		N/A	N/A	N/A	71-I-003	40 73 12	VENDOR SUPPLY
286	71-AIR-PG-0201	SHT BLOWER NO 2 INLET PRESSURE INDICATOR	PRESSURE GAUGE		N/A	N/A	N/A	71-I-003	40 73 12	VENDOR SUPPLY
287	71-AIR-PG-0202	SHT BLOWER NO 2 OUTLET PRESSURE INDICATOR	PRESSURE GAUGE		N/A	N/A	N/A	71-I-003	40 73 12	VENDOR SUPPLY
288	71-AIR-PIT-0102	SHT BLOWER NO 1 OUTLET PRESSURE TRANSMITTER	PRESSURE INDICATING TRANSMITTER		4-20 mA DC		2-WIRE	71-I-003	40 72 00	VENDOR SUPPLY
289	71-AIR-PIT-0202	SHT BLOWER NO 2 OUTLET PRESSURE TRANSMITTER	PRESSURE INDICATING TRANSMITTER		4-20 mA DC		2-WIRE	71-I-003	40 72 00	VENDOR SUPPLY
290	71-AIR-PSH-0102	SHT BLOWER NO 1 OUTLET PRESSURE SWITCH	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	71-I-003	40 72 00	VENDOR SUPPLY
291	71-AIR-PSH-0202	SHT BLOWER NO 2 OUTLET PRESSURE SWITCH	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	71-I-003	40 72 00	VENDOR SUPPLY
292	71-AIR-TDSH-0101	SHT BLOWER NO 1 OUTLET DIFF TEMPERATURE SWITCH	DIFFERENTIAL TEMPERATURE SWITCH		DRY CONTACT		N/A	71-I-003	40 74 00	VENDOR SUPPLY
293	71-AIR-TDSH-0201	SHT BLOWER NO 2 OUTLET DIFF TEMPERATURE SWITCH	DIFFERENTIAL TEMPERATURE SWITCH		DRY CONTACT		N/A	71-I-003	40 74 00	VENDOR SUPPLY
294	71-AIR-TG-0101	SHT BLOWER NO 1 OUTLET TEMPERATURE INDICATOR	TEMPERATURE GAUGE		N/A		N/A	71-I-003	40 74 00	VENDOR SUPPLY
295	71-AIR-TG-0201	SHT BLOWER NO 2 OUTLET TEMPERATURE INDICATOR	TEMPERATURE GAUGE		N/A		N/A	71-I-003	40 74 00	VENDOR SUPPLY
296	71-AIR-TSH-0101	SHT BLOWER NO 1 TEMPERATURE SWITCH	TEMPERATURE SWITCH		DRY CONTACT		N/A	71-I-003	40 74 00	VENDOR SUPPLY
297	71-AIR-TSH-0201	SHT BLOWER NO 2 TEMPERATURE SWITCH	TEMPERATURE SWITCH		DRY CONTACT		N/A	71-I-003	40 74 00	VENDOR SUPPLY
298	72-DWT-FIT-0001	DEWATERING SLUDGE FEED PUMP DISCHARGE HEADER FLOW	FLOW INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	72-I-001	40 71 00	VENDOR SUPPLY
299	72-DWT-FSL-0101	DEWATERING SLUDGE FEED PUMP NO 1 PLANT WATER LOW FLOW	FLOW SWITCH LOW		DRY CONTACT		N/A	72-I-001	40 71 00	VENDOR SUPPLY
300	72-DWT-FSL-0201	DEWATERING SLUDGE FEED PUMP NO 2 PLANT WATER LOW FLOW	FLOW SWITCH LOW		DRY CONTACT		N/A	72-I-001	40 71 00	VENDOR SUPPLY
301	72-DWT-PG-0101	DEWATERING SLUDGE FEED PUMP NO 1 SUCTION PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	72-I-001	40 73 12	VENDOR SUPPLY
302	72-DWT-PG-0102	DEWATERING SLUDGE FEED PUMP NO 1 OUTLET PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	72-I-001	40 73 12	VENDOR SUPPLY
303	72-DWT-PG-0201	DEWATERING SLUDGE FEED PUMP NO 2 SUCTION PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	72-I-001	40 73 12	VENDOR SUPPLY
304	72-DWT-PG-0202	DEWATERING SLUDGE FEED PUMP NO 2 OUTLET PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	72-I-001	40 73 12	VENDOR SUPPLY
305	72-DWT-PSH-0102	DEWATERING SLUDGE FEED PUMP NO 1 OUTLET PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	72-I-001	40 72 00	VENDOR SUPPLY
306	72-DWT-PSH-0202	DEWATERING SLUDGE FEED PUMP NO 2 OUTLET PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	72-I-001	40 72 00	VENDOR SUPPLY
307	72-DWT-PSL-0101	DEWATERING SLUDGE FEED PUMP NO 1 SUCTION PRESSURE	PRESSURE SWITCH		DRY CONTACT		N/A	72-I-001	40 72 00	VENDOR SUPPLY
308	72-DWT-PSL-0201	DEWATERING SLUDGE FEED PUMP NO 2 SUCTION PRESSURE	PRESSURE SWITCH		DRY CONTACT		N/A	72-I-001	40 72 00	VENDOR SUPPLY
309	72-DWT-TSH-0101	DEWATERING SLUDGE FEED PUMP NO 1 TEMPERATURE	TEMPERATURE SWITCH		DRY CONTACT		N/A	72-I-001	40 74 00	VENDOR SUPPLY
310	72-DWT-TSH-0201	DEWATERING SLUDGE FEED PUMP NO 2 TEMPERATURE	TEMPERATURE SWITCH		DRY CONTACT		N/A	72-I-001	40 74 00	VENDOR SUPPLY
311	72-NPW-PSL-0001	BELT FILTER PRESS WASHWATER PUMP DISCHARGE LOW PRESSURE	PRESSURE SWITCH		DRY CONTACT		N/A	72-I-002	40 72 00	VENDOR SUPPLY
312	73-FSW-AE-0001	DISK FILTER pH SENSOR	pH SENSOR		mV	SEE AIT	N/A	73-I-001	40 75 00	VENDOR SUPPLY
313	73-FSW-AIT-0001	DISK FILTER pH ANALYSER	ANALYZER INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	73-I-001	40 75 00	VENDOR SUPPLY
314	73-FSW-FIT-0001	DISK FILTER OVERFLOW EFFLUENT FLOW	FLOW INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	73-I-001	40 71 00	
315	73-FSW-FIT-0002	FILTERS SOLID WASTE PUMP DISCHARGE FLOW	FLOW INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	73-I-001	40 71 00	VENDOR SUPPLY
316	73-FSW-FIT-0003	FILTERS BACKWASH WASTE PUMP DISCHARGE FLOW	FLOW INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	73-I-001	40 71 00	VENDOR SUPPLY
317	73-FSW-FS-0001	DISK FILTER FLOW SWITCH	FLOW SWITCH		DRY CONTACT		N/A	73-I-001	40 71 00	VENDOR SUPPLY
318	73-FSW-LSH-0001	DISK FILTER HIGH LEVEL SWITCH	LEVEL SWITCH HIGH		DRY CONTACT		N/A	73-I-001	40 72 00	VENDOR SUPPLY
319	73-FSW-LT-0001	DISK FILTER HIGH LEVEL TRANSMITTER	LEVEL TRANSMITTER		4-20 mA DC		2-WIRE	73-I-001	40 72 00	VENDOR SUPPLY
320	73-FSW-PG-0003	FILTERS SOLID WASTE PUMP DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	73-I-001	40 73 12	VENDOR SUPPLY
321	73-FSW-PG-0004	FILTERS BACKWASH WASTE PUMP DISCHARGE PRESSURE	PRESSURE GAUGE		N/A	N/A	N/A	73-I-001	40 73 12	VENDOR SUPPLY
322	73-FSW-PIT-0001	FILTERS SOLID WASTE PUMP SUCTION PRESSURE	PRESSURE INDICATING TRANSMITTER		4-20 mA DC		2-WIRE	73-I-001	40 72 00	VENDOR SUPPLY
323	73-FSW-PIT-0002	FILTERS BACKWASH WASTE PUMP SUCTION PRESSURE	PRESSURE INDICATING TRANSMITTER		4-20 mA DC		2-WIRE	73-I-001	40 72 00	VENDOR SUPPLY
324	73-FSW-PSH-0003	FILTERS SOLID WASTE PUMP DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	73-I-001	40 72 00	VENDOR SUPPLY
325	73-FSW-PSH-0004	FILTERS BACKWASH WASTE PUMP DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	73-I-001	40 72 00	VENDOR SUPPLY
326	73-FSW-VIT-0001	DISK FILTER VIBRATION TRANSMITTER	VIBRATION TRANSMITTER		N/A		2-WIRE	73-I-001		VENDOR SUPPLY
327	90-HSO4-AE-0001	SUFURIC ACID DILUTION WATER CONDUCTIVITY SENSOR	CONDUCTIVITY SENSOR		N/A	N/A		90-I-007	40 75 00	
328	90-HSO4-AE-0002	SUFURIC ACID DILUTION WATER CONDUCTIVITY SENSOR	CONDUCTIVITY SENSOR		N/A	N/A		90-I-007	40 75 00	
329	90-HSO4-AIT-0001	SUFURIC ACID DILUTION WATER CONDUCTIVITY ANALYZER	ANALYZER INDICATING TRANSMITTER		4-20 mA DC	N/A	4 - WIRE	90-I-007	40 75 00	
330	90-HSO4-AIT-0002	SUFURIC ACID DILUTION WATER CONDUCTIVITY ANALYZER	ANALYZER INDICATING TRANSMITTER		4-20 mA DC	N/A	4 - WIRE	90-I-007	40 75 00	
331	90-NOCL-FSH-0001	SODIUM HYPOCHLORITE AREA EYEWASH FLOW SWITCH	FLOW SWITCH		DRY CONTACT	N/A	N/A	90-I-001		VENDOR SUPPLY
332	90-NHS-FSH-0002	SODIUM BISULFITE STORAGE AREA EYEWASH FLOW SWITCH	FLOW SWITCH		DRY CONTACT	N/A	N/A	90-I-004		VENDOR SUPPLY
333	90-ANTI-FSH-0003	ANTISCALANT STORAGE AREA EYEWASH FLOW SWITCH	FLOW SWITCH		DRY CONTACT	N/A	N/A	90-I-005		VENDOR SUPPLY
334	90-CA-FSH-0004	CITRIC ACID STORAGE AREA EYEWASH FLOW SWITCH	FLOW SWITCH		DRY CONTACT	N/A	N/A	90-I-006		VENDOR SUPPLY
335	90-HSO4-FSH-0005	SULFURIC ACID STORAGE AREA EYEWASH FLOW SWITCH	FLOW SWITCH		DRY CONTACT	N/A	N/A	90-I-007		VENDOR SUPPLY
336	90-POLF-FSH-0006	THICKENING POLYMER STORAGE AREA EYEWASH FLOW SWITCH	FLOW SWITCH		DRY CONTACT	N/A	N/A	90-I-008		VENDOR SUPPLY
337	90-NAOH-LE-0001	SODIUM HYDROXIDE STORAGE TANK ULTRASONIC LEVEL SENSOR	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	90-I-003	40 72 00	
338	90-NOCL-LE-0001	SODIUM HYPOCHLORITE STORAGE TANK ULTRASONIC LEVEL SENSOR	PRIMARY LEVEL ELEMENT/SENSOR		mV	SEE LIT	N/A	90-I-001	40 72 00	
339	90-NAOH-LG-0001	SODIUM HYDROXIDE STORAGE TANK LEVEL INDICATOR	SIGHT GLASS INDICATOR		N/A	N/A	N/A	90-I-003	40 72 00	
340	90-NOCL-LG-0001	SODIUM HYPOCHLORITE STORAGE TANK LEVEL INDICATOR	SIGHT GLASS INDICATOR		N/A	N/A	N/A	90-I-001	40 72 00	
341	90-NAOH-LIT-0001	SODIUM HYDROXIDE STORAGE TANK ULTRASONIC LEVEL TRANSMITTER	LEVEL INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	90-I-003	40 72 00	
342	90-NOCL-LIT-0001	SODIUM HYPOCHLORITE STORAGE TANK ULTRASONIC LEVEL TRANSMITTE	LEVEL INDICATING TRANSMITTER		4-20 mA DC		4 - WIRE	90-I-001	40 72 00	
343	90-ANTI-MSH-0001	ANTISCALANT METERING PUMP NO 1 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-005		VENDOR SUPPLY
344	90-CA-MSH-0101	CITRIC ACID METERING PUMP NO 21 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-006		VENDOR SUPPLY
345	90-CA-MSH-0201	CITRIC ACID METERING PUMP NO 2 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-006		VENDOR SUPPLY
346	90-HSO4-MSH-0101	SULFURIC ACID METERING PUMP NO 1 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-007		VENDOR SUPPLY

INSTRUMENT DEVICE SCHEDULE - MORRO BAY WRF

Item	Tag	Service Description	Device Type	Size	Output Type	Output Range	Power Type	P&ID Drawing	Specification	Remarks
347	90-HSO4-MSH-0201	SULFURIC ACID METERING PUMP NO 2 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-007		VENDOR SUPPLY
348	90-NAOH-MSH-0101	SODIUM HYDROXIDE METERING PUMP NO 1 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-003		VENDOR SUPPLY
349	90-NAOH-MSH-0201	SODIUM HYDROXIDE METERING PUMP NO 2 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-003		VENDOR SUPPLY
350	90-NAOH-MSH-0301	SODIUM HYDROXIDE METERING PUMP NO 3 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-003		VENDOR SUPPLY
351	90-NHS-MSH-0001	SODIUM BISULFITE METERING PUMP NO 1 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-004		VENDOR SUPPLY
352	90-NOCL-MSH-0101	SODIUM HYPOCHLORITE METERING PUMP NO 1 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-001		VENDOR SUPPLY
353	90-NOCL-MSH-0201	SODIUM HYPOCHLORITE METERING PUMP NO 2 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-001		VENDOR SUPPLY
354	90-NOCL-MSH-0301	SODIUM HYPOCHLORITE METERING PUMP NO 3 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-001		VENDOR SUPPLY
355	90-NOCL-MSH-0401	SODIUM HYPOCHLORITE METERING PUMP NO 4 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-002		VENDOR SUPPLY
356	90-NOCL-MSH-0501	SODIUM HYPOCHLORITE METERING PUMP NO 5 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-002		VENDOR SUPPLY
357	90-NOCL-MSH-0601	SODIUM HYPOCHLORITE METERING PUMP NO 6 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-002		VENDOR SUPPLY
358	90-NOCL-MSH-0701	SODIUM HYPOCHLORITE METERING PUMP NO 7 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-002		VENDOR SUPPLY
359	90-POLF-MSH-0001	THICKENING POLYMER METERING PUMP NO 1 MOISTURE	MOISTURE DETECTION SWITCH		DRY CONTACT	N/A	N/A	90-I-008		
360	90-ANTI-PG-0001	ANTISCALANT METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-005	40 73 12	VENDOR SUPPLY
361	90-ANTI-PG-0002	ANTISCALANT METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-005	40 73 12	VENDOR SUPPLY
362	90-CA-PG-0101	CITRIC ACID METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-006	40 73 12	VENDOR SUPPLY
363	90-CA-PG-0102	CITRIC ACID METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-006	40 73 12	VENDOR SUPPLY
364	90-CA-PG-0201	CITRIC ACID METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-006	40 73 12	VENDOR SUPPLY
365	90-CA-PG-0202	CITRIC ACID METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-006	40 73 12	VENDOR SUPPLY
366	90-HSO4-PG-0101	SULFURIC ACID METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-007	40 73 12	
367	90-HSO4-PG-0102	SULFURIC ACID METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-007	40 73 12	
368	90-HSO4-PG-0201	SULFURIC ACID METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-007	40 73 12	
369	90-HSO4-PG-0202	SULFURIC ACID METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-007	40 73 12	
370	90-NAOH-PG-0101	SODIUM HYDROXIDE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-003	40 73 12	VENDOR SUPPLY
371	90-NAOH-PG-0102	SODIUM HYDROXIDE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-003	40 73 12	VENDOR SUPPLY
372	90-NAOH-PG-0201	SODIUM HYDROXIDE METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-003	40 73 12	VENDOR SUPPLY
373	90-NAOH-PG-0202	SODIUM HYDROXIDE METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-003	40 73 12	VENDOR SUPPLY
374	90-NAOH-PG-0301	SODIUM HYDROXIDE METERING PUMP NO 3 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-003	40 73 12	VENDOR SUPPLY
375	90-NAOH-PG-0302	SODIUM HYDROXIDE METERING PUMP NO 3 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-003	40 73 12	VENDOR SUPPLY
376	90-NHS-PG-0001	SODIUM BISULFITE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-004	40 73 12	VENDOR SUPPLY
377	90-NHS-PG-0002	SODIUM BISULFITE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-004	40 73 12	VENDOR SUPPLY
378	90-NOCL-PG-0101	SODIUM HYPOCHLORITE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-001	40 73 12	VENDOR SUPPLY
379	90-NOCL-PG-0102	SODIUM HYPOCHLORITE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-001	40 73 12	VENDOR SUPPLY
380	90-NOCL-PG-0201	SODIUM HYPOCHLORITE METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-001	40 73 12	VENDOR SUPPLY
381	90-NOCL-PG-0202	SODIUM HYPOCHLORITE METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-001	40 73 12	VENDOR SUPPLY
382	90-NOCL-PG-0301	SODIUM HYPOCHLORITE METERING PUMP NO 3 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-001	40 73 12	VENDOR SUPPLY
383	90-NOCL-PG-0302	SODIUM HYPOCHLORITE METERING PUMP NO 3 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-001	40 73 12	VENDOR SUPPLY
384	90-NOCL-PG-0401	SODIUM HYPOCHLORITE METERING PUMP NO 4 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-002	40 73 12	VENDOR SUPPLY
385	90-NOCL-PG-0402	SODIUM HYPOCHLORITE METERING PUMP NO 4 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-002	40 73 12	VENDOR SUPPLY
386	90-NOCL-PG-0501	SODIUM HYPOCHLORITE METERING PUMP NO 5 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-002	40 73 12	VENDOR SUPPLY
387	90-NOCL-PG-0502	SODIUM HYPOCHLORITE METERING PUMP NO 5 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-002	40 73 12	VENDOR SUPPLY
388	90-NOCL-PG-0601	SODIUM HYPOCHLORITE METERING PUMP NO 6 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-002	40 73 12	VENDOR SUPPLY
389	90-NOCL-PG-0602	SODIUM HYPOCHLORITE METERING PUMP NO 6 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-002	40 73 12	VENDOR SUPPLY
390	90-NOCL-PG-0701	SODIUM HYPOCHLORITE METERING PUMP NO 7 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-002	40 73 12	VENDOR SUPPLY
391	90-NOCL-PG-0702	SODIUM HYPOCHLORITE METERING PUMP NO 7 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-002	40 73 12	VENDOR SUPPLY
392	90-POLF-PG-0001	THICKENING POLYMER METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-008	40 73 12	
393	90-NPW-PG-0001	THICKENING POLYMER DILUTION WATER PRESSURE	PRESSURE GAUGE	4-1/2"	N/A	N/A	N/A	90-I-008	40 73 12	
394	90-ANTI-PSH-0001	ANTISCALANT METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-005	40 72 00	VENDOR SUPPLY
395	90-CA-PSH-0101	CITRIC ACID METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-006	40 72 00	VENDOR SUPPLY
396	90-CA-PSH-0201	CITRIC ACID METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-006	40 72 00	VENDOR SUPPLY
397	90-HSO4-PSH-0101	SULFURIC ACID METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-007	40 72 00	VENDOR SUPPLY
398	90-HSO4-PSH-0201	SULFURIC ACID METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-007	40 72 00	VENDOR SUPPLY
399	90-NAOH-PSH-0101	SODIUM HYDROXIDE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-003	40 72 00	VENDOR SUPPLY
400	90-NAOH-PSH-0201	SODIUM HYDROXIDE METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-003	40 72 00	VENDOR SUPPLY
401	90-NAOH-PSH-0301	SODIUM HYDROXIDE METERING PUMP NO 3 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-003	40 72 00	VENDOR SUPPLY
402	90-NHS-PSH-0001	SODIUM BISULFITE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-004	40 72 00	VENDOR SUPPLY
403	90-NOCL-PSH-0101	SODIUM HYPOCHLORITE METERING PUMP NO 1 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-001	40 72 00	VENDOR SUPPLY
404	90-NOCL-PSH-0201	SODIUM HYPOCHLORITE METERING PUMP NO 2 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-001	40 72 00	VENDOR SUPPLY
405	90-NOCL-PSH-0301	SODIUM HYPOCHLORITE METERING PUMP NO 3 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-001	40 72 00	VENDOR SUPPLY
406	90-NOCL-PSH-0401	SODIUM HYPOCHLORITE METERING PUMP NO 4 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-002	40 72 00	VENDOR SUPPLY
407	90-NOCL-PSH-0501	SODIUM HYPOCHLORITE METERING PUMP NO 5 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-002	40 72 00	VENDOR SUPPLY
408	90-NOCL-PSH-0601	SODIUM HYPOCHLORITE METERING PUMP NO 6 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-002	40 72 00	VENDOR SUPPLY
409	90-NOCL-PSH-0701	SODIUM HYPOCHLORITE METERING PUMP NO 7 DISCHARGE PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-002	40 72 00	VENDOR SUPPLY
410	90-NPW-PSL-0001	THICKENING POLYMER DILUTION WATER PRESSURE	PRESSURE SWITCH HIGH		DRY CONTACT		N/A	90-I-008	40 72 00	VENDOR SUPPLY
411	90-HSO4-TE-0001	SUFURIC ACID DILUTION WATER TEMPERATURE SENSOR	TEMPERATURE ELEMENT		N/A	N/A	N/A	90-I-007	40 74 00	
412	90-HSO4-TE-0002	SUFURIC ACID DILUTION WATER TEMPERATURE SENSOR	TEMPERATURE ELEMENT		N/A	N/A	N/A	90-I-007	40 74 00	
413	90-HSO4-TIT-0001	SUFURIC ACID DILUTION WATER TEMPERATURE TRANSMITTER	TEMPERATURE TRANSMITTER		4-20 mA DC	N/A	2 - WIRE	90-I-007	40 74 00	
414	90-HSO4-TIT-0002	SUFURIC ACID DILUTION WATER TEMPERATURE TRANSMITTER	TEMPERATURE TRANSMITTER		4-20 mA DC	N/A	2 - WIRE	90-I-007	40 74 00	
415	90-ANTI-WE-0001	ANTISCALANT STORAGE TOTE WEIGHT SENSOR	WEIGHT ELEMENT/SENSOR		mV	SEE WIT	N/A	90-I-005	40 72 00	VENDOR SUPPLY
416	90-CA-WE-0001	CITRIC ACID STORAGE TOTE WEIGHT SENSOR	WEIGHT ELEMENT/SENSOR		mV	SEE WIT	N/A	90-I-006	40 72 00	VENDOR SUPPLY
417	90-HSO4-WE-0001	SULFURIC ACID STORAGE TOTE WEIGHT SENSOR	WEIGHT ELEMENT/SENSOR		mV	SEE WIT	N/A	90-I-007	40 72 00	VENDOR SUPPLY
418	90-NHS-WE-0035	SODIUM BISULFITE STORAGE TOTE WEIGHT SENSOR	WEIGHT ELEMENT/SENSOR		mV	SEE WIT	N/A	90-I-004	40 72 00	VENDOR SUPPLY
419	90-POLF-WE-0001	THICKENING POLYMER STORAGE TOTE WEIGHT SENSOR	WEIGHT ELEMENT/SENSOR		mV	SEE WIT	N/A	90-I-008	40 72 00	VENDOR SUPPLY
420	90-ANTI-WIT-0001	ANTISCALANT STORAGE TOTE WEIGHT TRANSMITTER	WEIGHT TRANSMITTER		4-20 mA DC		4 - WIRE	90-I-005	40 72 00	VENDOR SUPPLY
421	90-CA-WIT-0001	CITRIC ACID STORAGE TOTE WEIGHT TRANSMITTER	WEIGHT TRANSMITTER		4-20 mA DC		4 - WIRE	90-I-006	40 72 00	VENDOR SUPPLY
422	90-HSO4-WIT-0001	SULFURIC ACID STORAGE TOTE WEIGHT TRANSMITTER	WEIGHT TRANSMITTER		4-20 mA DC		4 - WIRE	90-I-007	40 72 00	VENDOR SUPPLY
423	90-NHS-WIT-0035	SODIUM BISULFITE STORAGE TOTE WEIGHT TRANSMITTER	WEIGHT TRANSMITTER		4-20 mA DC		4 - WIRE	90-I-004	40 72 00	VENDOR SUPPLY
424	90-POLF-WIT-0001	THICKENING POLYMER STORAGE TOTE WEIGHT TRANSMITTER	WEIGHT TRANSMITTER		4-20 mA DC		4 - WIRE	90-I-008	40 72 00	VENDOR SUPPLY
END										

Section 40 62 00

COMPUTER SYSTEM HARDWARE

PART 1 – GENERAL

1-1. SCOPE. This section covers the furnishing and installation of standard computer system hardware fully configured to work with the software specified in the Computer System Software section. Principal items of the computer and peripheral hardware to be furnished are specified or are indicated on the control system block diagram on the Drawings.

System Supplier shall furnish all necessary interconnecting cables, accessories, and appurtenances as well as additional computer or peripheral hardware required for proper operation and to meet the functional requirements indicated on the Drawings and specified herein.

All equipment shall be capable of tolerating and "riding through" a power interruption of 8 milliseconds or less without interruption of normal operation.

1-1.02. Control System. Section Instrumentation and Control System shall apply to all computer hardware furnished under this section.

1-2. GENERAL. Equipment furnished and installed 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, unless exceptions are noted by Design-Builder.
1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-3. SUBMITTALS. Submittals shall be as specified in the Instrumentation and Control System section .

1-4. DELIVERY, STORAGE, AND SHIPPING. Delivery, storage and shipping shall be as specified in the Instrumentation and Control System section.

1-5. SPARE PARTS. The following spare parts and consumables shall be provided.

3 toner kits and 3,000 sheets of paper for report printer.

25 writeable media disks.

3 ink cartridges of each color and 1,000 sheets of paper for

graphics printer.

All consumables and spares shall be supplied by the computer or printer manufacturer or by a vendor expressly recommended by the manufacturer. System Supplier shall replace any consumables or spares that are spent during setup, testing, and commissioning of the system.

PART 2 - PRODUCTS

2-1. SYSTEM COMPUTERS. System Supplier shall ensure that all computers are configured to operate properly with all software, input/output devices, and peripherals supplied.

2-1.01. Server Computers. Each Server Computer shall be comprised of the following configuration. This configuration is to be provided as a minimum:

Processor type.	Dual-Core (Intel Xeon or AMD OpteronQuad Core Intel Xeon
Processor speed.	3.6 GHz
Monitor type.	LCD with LED backlight, 16:9 aspect ratio
Monitor size.	21 inch
Memory size (RAM).	16 GB
Number of Ethernet cards.	2
Enclosure style.	19" rack-mount
Manufacturer.	Dell, Hewlett Packard Enterprise

Two (2) 300 GB SATA hard drives with integrated RAID controller.

Single CPU (with dual CPU capabilities).

16X DVD-ROM.

Integrated VGA compatible video controller.

10 MB Cache.

Six hot-pluggable hard drive bays.

Redundant power supplies.

Scroll Mouse.

Standard Windows keyboard.

2 Serial Ports standard.

1 Parallel Ports standard.

4 USB Ports.

2-1.01.01. Magnetic Storage Device. Not used.

2-1.01.02. Removable Hard Drive. A removable hard drive shall be supplied and shall be capable of storing a minimum of 80 GB of data on a removable cartridge. The drive shall be internally or externally mounted. The drive shall be Iomega Jaz, Castlewood Orb, or equal.

2-1.01.03. DLT Tape. Not used.

2-1.01.04. CD/DVD-RW Drive. A DVD-RW (read/write) drive shall be supplied and shall be capable of Orange Book standard with a minimum of 20x read and 16x record and of playing DVD disks. DVD drive shall be manufactured by HP, Sony, Panasonic or equal. DVD drives shall be supplied with spare disks.

2-1.01.05. Serial Communications Port Expander. Not used.

2-1.02. Workstation Computers.
Each Workstation Computer shall be comprised of the following configuration. This configuration is to be provided as a minimum:

Processor type.	Dual-Core (Intel Xeon or AMD Opteron
Processor speed.	3.8 Ghz
Monitor type.	Flat Panel LCD with LED backlight
Monitor size.	21 inch
Memory size (RAM).	8 GB
Manufacturer.	Dell, Hewlett Packard

500 GB SATA hard drive.

Single CPU.

CD/DVD ROM.

256 MB AGP video card.

2 MB Cache.

One 10/100/1000 Mbps RJ-45 connectivity Ethernet cards.

Scroll mouse.

Standard Windows keyboard.

1 Parallel Ports standard.

4 USB Ports

Sound Card and speakers.

2-1.02.01. Magnetic Storage Device. Not used.

2-1.02.02. CD-RW/DVD Drive. The CD-RW (read/write)/DVD drive shall be supplied and shall be capable of Orange Book standard with a minimum of 32x read and 8x record and of playing DVD disks. CD-RW/DVD drive shall be manufactured by HP, Sony, Panasonic or equal. CD-RW/DVD drives shall be supplied with spare disks.

2-1.03. Notebook Computer. A notebook computer shall be provided. The notebook computer shall be configured as a minimum of a Intel Core i7 processor, minimum 2.8 GHz processor speed, with a 14.1" TFT display, 8 GB of RAM, one 500 GB hard drive, CD/DVD-RW, video controller with 1 GB of memory, and Ethernet card that supports 10/100/1000 Mbps RJ-45 connectivity, and integrated sound. The notebook computer shall be provided with a lithium ion battery to provide a minimum of three hours of use. The notebook computer shall be a Dell Latitude, Toshiba Tecra, or equal.

Each notebook computer shall be provided with a docking station with the following features:

Integral 10/100/1000 Base-TX Ethernet connection

Two (2) 3.3V and 5V PCI expansion slots

Monitor and monitor stand

Locking mechanism

Standard I/O ports – serial, parallel, video, mouse, keyboard, USB

Standard Windows keyboard

Two/Three button Intellimouse

2-2. SYSTEM PRINTERS.

2-2.01. Alarms and Events Printers. Not used.

2-2.02. Report Printer. Laser type printer(s) for printing reports shall be provided, and shall be capable of printing on letter, legal, and tabloid sized sheets of standard paper. The printer shall accept paper fed manually or from one of two paper trays, each with a minimum capacity of 200 sheets.

The report printer shall print at least 35 pages of text per minute at a resolution of 1200 dpi or greater. The printer shall contain a minimum of 48 MB of on-board RAM, expandable to 320 MB. The report printer shall be a Hewlett Packard LaserJet Enterprise M500 series series or equal.

Report printer(s) shall be provided with a 10/100/1000 Base-TX interface to provide connectivity to the computers over the Ethernet network.

2-2.03. Color Graphics Printer.
Color graphics printer(s) for producing color plots of process graphic screens, trends, and charts shall be provided and shall be of color inkjet type. Color graphics printers shall not require the use of thermally sensitive, chemically treated, or other special paper, and shall meet at least the following minimum requirements:

Shall be capable of delivering 20 pages per minute at the best color quality print speed.

Shall utilize at least 4 separate color print heads for accurate color reproduction.

Shall have a print quality of 1200 x 1200 dpi in the color print mode.

Color graphics printer(s) shall be Hewlett Packard OfficeJet Pro 8000 Series or equal.

The color graphics printer shall be provided with a 10/100Base-TX interface to provide connectivity to the computers over the Ethernet network.

PART 3 - EXECUTION

3-1. INSTALLATION REQUIREMENTS. Installation, field check, testing and training shall be as described in the Instrumentation and Control System section.

End of Section

Section 40 64 00

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 – GENERAL

1-1. SCOPE. This section covers the alternate/optional pricing programmable logic controllers (PLCs), including associated input/output hardware to control process equipment and serve as the interface to field devices.

1-1.01. Control System. The Instrumentation and Control System section shall apply to all equipment furnished under this section. Additional PLC software requirements are indicated in Software Control Block Descriptions section.

1-2. GENERAL. Equipment furnished and installed 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, unless exceptions are noted by Design-Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Drawings. Supplementing this section, the Drawings and equipment specifications indicate the number and types of PLCs, locations of PLCs, who is providing the PLCs and provide diagrams and schematics regarding connection and interaction with other equipment. All hardware, including power supplies, special cables, and other appurtenant equipment, shall be provided to meet the functional requirements described herein and indicated on the Drawings.

1-2.03. I/O List. An input/output (I/O) field device signal listing is included as an appendix attached to this section.

1-3. SUBMITTALS. Submittals shall be as specified in the Instrumentation and Control System, Submittal Procedures, and Schedule of Submittals sections.

1-4. DELIVERY, STORAGE, AND SHIPPING. Delivery, storage and shipping shall be as specified in the Instrumentation and Control System Section.

1-5. SPARE PARTS. The System Supplier shall provide spare parts per the general Terms and Conditions

PART 2 - PRODUCTS

2-1. GENERAL. All equipment furnished under this section shall be expressly selected by System Supplier for its superior quality for the intended purpose and shall comply with the following requirements.

2-1.01. Interchangeability. All programmable logic controller systems shall be products of the same manufacturer and of the same series or product line. Processors, local and remote input/output hardware, communications modules, and specialty modules such as coprocessors and ASCII modules shall be interchangeable among all I/O panels and systems. PLC modules and hardware by other manufacturers will be acceptable only if the PLC manufacturer does not offer suitable modules and hardware for the same functions.

2-1.02. Initial, Spare, and Future Memory (RAM). System Supplier shall provide adequate memory for the amount of I/O, control algorithms, and communications in the initial system.

Each programmable logic controller shall include provisions for future expansion and shall have 100 percent spare memory capacity and 100 percent spare data capacity installed. The spare memory capacity shall be documented by submitting to Design-Builder, during factory testing, a statement indicating the amounts of memory of all types being utilized and the total amount available in each system. The statement shall include an estimate of the total program and data memory necessary, including spare memory, based on the I/O hardware for the system, and previous programming experience.

2-1.03. Spare I/O. Each PLC input/output enclosure shall be provided with at least 20 percent spare inputs and outputs of each type. Spare I/O shall be installed, wired, and interfaced properly to the terminal strip. The spare I/O shall be in addition to any I/O installed and reserved for future process signals as may be indicated on the I/O list. In addition, each PLC input/output enclosure shall be capable of accommodating 25 percent of additional input/output capacity of each type as originally assembled, without the need for additional expansion racks, communication adapters, cables, or PLC power supplies.

2-1.04. Expandability. Each PLC processor and associated I/O shall have a future expandability of at least 50 percent of the provided system.

2-1.05. Acceptable Manufacturers. The PLCs shall be Schneider Electric/Modicon, without exception.

2-1.06. Signal Power Supplies. Regulated dc power supplies shall be provided in each PLC enclosure for analog inputs, digital outputs, digital inputs. Power supplies shall be suitable for an input voltage variation of ±10 percent, and the

supply output shall be fused or protected against short-circuiting. Output voltage regulation shall be as required by the instrumentation equipment supplied under another section.

The loop power supply shall be separate from the power supply circuit for the processor and racks.

The power source for all digital inputs from field devices shall be separately fused for each digital input module. Unless otherwise noted, all field devices will be provided with dry contacts that close to provide an input to the PLC.

2-1.07. Appurtenances. The PLC processor and I/O hardware shall be provided as complete systems, as shown on the control system block diagram drawings. The PLCs shall include all necessary hardware and software for a complete working system. All special rack or panel mounted power supplies, special interconnecting and programming cables, special grounding hardware, or isolation devices shall be furnished for proper operation of the equipment. Signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, intrinsically safe relays and current repeaters, surge suppression devices, and isolation devices shall be furnished and installed for proper operation of the equipment.

2-1.08. PLC Arrangement. The PLCs shall be distributed and arranged as indicated on the Drawings. PLC I/O for duty/standby equipment from separate process trains shall be connected to separate I/O modules.

2-1.09. Service Conditions. PLCs will be installed in air conditioned rooms, non air conditioned room, or soutdoors where the ambient temperature range is 6-22°C. PLCs shall be furnished with sun shades and air conditioned and heated enclosures.

2-2. LARGE PLC PROCESSOR. The Schneider Electric/Modicon M580 programmable logic controller processor shall be an industrial-type rack-mounted unit that utilizes battery-backed CMOS type or nonvolatile type memory. Battery backed memory shall include integral batteries with sufficient capacity for at least 6 months' memory retention without power to the processing unit. Standby and shelf life of the batteries shall be at least 5 years.

The system shall include an Erasable Programmable Read Only Memory (EPROM) card for storage of the user program. The processor shall automatically download the user program from the EPROM upon startup after a power loss. The EPROM shall be programmable by the PLC or PLC software, without the use of external PROM programmable equipment.

2-2.01. Diagnostics. The processor shall utilize self-monitoring diagnostic techniques and shall contain easily visible LED diagnostic indicators for "run" and

"halt" conditions as well as memory and input/output error conditions. Diagnostic codes shall also be available through the programming device to facilitate troubleshooting.

2-2.02. Programming Port. The processor shall include a programming port that is available for programming and monitoring on-line after the system is fully functional, and after all communications, human machine interface (HMI), and network connections have been made. Removal or disruption of network communications, remote I/O communications, and HMIs to allow for on-line programming and monitoring will not be acceptable. A key switch shall be provided on the processor for selection of the operating mode and as a security measure.

2-2.03. Communications. The processor shall be programmed to operate autonomously, regardless of communications status with other units. Each programmable controller shall be furnished complete with communication modules for local and remote input/output hardware communications, communications with other programmable controllers, and communication with host computers as shown on the block diagram.

2-2.04. Environment. The processor shall be suitable for operation in the environments specified in another section.

2-2.05. Programming. The processor shall be programmable using the IEC 1131 international programming standards and ladder logic programming. IEC 1131 programming shall include the following:

Functional Block Diagram

Functional Block Diagram programming shall include a minimum of the following capabilities:

Contacts, coils, branching.

Data comparisons.

On-delay and off-delay timers.

Counters with comparators.

Floating point Math and Logical instructions.

PID loop control.

Jumps and Subroutine functions.

Master control relay.

Transitional or one-shot outputs.

Standard and user-defined data tables for digital and analog value

storage.

Remote I/O capability.

Fault-mode sub-routine.

2-2.06. Programming Capabilities. The processor shall include the following capabilities for programming, debugging of programs, and troubleshooting.

Off-line programming.

On-line programming.

On-line status of coils and registers.

Input/output forcing.

2-2.07. Hardware Configuration. Processors shall be configured for standard rack mounting. Each programmable logic controller processor shall include integral communications ports for the programming device, remote input/output, HMI device, or remote communications interfaces.

2-2.08. Input/Output Hardware. Input/output hardware shall be arranged as indicated on the Drawings. Programmable logic controller systems shall support the following types of input/output modules.

24 volt dc digital input and output.

4-20 mA dc analog input and output.

Platinum RTD analog input.

All digital input/output hardware shall include isolation against surges of at least 1500 volts. All output hardware connected to inductive loads shall be supplied with surge suppression devices and recommended by the PLC manufacturer to prevent damage to output hardware. Combination input/output modules will not be acceptable.

2-2.08.01. Wiring Terminals. All input/output modules shall utilize easily removable plug-in or hinged field wiring terminals to allow removal of modules without disconnecting individual wires.

2-2.08.02. I/O Circuit Power Supply. Outputs for motor driven equipment will typically be powered from the driven equipment. Digital outputs for miscellaneous equipment shall be powered either from the controlled equipment or the PLC enclosure as indicated on the Drawings or as coordinated with the controlled equipment supplier. Outputs that control process equipment specified under other sections or provided under other contracts shall be fully isolated or shall

operate either interposing relays or relay-type digital output modules in the PLC cabinet.

2-2.08.03. Digital Input Modules. Digital input modules shall sense voltages between 20 and 28 volts dc and shall have LED indicators for each point to display the status of the field contact. Each input module shall be suitable for being connected to a separate voltage source and return. Return voltage may be common to the entire input module. Digital input modules shall provide complete electrical isolation between individual inputs. Digital input modules shall have multiple inputs.

2-2.08-04. Digital Output Modules. Digital output modules shall control voltages from 20 and 28 volts dc and shall be rated at least 1 ampere. Outputs shall be individually fused and shall have LED indicators to display output status. Outputs shall withstand a surge of at least 80 amperes for one cycle and shall have an off-state leakage current not to exceed 2.0 mA. Digital output modules shall provide complete electrical isolation between individual output circuits. Digital output modules shall have multiple outputs.

2-2.08.05. Relay Digital Output Modules. Not used.

2-2.08.06. Analog Input Modules. Analog input modules shall accept linear 4-20 mA dc signals from field transmitters. Analog to digital conversion accuracy shall be at least 12-bit (0-4095 count) resolution. Analog input modules shall have multiple inputs. Each input shall be fully isolated from the other inputs.

2-2.08.07. Analog Output Modules. Not used.Analog output modules shall transmit linear 4-20 mA dc signals to field devices. Loop power for all analog outputs shall be provided by regulated power supplies in each input/output enclosure and shall be capable of driving a 0 to 600 ohm load. Digital to analog conversion accuracy shall be at least 12-bit (0-4095 count) resolution. Analog output modules shall have multiple outputs.

2-2.08.08. Panel Terminations. All PLC input/output signals for field connections shall be terminated through panel enclosure terminal strips. Direct connection of field wiring to the I/O module terminals is not acceptable.

2-2.08.09. Interposing Relays. Interposing relays shall be incorporated on all I/O circuits as shown on the PLC input/output listing, where required by the application of isolate foreign power sources, where the continuous output rating of the PLC relay digital or output module is not sufficient to power the connected device or equipment, or where otherwise required by the System Supplier's equipment. Interposing relays shall be provided for any digital output module output signal that leaves the PLC enclosure. Interposing relays shall be mounted in the PLC enclosure containing the output module that activates the relays.

2-3. MINI PLC PROCESSOR. The Schneider Electric/Modicon M340 programmable logic controller processor shall be an industrial type that utilizes battery-backed CMOS type or non-volatile type memory. Battery-backed memory shall include integral batteries with sufficient capacity for at least 6 months' memory retention without power to the processing unit. Standby and shelf life of the batteries shall be at least 5 years.

2-3.01. Diagnostics. The processor shall utilize self-monitoring diagnostic techniques. Easily visible LEDs shall indicate "run" and "halt" status as well as memory and input/output error conditions. Diagnostic codes shall also be available through the programming device to facilitate troubleshooting.

2-3.02. Programming Port. The processor shall include a programming port that is available for programming and monitoring on-line after the system is fully functional. Removal or disruption of network communications, remote I/O communications, or HMIs to permit programming and monitoring will not be acceptable.

2-3.03. Communications. The processor shall be programmed to operate autonomously, regardless of communications status with other units.

2-3.04. Environment. The processor shall be suitable for operation in the environments specified in another section. A key switch shall be provided on the processor to select the operating mode and as a security measure.

2-3.05. Programming. The processor shall be programmable using conventional relay ladder logic, or as required, and shall include the following functions and features.

Contacts, coils, branching.

Data comparisons.

On-delay and off-delay timers.

Counters with comparators.

Floating Point Math and Logical instructions.

Master control relay.

Transitional or one-shot outputs.

Standard and user-defined data tables for digital and analog value storage.

2-3.06. Capabilities. The processor shall include the following capabilities for programming, debug of programs, and troubleshooting.

Off-line programming.

On-line status of coils and registers.

Input/output forcing.

2-3.07. Configuration. Processors shall be configured for standard rack mounting and shall be of plug-in printed circuit board construction. Each programmable logic controller shall include integral communications ports for the programming device, remote input/output, HMI device, or remote communications interfaces as required.

Programmable logic controller systems shall support the following types of input/output.

24 volt dc digital input and output.

4-20 mA dc analog input and output.

2-3.08. Input/Output Hardware. Input/output hardware shall be supplied in standard modules of 4, 8, 16, or 32 points each for assembly in local and remote input/output enclosures.

All input/output hardware shall be entirely contained within the PLC enclosure.

Programmable logic controllers having fixed, non-removable input/output hardware are not acceptable.

All digital input/output hardware shall include isolation against surges of at least 1500 volts. All output hardware connected to inductive loads shall be supplied with surge suppression devices as required and recommended by the PLC manufacturer to prevent damage to output hardware. Combination input/output modules will be acceptable if they meet all of the requirements in the following subparagraphs.

2-3.08.01. Wiring Terminals. All input/output modules shall utilize easily removable plug-in or hinged field wiring terminals to allow removal of modules without disconnecting individual wires.

2-3.08.02. I/O Circuit Power Supply. Outputs for motor driven equipment will typically be powered from the driven equipment. Digital outputs for miscellaneous equipment shall be powered either from the controlled equipment or the PLC enclosure as indicated on the Drawings or as coordinated with the controlled equipment supplier. Outputs that control process equipment specified under other sections or provided under other contracts shall be fully isolated or shall operate relay-type digital output modules or interposing relays in the PLC cabinet.

2-3.08.03. Digital Input Modules. Digital input modules shall sense voltages between 20 and 28 volts dc and shall have LED indicators for each point to display the status of the field contact. Each input module shall be suitable for being connected to a separate voltage source and return. Return voltage may be common to the entire input module. Digital input modules shall provide complete electrical isolation between individual inputs.

2-3.08.04. Digital Output Modules. Digital output modules shall control voltages from 20 and 28 volts dc and shall be rated at least 1 ampere. Outputs shall be individually fused and shall have LED indicators to display output status. Each digital output shall be provided with an interposing relay. Outputs shall withstand a surge of at least 80 amperes for one cycle and shall have an off-state leakage current not to exceed 2.0 mA. Digital input modules shall provide complete electrical isolation between individual inputs.

2-3.08.05. Relay Digital Output Modules. Not used.

2-3.08.06. Analog Input Modules. Analog input modules shall accept linear 4-20 mA dc signals from field transmitters. Input circuitry shall be floating differential type designed to prevent loop grounding. Analog to digital conversion accuracy shall be at least 12 bit (0-4095 count) resolution. Where analog input signals are grounded outside of the PLC enclosure, isolation shall be provided for the associated analog input point either on the analog input module or through an I/I signal isolator provided in the PLC enclosure.

2-3.08.07. Analog Output Modules. Analog output modules shall transmit linear 4-20 mA dc signals to field devices. Loop power for all analog outputs shall be provided by regulated power supplies in each input/output enclosure and shall be capable of driving a 0 to 600 ohm load. Digital to analog conversion accuracy shall be at least 12 bit (0-4095 count) resolution.

2-3.08.08. Panel Terminations. All PLC input/output signals for field connections shall be terminated through panel enclosure terminal strips. Direct connection of field wiring to the I/O module terminals is not acceptable.

2-4. COMMUNICATIONS. Each programmable controller system shall be furnished complete with communication hardware modules for local input/output hardware, remote input/output hardware, other programmable controllers, or for host computers.

Communication hardware shall be compatible with the cable, data highway, fiber optic, or radio communication media. Ethernet components and cable are specified in other specification sections.

2-4.01. Addressability. Each programmable logic controller shall be individually addressable so that only the selected controller responds when queried. At least

64 distinct network addresses shall be available. IP addressing shall be used. Designation of a controller's network address may be either a software or hardware function.

2-4.02. Communications Hardware. System Supplier shall provide all necessary communications hardware. Hardware shall be included for, but not be limited to, remote I/O, data highway, host computer, fiber optics, Ethernet and radio.

2-4.02.01. PLC to PLC Communications Hardware. Each PLC shall communicate to other PLCs over a network as shown on the control system block diagram. System Supplier shall include all rack mounted, enclosure mounted, or desktop mounted communications modules required for a complete working system.

2-4.02.02. PLC to Remote I/O Communications Hardware. The master PLC shall communicate with the remote PLC rack over a remote I/O communications network. System Supplier shall include all rack mounted, enclosure mounted, or desktop mounted communications modules required for a complete working system.

2-4.02.03. PLC to Host Communications Hardware. Each PLC shall communicate to the host computer over a network as shown on the control system block diagram. System Supplier shall include all rack mounted, enclosure mounted, or desktop mounted communications modules required for a complete working system. The computer system hardware is covered in another section.

2-4.03. Communications Media. System Supplier shall provide all necessary cabling for the PLC communications network and PLC remote I/O communications network. Communications cables shall meet the requirements of the manufacturers of the PLCs and communications modules. PLC communications media shall be as specified under the Network Systems section.

2-5. MEDIA CONVERTERS. Not Used.

2-6. TELEPHONE NETWORKS. Not used

2-7. SERIAL NETWORKS. Not Used.

2-8. PROGRAMMING DEVICE HARDWARE. The programming device shall be a portable laptop computer as specified in the Computer System Hardware section. System Supplier shall provide two interconnecting cables, each 5 meters long, to connect the computer to the programmable logic controller. The cables shall be shielded data cable and shall be terminated on both ends with the appropriate connectors. Connectors shall be labeled to identify the connected equipment.

2-8.01. Special Devices. System Supplier shall provide two sets of any special devices (such as null modems, adapter cards, interface converters, etc.) required to establish an operational programming line between the programmable logic controllers and programming device.

2-9. PROGRAMMING SOFTWARE. System Supplier shall furnish one licensed copy of PLC programming software for the Owner and one licensed copy for the Design-Builder. The software shall be suitable for running on a laptop computer running Windows 10 operating system software. A full legal set of programming software documentation shall accompany each copy of the software. Each copy of the programming software shall include all necessary device drivers and add-on software packages.

2-9.01. Standard Product. The programming software shall be personal computer based and a standard product of the PLC manufacturer. The software shall be Schneider Electric/Modicon EcoStruxure Control Expert.

2-9.02. PLC Simulation. Not used .

2-9.03. Programming Software Features. The programming software shall allow off-line development of all PLC-related programming, including user annotation of the program, and creation and printing of application programs and I/O cross-reference lists. Special programming tasks originally provided by System Supplier shall also be included.

On-line features shall include IEC-61131 standards program modification, ladder-logic modification, program language modification, monitoring of real-time ladder-logic execution, monitoring of program execution, monitoring and manipulation of timer and counter preset and present values, monitoring and forcing of physical I/O, and monitoring and manipulation of analog (register) and bit (binary) data table values. PLC and I/O hardware diagnostic and status information shall be accessible using the software in on-line mode.

2-10. SYSTEM ENCLOSURES. Programmable logic controllers and input/output hardware shall be housed in shop-assembled panels as indicated on the Drawings and as described in the Panels, Consoles, and Appurtenances section. Programmable logic controllers and input/output hardware shall be housed in existing panels or panels provided by others.

2-11. OPERATOR INTERFACE TERMINALS. Operator interface terminals (OIT) shall be microprocessor-based flat panel type. The unit shall have data entry capabilities and shall include a password security function. The unit shall be connected to the PLC and shall display status, alarm, and diagnostic information. The unit shall provide a nominal diagonal display area dimension of 12”, with a minimum resolution of 800x600, 18 bit color, and a luminance of 300

cd/m^2. The OIT shall be furnished with a minimum of 8 MB of flash memory and 8 MB of system memory. The operator interface unit shall be provided with an Ethernet port for communications, and one serial RS-232 or RS-485 port for programming. The OIT shall be rated NEMA 4X, suitable for panel face.

Terminals shall be powered from 120 V ac, 60 Hz, single phase. Terminals shall be suitable for ambient temperatures of +32 to +130°F and a relative humidity of 5 to 95 percent.

One licensed copy of the OIT software used to create the screens shall be turned over to the Owner upon successful startup and commissioning of the system.

The operator interface unit shall be an Eaton PanelMate Power Pro 3000, or equal.

OIT shall provide graphic screens that shall be used by the operators to access all functions and setpoints necessary for comprehensive control. The Manufacturer shall be responsible for developing and configuring the custom graphic displays. Each piece of major process equipment that is monitored and controlled by the control system shall be displayed on the graphic screens. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. The manufacturer shall use the configuration standards and conventions to be established by direct coordination with the Owner that shall describe and define such items as proposed graphic display process line colors/representations; color standards for “on”, “off”, “opened”, “closed”, and “alarm” conditions; alarm handling conventions; how items will be selected for control; methods for navigation between displays; address usage/naming conventions; and security setup. The Owner utilizes the stop light standard where green is running and open while red is stopped or closed. Proposed displays shall be submitted to the Design-Builder and Owner for approval.

PART 3 - EXECUTION

3-1. INSTALLATION REQUIREMENTS. PLCs installation requirements are specified in Instrumentation and Control System section except as described herein.

Field check, testing, and training shall be as specified in the Instrumentation and Control System section.

3-2. CONFIGURATION.

3-2.01. PLC Programming and Configuration. Configuration services are specified in the Instrumentation and Control System section.

3-2.02. Communications Configuration. The communications shall be fully configured and installed by System Supplier, and shall be operational before application software configuration by others. Communications shall be configured as shown on the Drawings.

End of Section

Input/Output List - Legend/Description Sheet

Item. This is an arbitrary sequential number which is for reference only.
IO Type: This is the type of I/O signal, as follows:
AI = Analog Input
AO = Analog Output
DI = Discrete Input
DO = Discrete Output
PI = Pulse Input (totalizer or accumulator type input)
Description. This is the description or the function (i.e. Filter No. 1 Loss-of-Head).
Field Device. This is the tag number of equipment identifier associated with the I/O point.
Controller ID. This is a sequential number for a given type within a specific controller (PLC or DCU).
Analog Data (Signal Type). This will typically be 4-20mA, but could also be 1-5Vdc, serial, HART, FLD-BUS, or similar to indicate the signal type of the associated input or output.
Analog Data (Calibrated Range). This will be the scaled value of the input in engineering units.
Analog Data (Power). This will typically be '2-wire' for devices which are loop powered from the PLC enclosure, or '4-wire' for devices which are powered form external power supplies, unless noted otherwise.
Discrete Data (Signal Type). This will be 120VAC, 24VDC, or similar to indicate the signal type of the associated input or output.
Discrete Data (Closed State). This will indicate the state of the input or output when it is considered to be closed or energized (normal, alarm, running, failed, etc.).
Discrete Data (Power Source). This will indicate the location of the power source for the wetting voltage on the contacts, as follows:
Field = External field power source. (May require interposing relays or isolated I/O module type.)
Local = Power originates from within the PLC or I/O enclosure.

Discrete Data (Interp Relay). This will be either 'Yes' or 'No' to indicate whether the input or output requires an interposing relay. Relays are typically required to isolate external voltage sources. See specifications for additional details.
P&ID. This column indicates associated Process & Instrumentation Diagram.

Remarks. This column may include a cross reference to another specification section where applicable, or to a note which provides additional information. Notes are appended to the end of the I/O listing.

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
1	AI	FI	101	INFLUENT MAIN 1 FLOW	FIT-0101	21-CTRL-RIO-0001	4 -20 MA		4 -WIRE	N/A	N/A	N/A	N/A	21-I-001	
2	AI	FI	201	INFLUENT MAIN 1 FLOW	FIT-0201	21-CTRL-RIO-0001	4 -20 MA		4 -WIRE	N/A	N/A	N/A	N/A	21-I-001	
3	AI	FI	301	PLANT DRAIN SYSTEM FLOW	FIT-0301	21-CTRL-RIO-0001	4 -20 MA		4 -WIRE	N/A	N/A	N/A	N/A	21-I-001	
4	AI	LI	1	SAFE DIVERSION BOX LEVEL	LIT-0001	21-CTRL-RIO-0001	4 -20 MA		4 -WIRE	N/A	N/A	N/A	N/A	22-I-001	
5	AI	FI	1001	FINE SCREEN INLET HEADER FLOW	FIT-1001	21-CTRL-RIO-0001	4 -20 MA		4 -WIRE	N/A	N/A	N/A	N/A	22-I-001	
6	AI	ZI	1002	FINE SCREEN INLET HEADER FLOW CONTROL VALVE POSITION	V-1002	21-CTRL-RIO-0001	4 -20 MA		4 -WIRE	N/A	N/A	N/A	N/A	22-I-001	
7	AO	FI	1	COMPOSITE SAMPLER FLOW COMMAND		21-CTRL-RIO-0001	4 -20 MA		4 -WIRE	N/A	N/A	N/A	N/A	22-I-001	
8	AO	ZC	1002	FINE SCREEN INLET HEADER FLOW CONTROL VALVE POSITION COMMAND	V-1002	21-CTRL-RIO-0001	4 -20 MA		4 -WIRE	N/A	N/A	N/A	N/A	22-I-001	
9	DI	YA	2	BAR SCREEN NO.1 FAIL		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	FAIL	PLC	No	21-I-001	
10	DI	YI	2	BAR SCREEN NO.1 IN AUTO		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	IN AUTO	PLC	No	21-I-001	
11	DI	LAH	2	BAR SCREEN NO.1 HI LEVEL		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	HI LEVEL	PLC	No	21-I-001	
12	DI	YA	2	BAR SCREEN NO.1 E-STOP		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	E-STOP	PLC	No	21-I-001	
13	DI	YIR	2	BAR SCREEN NO.1 RUNNING		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	RUNNING	PLC	No	21-I-001	
14	DI	YIR	2	BAR SCREEN NO.1 LOW SPEED		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	LOW SPEED	PLC	No	21-I-001	
15	DI	YIR	2	BAR SCREEN NO.1 HIGH SPEED		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	HIGH SPEED	PLC	No	21-I-001	
16	DI	YI	1002		V-1002	21-CTRL-RIO-0001							No	21-I-001	
17	DI	ZIO	1002		V-1002	21-CTRL-RIO-0001							No	21-I-001	
18	DI	ZIC	1002		V-1002	21-CTRL-RIO-0001							No	21-I-001	
19	DI	YA	2	BAR SCREEN NO.2 FAIL		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	FAIL	PLC	No	21-I-002	
20	DI	YI	2	BAR SCREEN NO.2 IN AUTO		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	IN AUTO	PLC	No	21-I-002	
21	DI	LAH	2	BAR SCREEN NO.2 HI LEVEL		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	HI LEVEL	PLC	No	21-I-002	
22	DI	YA	2	BAR SCREEN NO.2 E-STOP		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	E-STOP	PLC	No	21-I-002	
23	DI	YIR	2	BAR SCREEN NO.2 RUNNING		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	RUNNING	PLC	No	21-I-002	
24	DI	YIR	2	BAR SCREEN NO.2 LOW SPEED		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	LOW SPEED	PLC	No	21-I-002	
25	DI	YIR	2	BAR SCREEN NO.2 HIGH SPEED		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	HIGH SPEED	PLC	No	21-I-002	
26	DI	YI	2002		V-2002	21-CTRL-RIO-0001							No	21-I-002	
27	DI	ZIO	2002		V-2002	21-CTRL-RIO-0001							No	21-I-002	
28	DI	ZIC	2002		V-2002	21-CTRL-RIO-0001							No	21-I-002	
29	DI	YIA	1	SCREEN CONVEYOR SYSTEM E-STOP		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	E-STOP	PLC	No	22-I-001	
30	DI	SI	1	SCREEN CONVEYOR SYSTEM ZERO SPEED		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	ZERO SPEED	PLC	No	22-I-001	
31	DI	IA	1	SCREEN CONVEYOR SYSTEM MOTOR OVERLOAD		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OVERLOAD	PLC	No	22-I-001	
32	DI	YIR	1	SCREEN CONVEYOR SYSTEM RUNNING		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	22-I-001	
33	DI	YI	1	SCREEN CONVEYOR SYSTEM IN REMOTE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	22-I-001	
34	DI	FA	1	COMPOSITE SAMPLER IN TROUBLE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN TRBL	PLC	No	22-I-001	
35	DI	YIR	1001	FINE SCREEN 1 IN AUTO		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN AUTO	PLC	No	22-I-001	
36	DI	YIR	1001	FINE SCREEN 1 RUNNING FAST		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING FAST	PLC	No	22-I-001	
37	DI	YIR	1001	FINE SCREEN 1 RUNNING SLOW		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING SLOW	PLC	No	22-I-001	
38	DI	FA	1001	FINE SCREEN 1 IN TROUBLE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN TRBL	PLC	No	22-I-001	
39	DI	PDA	1001	FINE SCREEN 1 HIGH DIFFERNTIAL PRESSURE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI DIFF PRESSURE	PLC	No	22-I-001	
40	DI	PAL	1001	FINE SCREEN 1 LOW SPRAY WATER PRESSURE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	LOW PRESSURE	PLC	No	22-I-001	
41	DI	YI	1002	FINE SCREEN INLET HEADER FLOW CONTROL VALVE IN REMOTE	V-1002	21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	22-I-001	
42	DI	YIR	2001	FINE SCREEN 2 IN AUTO		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN AUTO	PLC	No	22-I-001	
43	DI	YIR	2001	FINE SCREEN 2 RUNNING FAST		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING FAST	PLC	No	22-I-001	
44	DI	YIR	2001	FINE SCREEN 2 RUNNING SLOW		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING SLOW	PLC	No	22-I-001	
45	DI	FA	2001	FINE SCREEN 2 IN TROUBLE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN TRBL	PLC	No	22-I-001	
46	DI	PDA	2001	FINE SCREEN 2 HIGH DIFFERNTIAL PRESSURE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI DIFF PRESSURE	PLC	No	22-I-001	
47	DI	PAL	2001	FINE SCREEN 2 LOW SPRAY WATER PRESSURE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	LOW PRESSURE	PLC	No	22-I-001	
48	DI	YIR	1	ODOR CONTROL SYSTEM RUNNNING		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	23-I-001	
49	DI	YI	1	ODOR CONTROL SYSTEM IN REMOTE		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	23-I-001	
50	DI	UA	1	ODOR CONTROL SYSTEM COMMON FAIL		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	COMMON FAIL	PLC	No	23-I-001	
51	DO	UCR	1	START TRAIN 1 COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	START CMD	PLC	YES	21-I-001	
52	DO	UCR	1	STOP TRAIN 1 COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	STOP CMD	PLC	YES	21-I-001	
53	DO		1			21-CTRL-RIO-0001							No	21-I-001	
54	DO		1			21-CTRL-RIO-0001							No	21-I-001	
55	DO	SRC	2	SPEED RESET COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	RESET CMD	PLC	YES	21-I-001	
56	DO	ZCO	1002		V-1002	21-CTRL-RIO-0001							No	21-I-001	
57	DO	ZCC	1002		V-1002	21-CTRL-RIO-0001							No	21-I-001	
58	DO	SRC	2	SPEED RESET COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	RESET CMD	PLC	YES	21-I-002	
59	DO		2			21-CTRL-RIO-0001							No	21-I-002	
60	DO		2			21-CTRL-RIO-0001							No	21-I-002	
61	DO	UCR	2	START TRAIN 2 COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	START CMD	PLC	YES	21-I-002	
62	DO	UCR	2	STOP TRAIN 2 COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	STOP CMD	PLC	YES	21-I-002	
63	DO	ZCO	2002		V-2002	21-CTRL-RIO-0001							No	21-I-002	
64	DO	ZCC	2002		V-2002	21-CTRL-RIO-0001							No	21-I-002	
65	DO	UCR	1	SCREEN CONVEYOR SYSTEM RUN COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	22-I-001	
66	DO	UCR	1001	FINE SCREEN 1 RUN COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	22-I-001	
67	DO	UCR	2001	FINE SCREEN 1 RUN COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	22-I-001	
68	DO	UCR	1	ODOR CONTROL SYSTEM RUN COMMAND		21-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	23-I-001	
69	?	ZIO	2			21-RIO-001							No	21-I-002	
70	?	ZIC	2			21-RIO-001							No	21-I-002	
71	?	ZIO	2			21-RIO-001							No	21-I-002	
72	?	ZIC	2			21-RIO-001							No	21-I-002	
73	?	YI	2			21-RIO-001							No	21-I-002	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
74	?	PAH	2			21-RIO-001							No	21-I-002	
75	?	LAH	2			21-RIO-001							No	21-I-002	
76	?	LAH	2			21-RIO-001							No	21-I-002	
77	?	YI	2			21-RIO-001							No	21-I-002	
78	?		2			21-RIO-001							No	21-I-002	
79	?		2			21-RIO-001							No	21-I-002	
80	?	XX	2			21-RIO-001							No	21-I-002	
81	?	YIR	2			21-RIO-001							No	21-I-002	
82	?	YIR	2			21-RIO-001							No	21-I-002	
83	?	LAH	2			21-RIO-001							No	21-I-002	
84	?	LAH	2			21-RIO-001							No	21-I-002	
85	?	YI	2			21-RIO-001							No	21-I-002	
86	?	YI	2			21-RIO-001							No	21-I-002	
87	?		2			21-RIO-001							No	21-I-002	
88	?		2			21-RIO-001							No	21-I-002	
89	DI	YI	1001		V-1001	21-RIO-001							No	21-I-001	
90	DI	ZIO	1001		V-1001	21-RIO-001							No	21-I-001	
91	DI	ZIC	1001		V-1001	21-RIO-001							No	21-I-001	
92	DI	YI	2			21-RIO-001							No	21-I-002	
93	DI	YI	2			21-RIO-001							No	21-I-002	
94	DI	YIR	2			21-RIO-001							No	21-I-002	
95	DI	YIR	2			21-RIO-001							No	21-I-002	
96	DI	YIR	2			21-RIO-001							No	21-I-002	
97	DI	LAHH	2			21-RIO-001							No	21-I-002	
98	DI	YIR	2			21-RIO-001							No	21-I-002	
99	DI	LAHH	2			21-RIO-001							No	21-I-002	
100	DI	YI	2			21-RIO-001							No	21-I-002	
101	DI	YA	2			21-RIO-001							No	21-I-002	
102	DI	YA	2			21-RIO-001							No	21-I-002	
103	DI	YA	2			21-RIO-001							No	21-I-002	
104	DI	YI	2			21-RIO-001							No	21-I-002	
105	DI	YA	2			21-RIO-001							No	21-I-002	
106	DI	YA	2			21-RIO-001							No	21-I-002	
107	DI	YIR	2			21-RIO-001							No	21-I-002	
108	DI	YIR	2			21-RIO-001							No	21-I-002	
109	DI	LAHH	2			21-RIO-001							No	21-I-002	
110	DI	YI	1001		V-2001	21-RIO-001							No	21-I-002	
111	DI	ZIO	1001		V-2001	21-RIO-001							No	21-I-002	
112	DI	ZIC	1001		V-2001	21-RIO-001							No	21-I-002	
113	DO	ZCO	1001		V-1001	21-RIO-001							No	21-I-001	
114	DO	ZCC	1001		V-1001	21-RIO-001							No	21-I-001	
115	DO	ZCO	2			21-RIO-001							No	21-I-002	
116	DO	ZCC	2			21-RIO-001							No	21-I-002	
117	DO	ZCO	2			21-RIO-001							No	21-I-002	
118	DO	ZCC	2			21-RIO-001							No	21-I-002	
119	DO	SRC	2			21-RIO-001							No	21-I-002	
120	DO	SRC	2			21-RIO-001							No	21-I-002	
121	DO	ZCO	1001		V-2001	21-RIO-001							No	21-I-002	
122	DO	ZCC	1001		V-2001	21-RIO-001							No	21-I-002	
123	AI	FI	1	RECYCLED WATER PUMP COMMON OUTLET HEADER FLOW	TW-FIT-0001	31-CTRL-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	34-I-001	
124	AI	AI	1	BNR SPLITTER BOX pH LEVEL	AIT-0001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
125	AI	AI	1	RAS DEOX AREA TOTAL SUSPENDED SOLIDS CONTENT	AIT-0001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
126	AI	AI	1001	BNR ANOXIC AREA OXYGEN REDUCTION POTENTIAL	AIT-1001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
127	AI	LI	1001	BASIN 1 MIXED LIQUOR COLLECTION CHANNEL LEVEL	MEM-LIT-1001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
128	AI	AI	1002	AERATION BASIN 1 MLSS CONTENT	AIT-1002	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
129	AI	AI	1003	AERATION BASIN 1 AMMONIUM(NH4) CONTENT	AIT-1003	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
130	AI	AI	1003	AERATION BASIN 1 AMMONIA (NH3) CONTENT	AIT-1003	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
131	AI	FI	1101	BLOWERS TO AERATION BASIN DIFFUSERS AIR FLOW	FIT-1101	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
132	AI	ZI	1101	BLOWERS TO AERATION BASIN DIFFUSERS AIR ISO VALVE 1 POSITION FEEDBACK	V-1101	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-001	
133	AI	AI	1101	AERATION BASIN DISSOLVED OXYGEN CONTENT	AIT-1101	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
134	AI	FI	1201	BLOWERS TO AERATION BASIN 1 DIFFUSERS AIR FLOW	FIT-1201	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
135	AI	ZI	1201	BLOWERS TO AERATION BASIN 1 DIFFUSERS AIR ISO VALVE 2 POSITION FEEDBACK	V-1201	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-001	
136	AI	AI	1201	AERATION BASIN 1 DISSOLVED OXYGEN CONTENT	AIT-1201	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-001	
137	AI	AI	2001	BASIN 2 ANOXIC AREA OXYGEN REDUCTION POTENTIAL	BNR-AIT-2001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
138	AI	LI	2001	BASIN 2 MIXED LIQUOR COLLECTION CHANNEL LEVEL	MEM-LIT-2001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
139	AI	AI	2002	AERATION BASIN 2 MLSS CONTENT	BNR-AIT-2002	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
140	AI	AI	2003	AERATION BASIN 2 AMMONIA (NH3) CONTENT	BNR-AIT-2003	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
141	AI	AI	2003	AERATION BASIN 2 AMMONIUM (NH4) CONTENT	BNR-AIT-2003	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
142	AI	FI	2101	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR FLOW	AER-FIT-2101	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
143	AI	ZI	2101	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR ISO VALVE 1 POSITION FEEDBACK	AER-V-2101	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-002	
144	AI	AI	2101	AERATION BASIN 2 DISSOLVED OXYGEN CONTENT	BNR-AIT-2101	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
145	AI	FI	2201	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR FLOW	AER-FIT-2201	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
146	AI	ZI	2201	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR ISO VALVE 2 POSITION FEEDBACK	AER-V-2201	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-002	
147	AI	AI	2201	AERATION BASIN 2 DISSOLVED OXYGEN CONTENT	BNR-AIT-2201	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-002	
148	AI	LI	1	SCUM/WAS WETWELL LEVEL	WAS-LIT-0001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-003	
149	AI	FI	1	MBR RAS TO SCUM/WAS PUMPS HEADER FLOW	WAS-FIT-0001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-003	
150	AI	FI	2	SCUM/WAS PUMPS OUTLET HEADER FLOW	WAS-FIT-0002	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	31-I-003	
151	AI	PI	1	DRY SCREW PROCESS AIR BLOWERS COMMON HEADER LINE PRESSURE	AER-PIT-0001	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
152	AI	SI	101	DRY SCREW PROCESS AIR BLOWER NO. 1 SPEED INDICATION	LCP-0101	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
153	AI	II	101	DRY SCREW PROCESS AIR BLOWER NO. 1 MOTOR CURRENT	LCP-0101	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
154	AI	SI	201	DRY SCREW PROCESS AIR BLOWER NO. 2 SPEED INDICATION	LCP-0201	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
155	AI	II	201	DRY SCREW PROCESS AIR BLOWER NO. 2 MOTOR CURRENT	LCP-0201	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
156	AI	SI	301	DRY SCREW PROCESS AIR BLOWER NO. 3 SPEED INDICATION	LCP-0301	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
157	AI	II	301	DRY SCREW PROCESS AIR BLOWER NO. 3 MOTOR CURRENT	LCP-0301	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
158	AI	ZI	1001			31-CTRL-RIO-0001	4-20 mA			N/A	N/A	N/A	N/A	32-I-001	
159	AI	FI	1001	RAS COLLECTION CHANNEL NO. 1 TO RAS DEOX FLOW	RAS-FIT-1001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-001	
160	AI	LI	1002	RAS COLLECTION CHANNEL NO. 1 LEVEL	MEM-LIT-1002	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-001	
161	AI	ZI	1003	EJECTOR ASSEMBLY ISO VALVE POSITION FEEDBACK		31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-001	
162	AI	LI	2001	MEMBRANE BASIN 2 LEVEL	MEM-LIT-2001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-002	
163	AI	FI	2001	RAS COLLECTION CHANNEL NO. 2 TO RAS DEOX FLOW	RAS-FIT-2001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-002	
164	AI	ZI	2001			31-CTRL-RIO-0001	4-20 mA			N/A	N/A	N/A	N/A	32-I-002	
165	AI	LI	2002	RAS COLLECTION CHANNEL NO. 2 LEVEL	MEM-LIT-2002	31-CTRL-RIO-0001	4-20 mA			N/A	N/A	N/A	N/A	32-I-002	
166	AI	PI	1001	FILTRATE PUMP NO. 1 INLET HEADER PRESSURE	MEM-PIT-1001	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-003	
167	AI	SI	1001	FILTRATE PUMP NO. 1 SPEED FEEDBACK	VFD-1001	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-003	
168	AI	FI	1001	FILTRATE PUMP NO. 1 OUTLET FLOW	MEM-FIT-1001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-003	
169	AI	AI	1001	FILTRATE PUMP NO. 1 OUTLET TURBIDITY MEASUREMENT	MEM-AIT-1001	31-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-003	
170	AI	LI	101	RO FEED TANK 1 LEVEL	RO-LIT-0101	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	33-I-001	
171	AI	LI	201	RO FEED TANK 2 LEVEL	RO-LIT-0201	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	33-I-001	
172	AO	ZC	1101	BLOWERS TO AERATION BASIN DIFFUSERS AIR ISO VALVE 1 POSITION SETPT	V-1101	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-001	
173	AO	ZC	1201	BLOWERS TO AERATION BASIN 1 DIFFUSERS AIR ISO VALVE 2 POSITION SETPT	V-1201	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-001	
174	AO	ZC	2101	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR ISO VALVE 1 POSITION SETPT	AER-V-2101	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-002	
175	AO	ZC	2201	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR ISO VALVE 2 POSITION SETPT	AER-V-2201	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-002	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
176	AO	SC	101	DRY SCREW PROCESS AIR BLOWER NO. 1 SPEED CONTROL	LCP-0101	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
177	AO	SC	201	DRY SCREW PROCESS AIR BLOWER NO. 2 SPEED CONTROL	LCP-0201	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
178	AO	SC	301	DRY SCREW PROCESS AIR BLOWER NO. 3 SPEED CONTROL	LCP-0301	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-004	
179	AO	ZC	1001			31-CTRL-RIO-0001	4-20 mA			N/A	N/A	N/A	N/A	32-I-001	
180	AO	ZC	1003	EJECTOR ASSEMBLY ISO VALVE POSITION SETPT		31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-001	
181	AO	ZC	2001			31-CTRL-RIO-0001	4-20 mA			N/A	N/A	N/A	N/A	32-I-002	
182	AO	SC	1001	FILTRATE PUMP NO. 1 SPEED SETPT	VFD-1001	31-CTRL-RIO-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-003	
183	DI	UA	1	BNR SPLITTER BOX pH ANALYZER FAIL	AIT-0001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-001	
184	DI	UA	1	RAS DEOX AREA TOTAL SUSPENDED SOLIDS ANALYZER FAIL	AIT-0001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-001	
185	DI	UA	1001	BNR ANOXIC AREA OXYGEN REDUCTION POTENTIAL ANALYZER FAIL	AIT-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-001	
186	DI	YI	1001	BASIN 1 MBR FEED PUMP OUTLET VALVE IN REMOTE	BNR-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-001	
187	DI	ZIO	1001	BASIN 1 MBR FEED PUMP OUTLET VALVE OPENED	BNR-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	31-I-001	
188	DI	ZIC	1001	BASIN 1 MBR FEED PUMP OUTLET VALVE CLOSED	BNR-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	31-I-001	
189	DI	PAH	1001		BNR-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		PLC	No	31-I-001	
190	DI	YI	1001	BASIN 1 SCUM COLLECTION BOX TO WAS WETWELL ISO VALVE IN REMOTE	V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-001	
191	DI	YI	1001		V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		PLC	No	31-I-001	
192	DI	ZIC	1001	BASIN 1 SCUM COLLECTION BOX TO WAS WETWELL ISO VALVE CLOSED	V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	31-I-001	
193	DI	ZIC	1001		V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		PLC	No	31-I-001	
194	DI	ZIO	1001	BASIN 1 SCUM COLLECTION BOX TO WAS WETWELL ISO VALVE OPENED	V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	31-I-001	
195	DI	ZIO	1001		V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		PLC	No	31-I-001	
196	DI	UA	1002	AERATION BASIN 1 MLSS ANALYZER INSTRUMENT FAIL	AIT-1002	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-001	
197	DI	UA	1003	AERATION BASIN 1 AMMONIA/AMMONIUM ANALYZER INSTRUMENT FAIL	AIT-1003	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-001	
198	DI	YI	1101	BLOWERS TO AERATION BASIN DIFFUSERS AIR ISO VALVE 1 IN REMOTE	V-1101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-001	
199	DI	UA	1101	AERATION BASIN DISSOLVED OXYGEN ANALYSER INSTRUMENT FAIL	AIT-1101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-001	
200	DI	YI	1201	BLOWERS TO AERATION BASIN 1 DIFFUSERS AIR ISO VALVE 2 IN REMOTE	V-1201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-001	
201	DI	UA	1201	AERATION BASIN 1 DISSOLVED OXYGEN	AIT-1201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		PLC	No	31-I-001	
202	DI	UA	2001	BASIN 2 ANOXIC AREA ORP ANALYZER INSTRUMENT FAIL	BNR-AIT-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-002	
203	DI	YI	2001	BASIN 2 MBR FEED PUMP OUTLET VALVE IN REMOTE	BNR-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-002	
204	DI	ZIO	2001	BASIN 2 MBR FEED PUMP OUTLET VALVE OPENED	BNR-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	31-I-002	
205	DI	ZIC	2001	BASIN 2 MBR FEED PUMP OUTLET VALVE CLOSED	BNR-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	31-I-002	
206	DI	YI	2001	BASIN 2 SCUM COLLECTION BOX TO WAS HEADER ISO VALVE IN REMOTE	WAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-002	
207	DI	ZIO	2001	BASIN 2 SCUM COLLECTION BOX TO WAS HEADER ISO VALVE OPENED	WAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	31-I-002	
208	DI	ZIC	2001	BASIN 2 SCUM COLLECTION BOX TO WAS HEADER ISO VALVE CLOSED	WAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	31-I-002	
209	DI	UA	2002	AERATION BASIN 2 MLSS ANALYZER INSTRUMENT FAIL	BNR-AIT-2002	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-002	
210	DI	UA	2003	AERATION BASIN 2 AMMONIA/AMMONIUM ANALYZER INSTRUMENT FAIL	BNR-AIT-2003	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-002	
211	DI	YI	2101	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR ISO VALVE 1 IN REMOTE	AER-V-2101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-002	
212	DI	UA	2101	AERATION BASIN 2 DISSOLVED OXYGEN ANALYZER INSTRUMENT FAIL	BNR-AIT-2101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-002	
213	DI	YI	2201	BLOWERS TO AERATION BASIN 2 DIFFUSERS AIR ISO VALVE 2 IN REMOTE	AER-V-2201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-002	
214	DI	UA	2201	AERATION BASIN 2 DISSOLVED OXYGEN ANALYZER INSTRUMENT FAIL	BNR-AIT-2201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-002	
215	DI	LAHH	1	SCUM/WAS WETWELL LEVEL HIGH HIGH	WAS-LSHH-0001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	HI-HI	PLC	No	31-I-003	
216	DI	LALL	1	SCUM/WAS WETWELL LEVEL LOW LOW	WAS-LSLL-0001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	LO-LO	PLC	No	31-I-003	
217	DI	YA	101	DRY SCREW PROCESS AIR BLOWER NO. 1 FAULT	LCP-0101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	31-I-004	
218	DI	YI	101	DRY SCREW PROCESS AIR BLOWER NO. 1 IN REMOTE	LCP-0101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-004	
219	DI	YA	101	DRY SCREW PROCESS AIR BLOWER NO. 1 WARNING	LCP-0101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	WARNING	PLC	No	31-I-004	
220	DI	YIR	101	DRY SCREW PROCESS AIR BLOWER NO. 1 RUNNING	LCP-0101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-004	
221	DI	YA	201	DRY SCREW PROCESS AIR BLOWER NO. 2 FAULT	LCP-0201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	31-I-004	
222	DI	YI	201	DRY SCREW PROCESS AIR BLOWER NO. 2 IN REMOTE	LCP-0201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-004	
223	DI	YA	201	DRY SCREW PROCESS AIR BLOWER NO. 2 WARNING	LCP-0201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	WARNING	PLC	No	31-I-004	
224	DI	YIR	201	DRY SCREW PROCESS AIR BLOWER NO. 2 RUNNING	LCP-0201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-004	
225	DI	YA	301	DRY SCREW PROCESS AIR BLOWER NO. 3 FAULT	LCP-0301	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	31-I-004	
226	DI	YI	301	DRY SCREW PROCESS AIR BLOWER NO. 3 IN REMOTE	LCP-0301	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-004	
227	DI	YA	301	DRY SCREW PROCESS AIR BLOWER NO. 3 WARNING	LCP-0301	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	WARNING	PLC	No	31-I-004	
228	DI	YIR	301	DRY SCREW PROCESS AIR BLOWER NO. 3 RUNNING	LCP-0301	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-004	
229	DI	YI	1001			31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		PLC	No	32-I-001	
230	DI	YI	1001	CITRIC ACID SOLUTION FEED ISO VALVE IN REMOTE	CA-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-001	
231	DI	ZIO	1001	CITRIC ACID SOLUTION FEED ISO VALVE OPENED	CA-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-001	
232	DI	ZIC	1001	CITRIC ACID SOLUTION FEED ISO VALVE CLOSED	CA-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-001	
233	DI	YI	1001	MEMBRANE BASIN 1 INLET ISO VALVE IN REMOTE	MEM-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-001	
234	DI	ZIO	1001	MEMBRANE BASIN 1 INLET ISO VALVE OPENED	MEM-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-001	
235	DI	ZIC	1001	MEMBRANE BASIN 1 INLET ISO VALVE CLOSED	MEM-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-001	
236	DI	YI	1001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE IN REMOTE	NOCL-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-001	
237	DI	YI	1001	RAS COLLECTION CHANNEL NO. 1 TO RAS DEOX ISO VALVE IN REMOTE	RAS-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-001	
238	DI	ZIC	1001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE CLOSED	NOCL-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-001	
239	DI	ZIC	1001	RAS COLLECTION CHANNEL NO. 1 TO RAS DEOX ISO VALVE CLOSED	RAS-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-001	
240	DI	ZIO	1001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE OPENED	NOCL-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-001	
241	DI	ZIO	1001	RAS COLLECTION CHANNEL NO. 1 TO RAS DEOX ISO VALVE OPENED	RAS-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-001	
242	DI	YI	1003	EJECTOR ASSEMBLY ISO VALVE IN REMOTE		31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-001	
243	DI	LAHH	2001	MEMBRANE BASIN 2 LEVEL HIGH HIGH	MEM-LSHH-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	HI-HI	PLC	No	32-I-002	
244	DI	LALL	2001	MEMBRANE BASIN 2 LEVEL LOW LOW	MEM-LSLL-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	LO-LO	PLC	No	32-I-002	
245	DI	YI	2001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE IN REMOTE	NOCL-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-002	
246	DI	YI	2001	CITRIC ACID SOLUTION FEED ISO VALVE IN REMOTE	CA-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-002	
247	DI	ZIC	2001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE CLOSED	NOCL-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-002	
248	DI	ZIC	2001	CITRIC ACID SOLUTION FEED ISO VALVE CLOSED	CA-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-002	
249	DI	ZIO	2001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE OPENED	NOCL-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-002	
250	DI	ZIO	2001	CITRIC ACID SOLUTION FEED ISO VALVE OPENED	CA-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-002	
251	DI	YI	2001	RAS COLLECTION CHANNEL NO. 2 TO RAS DEOX ISO VALVE IN REMOTE	RAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-002	
252	DI	YI	2001	MEMBRANE BASIN 2 INLET ISO VALVE IN REMOTE	MEM-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-002	
253	DI	YI	2001			31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		PLC	No	32-I-002	
254	DI	ZIC	2001	RAS COLLECTION CHANNEL NO. 2 TO RAS DEOX ISO VALVE CLOSED	RAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-002	
255	DI	ZIC	2001	MEMBRANE BASIN 2 INLET ISO VALVE CLOSED	MEM-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-002	
256	DI	ZIO	2001	RAS COLLECTION CHANNEL NO. 2 TO RAS DEOX ISO VALVE OPENED	RAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-002	
257	DI	ZIO	2001	MEMBRANE BASIN 2 INLET ISO VALVE OPENED	MEM-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-002	
258	DI	YI	1001	FILTRATE PUMP NO. 1 IN REMOTE	VFD-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-003	
259	DI	YIR	1001	FILTRATE PUMP NO. 1 RUNNING	VFD-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	32-I-003	
260	DI	YA	1001	FILTRATE PUMP NO. 1 AFD FAULT	VFD-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	AFD FAULT	PLC	No	32-I-003	
261	DI	UA	1001	FILTRATE PUMP NO. 1 OUTLET TURBIDITY ANALYZER INSTRUMENT FAIL	MEM-AIT-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	32-I-003	
262	DI	YI	1005	FILTRATE PUMP NO. 1 INLET ISO VALVE CLOSE IN REMOTE	MEM-V-1005	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-003	
263	DI	ZIO	2001	FILTRATE PUMP NO. 1 INLET ISO VALVE OPENED	MEM-V-1005	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-003	
264	DI	ZIC	2001	FILTRATE PUMP NO. 1 INLET ISO VALVE CLOSED	MEM-V-1005	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-003	
265	DI	LAHH	101	RO FEED TANK 1 LEVEL HIGH HIGH	RO-LSHH-0101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	HI-HI	PLC	No	33-I-001	
266	DI	LALL	101	RO FEED TANK 1 LEVEL LOW LOW	RO-LSLL-0101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	LO-LO	PLC	No	33-I-001	
267	DI	LAHH	201	RO FEED TANK 2 LEVEL HIGH HIGH	RO-LSHH-0201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	HI-HI	PLC	No	33-I-001	
268	DI	LALL	201	RO FEED TANK 2 LEVEL LOW LOW	RO-LSLL-0201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	LO-LO	PLC	No	33-I-001	
269	DO	ZCC	1001	BASIN 1 SCUM COLLECTION BOX TO WAS WETWELL ISO VALVE CLOSE COMMAND	V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	31-I-001	
270	DO	ZCC	1001		V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		FIELD	YES	31-I-001	
271	DO	ZCO	1001	BASIN 1 SCUM COLLECTION BOX TO WAS WETWELL ISO VALVE OPEN COMMAND	V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	31-I-001	
272	DO	ZCO	1001		V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC		FIELD	YES	31-I-001	
273	DO	ZCO	1001	BASIN 1 MBR FEED PUMP OUTLET OPEN COMMAND	BNR-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	31-I-001	
274	DO	ZCC	1001	BASIN 1 MBR FEED PUMP OUTLET CLOSE COMMAND	BNR-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	31-I-001	
275	DO	ZCO	2001	BASIN 2 MBR FEED PUMP OUTLET VALVE OPEN CMD	BNR-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	31-I-002	
276	DO	ZCC	2001	BASIN 2 MBR FEED PUMP OUTLET VALVE CLOSE CMD	BNR-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	31-I-002	
277	DO	ZCO	2001	BASIN 2 SCUM COLLECTION BOX TO WAS HEADER ISO VALVE OPEN CMD	WAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	31-I-002	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
278	DO	ZCC	2001	BASIN 2 SCUM COLLECTION BOX TO WAS HEADER ISO VALVE CLOSE CMD	WAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	31-I-002	
279	DO	ZCO	2	RCW SYSTEM ISO VALVE OPEN CMD	RCW-V-0002	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	31-I-003	
280	DO	UCR	101	DRY SCREW PROCESS AIR BLOWER NO. 1 RUN CMD	LCP-0101	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	31-I-004	
281	DO	UCR	201	DRY SCREW PROCESS AIR BLOWER NO. 2 RUN CMD	LCP-0201	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	31-I-004	
282	DO	UCR	301	DRY SCREW PROCESS AIR BLOWER NO. 3 RUN CMD	LCP-0301	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	31-I-004	
283	DO	ZCC	1001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE CLOSE CMD	NOCL-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-001	
284	DO	ZCC	1001	RAS COLLECTION CHANNEL NO. 1 TO RAS DEOX ISO VALVE CLOSE CMD	RAS-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-001	
285	DO	ZCO	1001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE OPEN CMD	NOCL-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-001	
286	DO	ZCO	1001	RAS COLLECTION CHANNEL NO. 1 TO RAS DEOX ISO VALVE OPEN CMD	RAS-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-001	
287	DO	ZCO	1001	CITRIC ACID SOLUTION FEED ISO VALVE OPEN CMD	CA-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-001	
288	DO	ZCC	1001	CITRIC ACID SOLUTION FEED ISO VALVE CLOSE CMD	CA-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-001	
289	DO	ZCO	1001	MEMBRANE BASIN 1 INLET ISO VALVE OPEN CMD	MEM-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-001	
290	DO	ZCC	1001	MEMBRANE BASIN 1 INLET ISO VALVE CLOSE CMD	MEM-V-1001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-001	
291	DO	ZCC	2001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE CLOSE CMD	NOCL-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-002	
292	DO	ZCC	2001	CITRIC ACID SOLUTION FEED ISO VALVE CLOSE CMD	CA-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-002	
293	DO	ZCO	2001	SODIUM HYPOCHLORITE SOLUTION FEED ISO VALVE OPEN CMD	NOCL-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-002	
294	DO	ZCO	2001	CITRIC ACID SOLUTION FEED ISO VALVE OPEN CMD	CA-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-002	
295	DO	ZCC	2001	RAS COLLECTION CHANNEL NO. 2 TO RAS DEOX ISO VALVE CLOSE CMD	RAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-002	
296	DO	ZCC	2001	MEMBRANE BASIN 2 INLET ISO VALVE CLOSE COMMAND	MEM-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-002	
297	DO	ZCO	2001	RAS COLLECTION CHANNEL NO. 2 TO RAS DEOX ISO VALVE OPEN CMD	RAS-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-002	
298	DO	ZCO	2001	MEMBRANE BASIN 2 INLET ISO VALVE OPEN COMMAND	MEM-V-2001	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-002	
299	DO	ZCO	1014	FILTRATE PUMP NO. 1 OUTLET TURBIDITY INSTRUMENT ISO VALVE OPEN CMD	MEM-V-1014	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-003	
300	DO	ZCO	2001	FILTRATE PUMP NO. 1 INLET ISO VALVE OPEN CMD	MEM-V-1005	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-003	
301	DO	ZCC	2001	FILTRATE PUMP NO. 1 INLET ISO VALVE CLOSE CMD	MEM-V-1005	31-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-003	
302	AI	LI	1		FIT-1101	31-RIO-0001							No	31-I-001	
303	AI	VI	1		FIT-1101	31-RIO-0001							No	31-I-001	
304	AI	AI	1		AIT-0001	31-RIO-0001							No	31-I-001	
305	AI	FI	2		FIT-1101	31-RIO-0001							No	31-I-001	
306	AI	FI	3		FIT-1101	31-RIO-0001							No	31-I-001	
307	DI	FAH	1		FIT-1101	31-RIO-0001							No	31-I-001	
308	DI	LAH	1		FIT-1101	31-RIO-0001							No	31-I-001	
309	DI	PAH	3		BNR-V-1001	31-RIO-0001							No	31-I-001	
310	DI	PAH	4		BNR-V-1001	31-RIO-0001							No	31-I-001	
311	AI	LI	1001	MEMBRANE BASIN 1 LEVEL	MEM-LIT-1001	32-MBR-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-001	
312	AI	ZI	1001	MEMBRANE BASIN 1 AIR SUPPLY LINE ISO VALVE POSITION FEEDBACK	AIR-V-1001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-001	
313	AI	ZI	2001	MEMBRANE BASIN 2 AIR SUPPLY ISO VALVE POSITION FEEDBACK	AIR-V-2001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-002	
314	AI	PI	2001	FILTRATE PUMP NO. 2 INLET HEADER PRESSURE	MEM-PIT-2001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-004	
315	AI	SI	2001	FILTRATE PUMP NO. 2 SPEED FEEDBACK	VFD-2001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-004	
316	AI	FI	2001	FILTRATE PUMP NO. 2 OUTLET FLOW	MEM-FIT-2001	32-MBR-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-004	
317	AI	AI	2001	FILTRATE PUMP NO. 2 OUTLET TURBIDITY MEASUREMENT	MEM-AIT-2001	32-MBR-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-004	
318	AI	TI	1	RO FEED TANK INLET HEADER TEMPERATURE MEASUREMENT	MEM-TT-0001	32-MBR-LCP-0001	4-20 mA	32-104 DEGF	2-WIRE	N/A	N/A	N/A	N/A	32-I-005	
319	AI	AI	1	RO FEED TANK INLET HEADER NH3 MEASUREMENT	MEM-AIT-0001	32-MBR-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-005	
320	AI	AI	2	RO FEED TANK INLET HEADER TURBIDITY MEASUREMENT	MEM-AIT-0002	32-MBR-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-005	
321	AI	FI	1	ROTARY LOBE MEMBRANE SCOUR BLOWERS COMMON OUTLET HEADER FLOW	AIR-FIT-0001	32-MBR-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-006	
322	AI	PI	1	ROTARY LOBE MEMBRANE SCOUR BLOWERS COMMON OUTLET HEADER PRESSURE	AIR-PIT-0001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-006	
323	AI	SI	101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 SPEED INDICATION	LCP-0101	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-006	
324	AI	II	101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 MOTOR CURRENT	LCP-0101	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-006	
325	AI	SI	201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 SPEED INDICATION	LCP-0201	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-006	
326	AI	II	201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 MOTOR CURRENT	LCP-0201	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-006	
327	AI	SI	1	DRAIN PUMP SPEED FEEDBACK	VFD-0001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-007	
328	AI	FI	1	DRAIN PUMP OUTLET FLOW	DRN-FIT-0001	32-MBR-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	32-I-007	
329	AO	ZC	1001	MEMBRANE BASIN 1 AIR SUPPLY LINE ISO VALVE POSITION SETPT	AIR-V-1001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-001	
330	AO	ZC	2001	MEMBRANE BASIN 2 AIR SUPPLY ISO VALVE POSITION SETPT	AIR-V-2001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-002	
331	AO	SC	2001	FILTRATE PUMP NO. 2 SPEED SETPT	VFD-2001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-004	
332	AO	SC	101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 SPEED CONTROL	LCP-0101	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-006	
333	AO	SC	201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 SPEED CONTROL	LCP-0201	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-006	
334	AO	SC	1	DRAIN PUMP SPEED SETPT	VFD-0001	32-MBR-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	32-I-007	
335	DI	LAHH	1001	MEMBRANE BASIN 1 LEVEL HIGH HIGH	MEM-LSHH-1001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	HI-HI	PLC	No	32-I-001	
336	DI	LALL	1001	MEMBRANE BASIN 1 LEVEL LOW LOW	MEM-LSLL-1001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	LO-LO	PLC	No	32-I-001	
337	DI	YI	1001	MEMBRANE BASIN 1 AIR SUPPLY LINE ISO VALVE IN REMOTE	AIR-V-1001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-001	
338	DI	LAHH	1002	MEMBRANE BASIN 1 LEVEL HIGH HIGH	MEM-LSHH-1002	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	HI-HI	PLC	No	32-I-001	
339	DI	YI	2001	MEMBRANE BASIN 2 AIR SUPPLY ISO VALVE IN REMOTE	AIR-V-2001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-002	
340	DI	LAHH	2002	MEMBRANE BASIN 2 LEVEL HIGH HIGH	MEM-LSHH-2002	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	HI-HI	PLC	No	32-I-002	
341	DI	YI	2001	FILTRATE PUMP NO. 2 IN REMOTE	VFD-2001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-004	
342	DI	YIR	2001	FILTRATE PUMP NO. 2 RUNNING	VFD-2001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	32-I-004	
343	DI	YA	2001	FILTRATE PUMP NO. 2 AFD FAULT	VFD-2001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	AFD FAULT	PLC	No	32-I-004	
344	DI	UA	2001	FILTRATE PUMP NO. 2 OUTLET TURBIDITY ANALYZER INSTRUMENT FAIL	MEM-AIT-2001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	32-I-004	
345	DI	YI	2001	FILTRATE PUMP NO. 2 INLET ISO VALVE IN REMOTE	MEM-V-2005	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-004	
346	DI	ZIO	2001	FILTRATE PUMP NO. 2 INLET ISO VALVE OPENED	MEM-V-2005	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	32-I-004	
347	DI	ZIC	2001	FILTRATE PUMP NO. 2 INLET ISO VALVE CLOSED	MEM-V-2005	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	32-I-004	
348	DI	UA	1	RO FEED TANK INLET HEADER NH3 ANALYZER INSTRUMENT FAIL	MEM-AIT-0001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	32-I-005	
349	DI	UA	2	RO FEED TANK INLET HEADER TURBIDITY ANALYZER INSTRUMENT FAIL	MEM-AIT-0002	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	32-I-005	
350	DI	YA	101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 FAULT	LCP-0101	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	32-I-006	
351	DI	YI	101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 IN REMOTE	LCP-0101	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-006	
352	DI	YA	101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 WARNING	LCP-0101	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	WARNING	PLC	No	32-I-006	
353	DI	YIR	101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 RUNNING	LCP-0101	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	32-I-006	
354	DI	YA	201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 FAULT	LCP-0201	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	32-I-006	
355	DI	YI	201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 IN REMOTE	LCP-0201	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-006	
356	DI	YA	201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 WARNING	LCP-0201	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	WARNING	PLC	No	32-I-006	
357	DI	YIR	201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 RUNNING	LCP-0201	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	32-I-006	
358	DI	YI	1	DRAIN PUMP IN REMOTE	VFD-0001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	32-I-007	
359	DI	YIR	1	DRAIN PUMP RUNNING	VFD-0001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	32-I-007	
360	DI	YA	1	DRAIN PUMP FAIL	VFD-0001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	32-I-007	
361	DO	ZCO	1002	AIR SUPPLY ASSEMBLY ISO VALVE OPEN CMD	IA-V-1002	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-001	
362	DO	ZCO	2002	MEMBRANE BASIN 2 AIR SUPPLY LINE ISO VALVE OPEN CMD	V-2002	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-002	
363	DO	ZCO	2001	FILTRATE PUMP NO. 2 INLET ISO OPEN CMD	MEM-V-2005	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-004	
364	DO	ZCC	2001	FILTRATE PUMP NO. 2 INLET ISO CLOSE CMD	MEM-V-2005	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	32-I-004	
365	DO	ZCO	2014	FILTRATE PUMP NO. 2 OUTLET TURBIDITY INSTRUMENT ISO VALVE OPEN CMD	MEM-V-2014	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	32-I-004	
366	DO	UCR	101	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 1 RUN CMD	LCP-0101	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	32-I-006	
367	DO	UCR	201	ROTARY LOBE MEMBRANE SCOUR BLOWER NO. 2 RUN CMD	LCP-0201	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	32-I-006	
368	DO	UCR	1	DRAIN PUMP RUN CMD	VFD-0001	32-MBR-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	32-I-007	
369	AI	AI	1	RO FEED PUMPS COMMON HEADER INLET CONDUCTIVITY	RO-AIT-0001	51-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-001	
370	AI	FI	1	RO FEED PUMPS COMMON HEADER INLET FLOW	RO-FIT-0001	51-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-001	
371	AI	AI	2	RO FEED PUMPS COMMON HEADER INLET TURBIDITY	RO-AIT-0002	51-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-001	
372	AI	AI	3	RO FEED PUMPS COMMON HEADER INLET ORP	RO-AIT-0003	51-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-001	
373	AI	AI	4	RO FEED PUMPS COMMON HEADER INLET FREE CHLORINE	RO-AIT-0004	51-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-001	
374	AI	AI	5	RO FEED PUMPS COMMON HEADER INLET MONO-CHLORIMINE/AMMONIA	RO-AIT-0005	51-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-001	
375	AI	AI	6	RO FEED PUMPS COMMON HEADER INLET pH	RO-AIT-0006	51-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-001	
376	AI	AI	6	RO FEED PUMPS COMMON HEADER INLET TEMP	RO-AIT-0006	51-CTRL-RIO-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-001	
377	AI	SI	101	RO PUMP 1 SPEED FEEDBACK	AFD-0101	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	
378	AI	DPI	103	RO CARTRIDGE FILTER NO. 1 DIFF. PRESSURE	PDIT-0103	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	
379	AI	SI	201	RO PUMP 2 SPEED FEEDBACK	AFD-0201	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
380	AI	DPI	203	RO CARTRIDGE FILTER NO. 2 DIFF. PRESSURE	PDIT-0203	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	
381	AI	SI	301	RO PUMP 3 SPEED FEEDBACK	AFD-0301	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	
382	AI	DPI	303	RO CARTRIDGE FILTER NO. 3 DIFF. PRESSURE	PDIT-0303	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	
383	AI	FI	1	SEWER OR STORM DRAIN FLOW	CAL-FIT-0001	51-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	61-I-001	
384	AI	LI	1	BACKWASH WASTE HOLDING TANK LEVEL	CAL-LIT-0001	51-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	61-I-001	
385	AI	SI	1	CALCITE VESSEL FLUSH PUMP SPEED FEEDBACK	AFD-0001	51-CTRL-RIO-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	61-I-001	
386	AI	LI	1	STORAGE TANK LEVEL	TW-LIT-0001	51-CTRL-RIO-0001	4 - 20 MA		2 - WIRE	N/A	N/A	N/A	No	62-I-001	
387	AI	AI	1	STORAGE TANK DISCHARGE TOTAL CHLORINE	TW-AIT-0001	51-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	62-I-001	
388	AI	AI	2	STORAGE TANK DISCHARGE CONDUCTIVITY	TW-AIT-0002	51-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	62-I-001	
389	AI	AI	3	STORAGE TANK DISCHARGE pH	TW-AIT-0003	51-CTRL-RIO-0001	4 - 20 MA	0 - 14	4 - WIRE	N/A	N/A	N/A	No	62-I-001	
390	AI	PI	1	IPR PUMP STATION DISCHARGE HEADER PRESSURE	TW-PIT-0001	51-CTRL-RIO-0001	4 - 20 MA		2 - WIRE	N/A	N/A	N/A	No	63-I-001	
391	AI	FI	1	IPR PUMP STATION DISCHARGE HEADER FLOW	TW-FIT-0001	51-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	63-I-001	
392	AI	AI	8	IPR PUMP STATION DISCHARGE HEADER pH	TW-AIT-0008	51-CTRL-RIO-0001	4 - 20 MA	0 - 14	4 - WIRE	N/A	N/A	N/A	No	63-I-001	
393	AI	SI	101	IPR PUMP NO 1 SPEED FEEDBACK	AFD-0101	51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	63-I-001	
394	AI	SI	201	IPR PUMP NO 2 SPEED FEEDBACK	AFD-0201	51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	63-I-001	
395	AI	SI	301	IPR PUMP NO 3 SPEED FEEDBACK	AFD-0301	51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	63-I-001	
396	AI	LI	1	OUTFALL BALANCING TANK LEVEL	TW-LIT-0001	51-CTRL-RIO-0001	4 - 20 MA		2 - WIRE	N/A	N/A	N/A	No	64-I-001	
397	AI	FI	1	OUTFALL PUMP STATION DISCHARGE HEADER FLOW	TW-FIT-0001	51-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	64-I-001	
398	AI	SI	101	OUTFALL PUMP NO 1 SPEED FEEDBACK	101	51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	64-I-001	
399	AI	SI	201	OUTFALL PUMP NO 2 SPEED FEEDBACK		51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	64-I-001	
400	AI	SI	301	OUTFALL PUMP NO 3 SPEED FEEDBACK		51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	64-I-001	
401	AI	SI	401	OUTFALL PUMP NO 4 SPEED FEEDBACK		51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	64-I-001	
402	AI	AI	1	OUTFALL PUMP STATION DISCHARGE HEADER FREE CHLORINE	TW-AIT-0001	51-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	65-I-001	
403	AO	SC	101	RO PUMP 1 SPEED SETPOINT	AFD-0101	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	
404	AO	SC	201	RO PUMP 2 SPEED SETPOINT	AFD-0201	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	
405	AO	SC	301	RO PUMP 3 SPEED SETPOINT	AFD-0301	51-CTRL-RIO-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-002	
406	AO	SC	1	CALCITE VESSEL FLUSH PUMP SPEED SET POINT	AFD-0001	51-CTRL-RIO-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	61-I-001	
407	AO	SC	101	IPR PUMP NO 1 SPEED SET POINT	AFD-0101	51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	63-I-001	
408	AO	SC	201	IPR PUMP NO 2 SPEED SET POINT	AFD-0201	51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	63-I-001	
409	AO	SC	301	IPR PUMP NO 3 SPEED SET POINT	AFD-0301	51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	63-I-001	
410	AO	SC	101	OUTFALL PUMP NO 1 SPEED SET POINT	101	51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	64-I-001	
411	AO	SC	201	OUTFALL PUMP NO 2 SPEED SET POINT		51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	64-I-001	
412	AO	SC	301	OUTFALL PUMP NO 3 SPEED SET POINT		51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	64-I-001	
413	AO	SC	401	OUTFALL PUMP NO 4 SPEED SET POINT		51-CTRL-RIO-0001	4 - 20 MA	0 - 100%	4 - WIRE	N/A	N/A	N/A	No	64-I-001	
414	AO	FI	1	COMPOSITE SAMPLER FLOW NEAR OCEAN OUTFALL SET POINT		51-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	65-I-001	
415	DI	FA	1	RO FEED PUMPS COMMON HEADER INLET CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	51-I-001	
416	DI	YIR	1	RO INLET SAMPLE PUMP RUNNING	RO-P-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-001	
417	DI	UA	1	RO INLET SAMPLE PUMP FAIL	RO-P-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	51-I-001	
418	DI	FA	2	RO FEED PUMPS COMMON HEADER INLET TURBIDITY ANALYZER INSTRUMENT FAIL	RO-AIT-0002	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	51-I-001	
419	DI	FA	3	RO FEED PUMPS COMMON HEADER INLET ORP ANALYZER INSTRUMENT FAIL	RO-AIT-0003	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	51-I-001	
420	DI	FA	4	RO FEED PUMPS COMMON HEADER INLET FREE CHLORINE ANALYZER INSTRUMENT FAIL	RO-AIT-0004	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	51-I-001	
421	DI	FA	5	RO FEED PUMPS COMMON HEADER INLET MONO-CHLORIMINE/AMMONIA ANALYZER INSTRUMENT FAIL	RO-AIT-0005	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	51-I-001	
422	DI	FA	6	RO FEED PUMPS COMMON HEADER INLET pH/TEMP ANALYZER INSTRUMENT FAIL	RO-AIT-0006	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	51-I-001	
423	DI	YI	12	RO PUMP TO OCEAN OUTFALL TANK ISO VALVE IN REMOTE	RO-V-0012	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-001	
424	DI	ZIO	12	RO PUMP TO OCEAN OUTFALL TANK ISO VALVE OPENED	RO-V-0012	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-001	
425	DI	ZIC	12	RO PUMP TO OCEAN OUTFALL TANK ISO VALVE CLOSED	RO-V-0012	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-001	
426	DI	PAL	101	RO PUMP 1 SUCTION PRESSURE LOW	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	PRESSURE LOW	PLC	No	51-I-002	
427	DI	PAH	101	RO PUMP 1 DISCHARGE PRESSURE HIGH	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	PRESSURE HIGH	PLC	No	51-I-002	
428	DI	YI	101	RO PUMP 1 IN REMOTE	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-002	
429	DI	YIR	101	RO PUMP 1 RUNNING	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-002	
430	DI	UA	101	RO PUMP 1 FAILED	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-002	
431	DI	PAL	201	RO PUMP 2 SUCTION PRESSURE LOW	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	PRESSURE LOW	PLC	No	51-I-002	
432	DI	PAH	201	RO PUMP 2 DISCHARGE PRESSURE HIGH	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	PRESSURE HIGH	PLC	No	51-I-002	
433	DI	YI	201	RO PUMP 2 IN REMOTE	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-002	
434	DI	YIR	201	RO PUMP 2 RUNNING	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-002	
435	DI	UA	201	RO PUMP 2 FAILED	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-002	
436	DI	PAL	301	RO PUMP 3 SUCTION PRESSURE LOW	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	PRESSURE LOW	PLC	No	51-I-002	
437	DI	PAH	301	RO PUMP 3 DISCHARGE PRESSURE HIGH	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	PRESSURE HIGH	PLC	No	51-I-002	
438	DI	YI	301	RO PUMP 3 IN REMOTE	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-002	
439	DI	YIR	301	RO PUMP 3 RUNNING	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-002	
440	DI	UA	301	RO PUMP 3 FAILED	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-002	
441	DI	YI	307	RO FLUSH PUMPS TO RO SYSTEM 3 FLUSH VALVE IN REMOTE	RO-V-0307	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-002	
442	DI	ZIO	307	RO FLUSH PUMPS TO RO SYSTEM 3 FLUSH VALVE OPENED	RO-V-0307	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-002	
443	DI	ZIC	307	RO FLUSH PUMPS TO RO SYSTEM 3 FLUSH VALVE CLOSED	RO-V-0307	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-002	
444	DI	LAH	1	BUND LEVEL HIGH	CIP-LSH-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	LEVEL HIGH	PLC	No	51-I-009	
445	DI	FAH	1	EYEWASH FLOW DETECTED	CIP-FSH-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FLOW HIGH	PLC	No	51-I-009	
446	DI	UA	1	PROCESS BUILDING TEMP CONTROL PANEL	RO-TCP-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	51-I-010	
447	DI	YI	1	CALCITE VESSEL FLUSH PUMP IN REMOTE	AFD-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	61-I-001	
448	DI	YIR	1	CALCITE VESSEL FLUSH PUMP RUNNING	AFD-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	61-I-001	
449	DI	YA	1	CALCITE VESSEL FLUSH PUMP FAIL	AFD-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	61-I-001	
450	DI	YI	1	BACKWASH WASTE HOLDING TANK DRAIN VALVE IN REMOTE	CAL-V-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	61-I-001	
451	DI	ZIO	1	BACKWASH WASTE HOLDING TANK DRAIN VALVE OPENED	CAL-V-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	61-I-001	
452	DI	ZIC	1	BACKWASH WASTE HOLDING TANK DRAIN VALVE CLOSED	CAL-V-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	61-I-001	
453	DI	PDAH	101	CALCITE VESSEL NO 1 HIGH DIFFERENTIAL PRESSURE	CAL-PDS-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	DIFF PRESS HIGH	PLC	No	61-I-001	
454	DI	PDAH	201	CALCITE VESSEL NO 2 HIGH DIFFERENTIAL PRESSURE	CAL-PDS-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	DIFF PRESS HIGH	PLC	No	61-I-001	
455	DI	LALL	1	STORAGE TANK LOW LOW LEVEL	TW-LSLL-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	LO LO LEVEL	PLC	No	62-I-001	
456	DI	LAHH	1	STORAGE TANK HIGH HIGH LEVEL	TW-LSHH-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI HI LEVEL	PLC	No	62-I-001	
457	DI	YA	1	STORAGE TANK DISCHARGE TOTAL CHLORINE ANALYZER FAIL ALARM	TW-AIT-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	62-I-001	
458	DI	YA	2	STORAGE TANK DISCHARGE CONDUCTIVITY ANALYZER FAIL ALARM	TW-AIT-0002	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	62-I-001	
459	DI	YA	3	STORAGE TANK DISCHARGE pH ANALYZER FAIL ALARM	TW-AIT-0003	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	62-I-001	
460	DI	YA	8	IPR PUMP STATION DISCHARGE HEADER pH ALALYZER FAIL ALARM	TW-AIT-0008	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	63-I-001	
461	DI	YI	101	IPR PUMP NO 1 IN REMOTE	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	63-I-001	
462	DI	YIR	101	IPR PUMP NO 1 RUNNING	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	63-I-001	
463	DI	YA	101	IPR PUMP NO 1 FAIL	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	63-I-001	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
464	DI	PAH	101	IPR PUMP NO 1 DISCHARGE PRESSURE HIGH	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	63-I-001	
465	DI	YI	201	IPR PUMP NO 2 IN REMOTE	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	63-I-001	
466	DI	YIR	201	IPR PUMP NO 2 RUNNING	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	63-I-001	
467	DI	UA	201	IPR PUMP NO 2 FAIL	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	63-I-001	
468	DI	PAH	201	IPR PUMP NO 2 DISCHARGE PRESSURE HIGH	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	63-I-001	
469	DI	YI	301	IPR PUMP NO 3 IN REMOTE	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	63-I-001	
470	DI	YIR	301	IPR PUMP NO 3 RUNNING	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	63-I-001	
471	DI	UA	301	IPR PUMP NO 3 FAIL	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	63-I-001	
472	DI	PAH	301	IPR PUMP NO 3 DISCHARGE PRESSURE HIGH	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	63-I-001	
473	DI	LAL	1	OUTFALL BALANCING TANK LOW LEVEL	TW-LSL-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	LOW LEVEL	PLC	No	64-I-001	
474	DI	LAHH	1	OUTFALL BALANCING TANK HIGH HIGH LEVEL	TW-LSHH-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI HI LEVEL	PLC	No	64-I-001	
475	DI	YI	101	OUTFALL PUMP NO 1 IN REMOTE	101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	64-I-001	
476	DI	YIR	101	OUTFALL PUMP NO 1 RUNNING	101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	64-I-001	
477	DI	YA	101	OUTFALL PUMP NO 1 FAIL	101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	64-I-001	
478	DI	YI	201	OUTFALL PUMP NO 2 IN REMOTE		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	64-I-001	
479	DI	YIR	201	OUTFALL PUMP NO 2 RUNNING		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	64-I-001	
480	DI	YA	201	OUTFALL PUMP NO 2 FAIL		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	64-I-001	
481	DI	YI	301	OUTFALL PUMP NO 3 IN REMOTE		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	64-I-001	
482	DI	YIR	301	OUTFALL PUMP NO 3 RUNNING		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	64-I-001	
483	DI	YA	301	OUTFALL PUMP NO 3 FAIL		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	64-I-001	
484	DI	YI	401	OUTFALL PUMP NO 4 IN REMOTE		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	64-I-001	
485	DI	YIR	401	OUTFALL PUMP NO 4 RUNNING		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	64-I-001	
486	DI	YA	401	OUTFALL PUMP NO 4 FAIL		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	64-I-001	
487	DI	YA	1	OUTFALL PUMP STATION DISCHARGE HEADER FREE CHLORINE ANALYZER FAIL	TW-AIT-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	23 VDC	FAIL	PLC	No	65-I-001	
488	DI	FA	1	COMPOSITE SAMPLER FLOW NEAR OCEAN OUTFALL IN TROUBLE		51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN TROUBLE	PLC	No	65-I-001	
489	DO	UCR	1	RO INLET SAMPLE PUMP RUN COMMAND	RO-P-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-001	
490	DO	ZCO	12	RO PUMP TO OCEAN OUTFALL TANK ISO VALVE OPEN CMD	RO-V-0012	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-001	
491	DO	ZCC	12	RO PUMP TO OCEAN OUTFALL TANK ISO VALVE CLOSE CMD	RO-V-0012	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-001	
492	DO	UCR	101	RO PUMP 1 RUN CMD	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-002	
493	DO	UC	101	RO PUMP 1 RESET CMD	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RESET CMD	FIELD	YES	51-I-002	
494	DO	UCR	201	RO PUMP 2 RUN CMD	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-002	
495	DO	UC	201	RO PUMP 2 RESET CMD	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RESET CMD	FIELD	YES	51-I-002	
496	DO	UCR	301	RO PUMP 3 RUN CMD	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-002	
497	DO	UC	301	RO PUMP 3 RESET CMD	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RESET CMD	FIELD	YES	51-I-002	
498	DO	ZCO	307	RO FLUSH PUMPS TO RO SYSTEM 3 FLUSH VALVE OPEN CMD	RO-V-0307	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-002	
499	DO	ZCC	307	RO FLUSH PUMPS TO RO SYSTEM 3 FLUSH VALVE CLOSE CMD	RO-V-0307	51-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-002	
500	DO	UCR	1	CALCITE VESSEL FLUSH PUMP RUN COMMAND	AFD-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	61-I-001	
501	DO	ZCO	1	BACKWASH WASTE HOLDING TANK DRAIN VALVE OPEN COMMAND	CAL-V-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	61-I-001	
502	DO	ZCC	1	BACKWASH WASTE HOLDING TANK DRAIN VALVE CLOSE COMMAND	CAL-V-0001	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	61-I-001	
503	DO	UCR	101	IPR PUMP NO 1 RUN COMMAND	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	63-I-001	
504	DO	UCR	201	IPR PUMP NO 2 RUN COMMAND	AFD-0201	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	63-I-001	
505	DO	UCR	301	IPR PUMP NO 3 RUN COMMAND	AFD-0301	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	63-I-001	
506	DO	UCR	101	OUTFALL PUMP NO 1 RUN COMMAND	AFD-0101	51-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	64-I-001	
507	DI	YI	107	RO FLUSH PUMPS TO RO SYSTEM 1 FLUSH VALVE IN REMOTE	RO-V-0107	51-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-002	
508	DI	ZIO	107	RO FLUSH PUMPS TO RO SYSTEM 1 FLUSH VALVE OPENED	RO-V-0107	51-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-002	
509	DI	ZIC	107	RO FLUSH PUMPS TO RO SYSTEM 1 FLUSH VALVE CLOSED	RO-V-0107	51-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-002	
510	DI	YI	207	RO FLUSH PUMPS TO RO SYSTEM 2 FLUSH VALVE IN REMOTE	RO-V-0207	51-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-002	
511	DI	ZIO	207	RO FLUSH PUMPS TO RO SYSTEM 2 FLUSH VALVE OPENED	RO-V-0207	51-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-002	
512	DI	ZIC	207	RO FLUSH PUMPS TO RO SYSTEM 2 FLUSH VALVE CLOSED	RO-V-0207	51-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-002	
513	DO	ZCO	107	RO FLUSH PUMPS TO RO SYSTEM 1 FLUSH VALVE OPEN CMD	RO-V-0107	51-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-002	
514	DO	ZCC	107	RO FLUSH PUMPS TO RO SYSTEM 1 FLUSH VALVE CLOSE CMD	RO-V-0107	51-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-002	
515	DO	ZCO	207	RO FLUSH PUMPS TO RO SYSTEM 2 FLUSH VALVE OPEN CMD	RO-V-0207	51-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-002	
516	DO	ZCC	207	RO FLUSH PUMPS TO RO SYSTEM 2 FLUSH VALVE CLOSE CMD	RO-V-0207	51-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-002	
517	AI	ZC	1		CAL-V-0001	51-RIO-0001							No	61-I-001	
518	AO	ZC	1		CAL-V-0001	51-RIO-0001							No	61-I-001	
519	DI	YI	1		CAL-V-0001	51-RIO-0001							No	61-I-001	
520	AI	PI	1001	RO UNIT 1 STAGE 1 INLET PRESSURE	RO-PIT-1001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-003	
521	AI	AI	1001	RO UNIT 1 STAGE 1 PERMEATE CONDUCTIVITY	RO-AIT-1001	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-003	
522	AI	FI	1001	RO UNIT 1 STAGE 2 PERMEATE FLOW	RO-FIT-1001	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-003	
523	AI	SI	1001	RO UNIT 1 BOOSTER PUMP SPEED	RO-VFD-1001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-003	
524	AI	PI	1002	RO UNIT 1 STAGE 1 PERMEATE PRESSURE	RO-PIT-1002	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-003	
525	AI	AI	1002	RO UNIT 1 STAGE 2 PERMEATE CONDUCTIVITY	RO-AIT-1002	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-003	
526	AI	PI	1003	RO UNIT 1 STAGE 1 CONCENTRATE PRESSURE	RO-PIT-1003	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-003	
527	AI	PI	1004	RO UNIT 1 STAGE 2 INLET PRESSURE	RO-PIT-1004	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-003	
528	AI	PI	1005	RO UNIT 1 STAGE 2 CONCENTRATE PRESSURE	RO-PIT-1005	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-003	
529	AI	PI	2001	RO UNIT 2 STAGE 1 INLET PRESSURE	RO-PIT-2001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-004	
530	AI	AI	2001	RO UNIT 2 STAGE 1 PERMEATE CONDUCTIVITY	RO-AIT-2001	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-004	
531	AI	FI	2001	RO UNIT 2 STAGE 2 PERMEATE FLOW	RO-FIT-2001	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-004	
532	AI	SI	2001	RO UNIT 2 BOOSTER PUMP SPEED	RO-VFD-2001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-004	
533	AI	PI	2002	RO UNIT 2 STAGE 1 PERMEATE PRESSURE	RO-PIT-2002	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-004	
534	AI	AI	2002	RO UNIT 2 STAGE 2 PERMEATE CONDUCTIVITY	RO-AIT-2002	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-004	
535	AI	PI	2003	RO UNIT 2 STAGE 1 CONCENTRATE PRESSURE	RO-PIT-2003	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-004	
536	AI	PI	2004	RO UNIT 2 STAGE 2 INLET PRESSURE	RO-PIT-2004	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-004	
537	AI	PI	2005	RO UNIT 2 STAGE 2 CONCENTRATE PRESSURE	RO-PIT-2005	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-004	
538	AI	PI	3001	RO UNIT 3 STAGE 1 INLET PRESSURE	RO-PIT-3001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-005	
539	AI	AI	3001	RO UNIT 3 STAGE 1 PERMEATE CONDUCTIVITY	RO-AIT-3001	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-005	
540	AI	FI	3001	RO UNIT 3 STAGE 2 PERMEATE FLOW	RO-FIT-3001	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-005	
541	AI	SI	3001	RO UNIT 3 BOOSTER PUMP SPEED	RO-VFD-3001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-005	
542	AI	PI	3002	RO UNIT 3 STAGE 1 PERMEATE PRESSURE	RO-PIT-3002	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-005	
543	AI	AI	3002	RO UNIT 3 STAGE 2 PERMEATE CONDUCTIVITY	RO-AIT-3002	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-005	
544	AI	PI	3003	RO UNIT 3 STAGE 1 CONCENTRATE PRESSURE	RO-PIT-3003	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-005	
545	AI	PI	3004	RO UNIT 3 STAGE 2 INLET PRESSURE	RO-PIT-3004	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-005	
546	AI	PI	3005	RO UNIT 3 STAGE 2 CONCENTRATE PRESSURE	RO-PIT-3005	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-005	
547	AI	FI	1002	PERMATE FLOW FROM RO UNIT 1 VESSELS	RO-FIT-1002	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-006	
548	AI	FI	1003	CONCENTRATE FLOW FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM	RO-FIT-1003	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-006	
549	AI	AI	1003	PERMATE FROM RO UNIT 1 VESSELS CONDUCTIVITY	RO-AIT-1003	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-006	
550	AI	AI	1004	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM CONDUCTIVITY	RO-AIT-1004	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-006	
551	AI	PI	1006	PERMATE PRESSURE FROM RO UNIT 1 VESSELS	RO-PIT-1006	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-006	
552	AI	PI	1007	CONCENTRATE PRESSURE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM	RO-PIT-1007	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-006	
553	AI	PI	1008	CONCENTRATE PRESSURE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM	RO-PIT-1008	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-006	
554	AI	ZI	1047	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM MAIN VALVE POSITION FEEDBACK	RO-V-1047	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-006	
555	AI	FI	2002	PERMATE FLOW FROM RO UNIT 2 VESSELS	RO-FIT-2002	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-007	
556	AI	FI	2003	CONCENTRATE FLOW FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM	RO-FIT-2003	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-007	
557	AI	AI	2003	PERMATE FROM RO UNIT 2 VESSELS CONDUCTIVITY	RO-AIT-2003	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-007	
558	AI	AI	2004	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM CONDUCTIVITY	RO-AIT-2004	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-007	
559	AI	PI	2006	PERMATE PRESSURE FROM RO UNIT 2 VESSELS	RO-PIT-2006	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-007	
560	AI	PI	2007	CONCENTRATE PRESSURE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM	RO-PIT-2007	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-007	
561	AI	PI	2008	CONCENTRATE PRESSURE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM	RO-PIT-2008	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-007	
562	AI	ZI	2047	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM MAIN VALVE POSITION FEEDBACK	RO-V-2047	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-007	
563	AI	FI	3002		RO-FIT-3002	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-008	
564	AI	FI	3003	CONCENTRATE FLOW FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM	RO-FIT-3003	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-008	
565	AI	AI	3003	PERMATE FROM RO UNIT 3 VESSELS CONDUCTIVITY	RO-AIT-3003	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-008	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
566	AI	AI	3004	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM CONDUCTIVITY	RO-AIT-3004	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-008	
567	AI	PI	3006	PERMATE PRESSURE FROM RO UNIT 3 VESSELS	RO-PIT-3006	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-008	
568	AI	PI	3007	CONCENTRATE PRESSURE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM	RO-PIT-3007	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-008	
569	AI	PI	3008	CONCENTRATE PRESSURE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM	RO-PIT-3008	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-008	
570	AI	ZI	3047	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM MAIN VALVE POSITION FEEDBACK	RO-V-3047	51-RO-LCP-0001	4-20 mA	0 - 100%		N/A	N/A	N/A	N/A	51-I-008	
571	AI	FI	101	RO PERMEATE (MAKEUP) FLOW TO CIP MAKEUP TANK CIP-T-0101	CIP-FIT-0101	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-009	
572	AI	LI	101	CIP MAKEUP TANK CIP-T-0101 LEVEL	CIP-LIT-0101	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-009	
573	AI	LI	201	CIP MAKEUP TANK CIP-T-0201 LEVEL	CIP-LIT-0201	51-RO-LCP-0001	4-20 mA	0 - 100%	4-WIRE	N/A	N/A	N/A	N/A	51-I-009	
574	AI	AI	201	NEUTRALIZATION TANK CIP-T-0201 pH	CIP-AIT-0201	51-RO-LCP-0001	4-20 mA	0 - 14	4-WIRE	N/A	N/A	N/A	N/A	51-I-009	
575	AI	TI	1	RO CIP PUMP STATION DISCHARGE HEADER TEMPERATURE	CIP-TIT-0001	51-RO-LCP-0001	4-20 mA		2 -WIRE	N/A	N/A	N/A	N/A	51-I-010	
576	AI	AI	1	RO CIP PUMP STATION DISCHARGE HEADER Ph	CIP-AIT-0001	51-RO-LCP-0001	4-20 mA	0 - 14	4 -WIRE	N/A	N/A	N/A	N/A	51-I-010	
577	AI	FI	1	RO CIP PUMP STATION DISCHARGE HEADER FLOW	CIP-FIT-0001	51-RO-LCP-0001	4-20 mA		4 -WIRE	N/A	N/A	N/A	N/A	51-I-010	
578	AI	TI	1	RO CIP PUMP STATION DISCHARGE HEADER EDUCTOR TEMPERATURE	CIP-EDC-0001	51-RO-LCP-0001	4-20 mA		2 -WIRE	N/A	N/A	N/A	N/A	51-I-010	
579	AI	SI	101	RO CIP PUMP NO 1 SPEED INDICATION	RO-VFD-0101	51-RO-LCP-0001	4-20 mA			N/A	N/A	N/A	N/A	51-I-010	
580	AI	SI	201	RO CIP PUMP NO 2 SPEED INDICATION	RO-VFD-0201	51-RO-LCP-0001	4-20 mA			N/A	N/A	N/A	N/A	51-I-010	
581	AI	LI	1	RO FLUSH TANK LEVEL	RO-LIT-0001	51-RO-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-011	
582	AI	FI	2	RO FLUSH PUMP STATION DISCHARGE HEADER FLOW	RO-FIT-0002	51-RO-LCP-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	51-I-011	
583	AI	SI	102	RO FLUSH PUMP NO 1 SPEED INDICATION	RO-VFD-0102	51-RO-LCP-0001	4-20 mA			N/A	N/A	N/A	N/A	51-I-011	
584	AI	SI	202	RO FLUSH PUMP NO 2 SPEED INDICATION	RO-VFD-0202	51-RO-LCP-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	51-I-011	
585	AO	SC	1001	RO UNIT 1 BOOSTER PUMP SPEED SETPT	RO-VFD-1001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-003	
586	AO	SC	2001	RO UNIT 2 BOOSTER PUMP SPEED SETPT	RO-VFD-2001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-004	
587	AO	SC	3001	RO UNIT 3 BOOSTER PUMP SPEED SETPT	RO-VFD-3001	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-005	
588	AO	ZC	1047	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM MAIN VALVE POSITION SETPT	RO-V-1047	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-006	
589	AO	ZC	2047	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM MAIN VALVE POSITION SETPT	RO-V-2047	51-RO-LCP-0001	4-20 mA	0 - 100%	2-WIRE	N/A	N/A	N/A	N/A	51-I-007	
590	AO	ZC	3047	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM MAIN VALVE POSITION SETPT	RO-V-3047	51-RO-LCP-0001	4-20 mA	0 - 100%		N/A	N/A	N/A	N/A	51-I-008	
591	AO	SC	101	RO CIP PUMP NO 1 SPEED SET POINT	RO-VFD-0101	51-RO-LCP-0001	4-20 mA			N/A	N/A	N/A	N/A	51-I-010	
592	AO	SC	201	RO CIP PUMP NO 2 SPEED SET POINT	RO-VFD-0201	51-RO-LCP-0001	4-20 mA			N/A	N/A	N/A	N/A	51-I-010	
593	AO	SC	102	RO FLUSH PUMP NO 1 SPEED SET POINT	RO-VFD-0102	51-RO-LCP-0001	4-20 mA			N/A	N/A	N/A	N/A	51-I-011	
594	AO	SC	202	RO FLUSH PUMP NO 2 SPEED SET POINT	RO-VFD-0202	51-RO-LCP-0001	4-20 mA			N/A	N/A	N/A	N/A	51-I-011	
595	DI	YI	1001	RO UNIT 1 INLET VALVE IN REMOTE	RO-V-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-003	
596	DI	ZIO	1001	RO UNIT 1 INLET VALVE OPENED	RO-V-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-003	
597	DI	ZIC	1001	RO UNIT 1 INLET VALVE CLOSED	RO-V-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-003	
598	DI	YI	1001	RO UNIT 1 BOOSTER PUMP IN REMOTE	RO-VFD-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-003	
599	DI	YIR	1001	RO UNIT 1 BOOSTER PUMP RUNNING	RO-VFD-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-003	
600	DI	YA	1001	RO UNIT 1 BOOSTER PUMP FAILED	RO-VFD-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-003	
601	DI	YA	1001	RO UNIT 1 STAGE 1 PERMEATE CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-003	
602	DI	UA	1002	RO UNIT 1 STAGE 2 PERMEATE CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-1002	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-003	
603	DI	YI	2001	RO UNIT 2 INLET VALVE IN REMOTE	RO-V-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-004	
604	DI	ZIO	2001	RO UNIT 2 INLET VALVE OPENED	RO-V-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-004	
605	DI	ZIC	2001	RO UNIT 2 INLET VALVE CLOSED	RO-V-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-004	
606	DI	YI	2001	RO UNIT 2 BOOSTER PUMP IN REMOTE	RO-VFD-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-004	
607	DI	YIR	2001	RO UNIT 2 BOOSTER PUMP RUNNING	RO-VFD-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-004	
608	DI	YA	2001	RO UNIT 2 BOOSTER PUMP FAILED	RO-VFD-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-004	
609	DI	YA	2001	RO UNIT 2 STAGE 1 PERMEATE CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-004	
610	DI	YA	2002	RO UNIT 2 STAGE 2 PERMEATE CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-2002	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-004	
611	DI	YI	3001	RO UNIT 3 INLET VALVE IN REMOTE	RO-V-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-005	
612	DI	ZIO	3001	RO UNIT 3 INLET VALVE OPENED	RO-V-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-005	
613	DI	ZIC	3001	RO UNIT 3 INLET VALVE CLOSED	RO-V-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-005	
614	DI	YA	3001	RO UNIT 3 STAGE 1 PERMEATE CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-005	
615	DI	YI	3001	RO UNIT 3 BOOSTER PUMP IN REMOTE	RO-VFD-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-005	
616	DI	YIR	3001	RO UNIT 3 BOOSTER PUMP RUNNING	RO-VFD-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-005	
617	DI	YA	3001	RO UNIT 3 BOOSTER PUMP FAILED	RO-VFD-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-005	
618	DI	YA	3002	RO UNIT 3 STAGE 2 PERMEATE CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-3002	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-005	
619	DI	YA	1003	PERMATE FROM RO UNIT 1 VESSELS CONDUCTIVITY INSTRUMENT FAIL	RO-AIT-1003	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-006	
620	DI	YA	1004	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-1004	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-006	
621	DI	PAH	1006	PERMATE PRESSURE FROM RO UNIT 1 VESSELS HIGH	RO-PSH-1006	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	PRESSURE HIGH	PLC	No	51-I-006	
622	DI	YI	1040	PERMATE FROM RO UNIT 1 VESSELS TO OUTFALL BALANCING TANK VALVE IN REMOTE	RO-V-1040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-006	
623	DI	ZIO	1040	PERMATE FROM RO UNIT 1 VESSELS TO OUTFALL BALANCING TANK VALVE OPENED	RO-V-1040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-006	
624	DI	ZIC	1040	PERMATE FROM RO UNIT 1 VESSELS TO OUTFALL BALANCING TANK VALVE CLOSED	RO-V-1040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-006	
625	DI	YI	1042	PERMATE FROM RO UNIT 1 VESSELS TO UV SYSTEM VALVE IN REMOTE	RO-V-1042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-006	
626	DI	ZIO	1042	PERMATE FROM RO UNIT 1 VESSELS TO UV SYSTEM VALVE OPENED	RO-V-1042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-006	
627	DI	ZIC	1042	PERMATE FROM RO UNIT 1 VESSELS TO UV SYSTEM VALVE CLOSED	RO-V-1042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-006	
628	DI	YI	1047	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM MAIN VALVE IN REMOTE	RO-V-1047	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-006	
629	DI	YI	1048	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN REMOTE	RO-V-1048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-006	
630	DI	ZIO	1048	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN OPENED	RO-V-1048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-006	
631	DI	ZIC	1048	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN CLOSED	RO-V-1048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-006	
632	DI	YA	2003	PERMATE FROM RO UNIT 2 VESSELS CONDUCTIVITY INSTRUMENT FAIL	RO-AIT-2003	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-007	
633	DI	YA	2004	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-2004	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-007	
634	DI	PAH	2006	PERMATE PRESSURE FROM RO UNIT 2 VESSELS HIGH	RO-PSH-2006	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	PRESSURE HIGH	PLC	No	51-I-007	
635	DI	YI	2040	PERMATE FROM RO UNIT 2 VESSELS TO OUTFALL BALANCING TANK VALVE IN REMOTE	RO-V-2040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-007	
636	DI	ZIO	2040	PERMATE FROM RO UNIT 2 VESSELS TO OUTFALL BALANCING TANK VALVE OPENED	RO-V-2040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-007	
637	DI	ZIC	2040	PERMATE FROM RO UNIT 2 VESSELS TO OUTFALL BALANCING TANK VALVE CLOSED	RO-V-2040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-007	
638	DI	YI	2042	PERMATE FROM RO UNIT 2 VESSELS TO UV SYSTEM VALVE IN REMOTE	RO-V-2042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-007	
639	DI	ZIO	2042	PERMATE FROM RO UNIT 2 VESSELS TO UV SYSTEM VALVE OPENED	RO-V-2042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-007	
640	DI	ZIC	2042	PERMATE FROM RO UNIT 2 VESSELS TO UV SYSTEM VALVE CLOSED	RO-V-2042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-007	
641	DI	YI	2047	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM MAIN VALVE IN REMOTE	RO-V-2047	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-007	
642	DI	YI	2048	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN REMOTE	RO-V-2048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-007	
643	DI	ZIO	2048	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN OPENED	RO-V-2048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-007	
644	DI	ZIC	2048	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN CLOSED	RO-V-2048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-007	
645	DI	YA	3003	PERMATE FROM RO UNIT 3 VESSELS CONDUCTIVITY INSTRUMENT FAIL	RO-AIT-3003	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-008	
646	DI	YA	3004	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM CONDUCTIVITY ANALYZER INSTRUMENT FAIL	RO-AIT-3004	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-008	
647	DI	PAH	3006	PERMATE PRESSURE FROM RO UNIT 3 VESSELS HIGH	RO-PSH-3006	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	PRESSURE HIGH	PLC	No	51-I-008	
648	DI	YI	3040	PERMATE FROM RO UNIT 3 VESSELS TO OUTFALL BALANCING TANK VALVE IN REMOTE	RO-V-3040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-008	
649	DI	ZIO	3040	PERMATE FROM RO UNIT 3 VESSELS TO OUTFALL BALANCING TANK VALVE OPENED	RO-V-3040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-008	
650	DI	ZIC	3040	PERMATE FROM RO UNIT 3 VESSELS TO OUTFALL BALANCING TANK VALVE CLOSED	RO-V-3040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-008	
651	DI	YI	3042	PERMATE FROM RO UNIT 3 VESSELS TO UV SYSTEM VALVE IN REMOTE	RO-V-3042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-008	
652	DI	ZIO	3042	PERMATE FROM RO UNIT 3 VESSELS TO UV SYSTEM VALVE OPENED	RO-V-3042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-008	
653	DI	ZIC	3042	PERMATE FROM RO UNIT 3 VESSELS TO UV SYSTEM VALVE CLOSED	RO-V-3042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-008	
654	DI	YI	3047	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM MAIN VALVE IN REMOTE	RO-V-3047	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-008	
655	DI	YI	3048	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN REMOTE	RO-V-3048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-008	
656	DI	ZIO	3048	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN OPENED	RO-V-3048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENDED	PLC	No	51-I-008	
657	DI	ZIC	3048	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN CLOSED	RO-V-3048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-008	
658	DI	YI	1	NEUTRALIZATION TANK CIP-T-0201 MIXER IN REMOTE	MCC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-009	
659	DI	YIR	1	NEUTRALIZATION TANK CIP-T-0201 MIXER IN RUNNING	MCC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-009	
660	DI	YA	1	NEUTRALIZATION TANK CIP-T-0201 MIXER IN FAIL	MCC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-009	
661	DI	LAH	101	CIP MAKEUP TANK CIP-T-0101 LEVEL HIGH	CIP-LSH-0101	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	LEVEL HIGH	PLC	No	51-I-009	
662	DI	LAL	101	CIP MAKEUP TANK CIP-T-0101 LEVEL LOW	CIP-LSL-0101	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	LEVEL LOW	PLC	No	51-I-009	
663	DI	ZIO	103	RO PERMEATE (MAKEUP) TO CIP MAKEUP TANK CIP-T-0101 VALVE OPENED	CIP-V-0103	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-009	
664	DI	ZIC	103	RO PERMEATE (MAKEUP) TO CIP MAKEUP TANK CIP-T-0101 VALVE CLOSED	CIP-V-0103	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-009	
665	DI	YI	103	RO PERMEATE (MAKEUP) TO CIP MAKEUP TANK CIP-T-0101 VALVE IN REMOTE	CIP-V-0103	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-009	
666	DI	LAH	201	NEUTRALIZATION TANK CIP-T-0201 LEVEL HIGH	CIP-LSH-0201	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	LEVEL HIGH	PLC	No	51-I-009	
667	DI	LAL	201	NEUTRALIZATION TANK CIP-T-0201 LEVEL LOW	CIP-LSL-0201	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	LEVEL LOW	PLC	No	51-I-009	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
668	DI	YA	201	NEUTRALIZATION TANK CIP-T-0201 pH INSTRUMENT FAIL	CIP-AIT-0201	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAILED	PLC	No	51-I-009	
669	DI	PDAH	1	RO CIP PS DISCHARGE CARTRIDGE HIGH DIFFERENTIAL PRESSURE	CIP-PDSH-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	HI DIFF PRESS	PLC	No	51-I-010	
670	DI	PAH	1	RO CIP PS DISCHARGE HEADER HIGH PRESSURE	CIP-PSH-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	HI PRESSURE	PLC	No	51-I-010	
671	DI	YA	1	RO CIP PUMP STATION DISCHARGE HEADER Ph ANALYZER FAIL	CIP-AIT-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	51-I-010	
672	DI	YI	1	RO CIP PUMP STATION DISCHARGE HEADER EDUCTOR IN REMOTE	CIP-EDC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-010	
673	DI	YIR	1	RO CIP PUMP STATION DISCHARGE HEADER EDUCTOR RUNNING	CIP-EDC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-010	
674	DI	YA	1	RO CIP PUMP STATION DISCHARGE HEADER EDUCTOR FAIL	CIP-EDC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	51-I-010	
675	DI	YIR	101	RO CIP PUMP NO 1 RUNNING	RO-VFD-0101	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-010	
676	DI	YA	101	RO CIP PUMP NO 1 FAIL	RO-VFD-0101	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	51-I-010	
677	DI	YI	101	RO CIP PUMP NO 1 IN REMOTE	RO-VFD-0101	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-010	
678	DI	YIR	201	RO CIP PUMP NO 2 RUNNING	RO-VFD-0201	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-010	
679	DI	YA	201	RO CIP PUMP NO 2 FAIL	RO-VFD-0201	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	51-I-010	
680	DI	YI	201	RO CIP PUMP NO 2 IN REMOTE	RO-VFD-0201	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-010	
681	DI	LAL	1	RO FLUSH TANK LOW LOW LEVEL	RO-LSLL-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	LO LO LEVEL	PLC	No	51-I-011	
682	DI	LAH	1	RO FLUSH TANK HIGH HIGH LEVEL	RO-LSHH-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	HI HI LEVEL	PLC	No	51-I-011	
683	DI	ZIO	13	RO FLUSH TANK INLET VALVE OPENED	RO-V-0013	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	51-I-011	
684	DI	ZIC	13	RO FLUSH TANK INLET VALVE CLOSED	RO-V-0013	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	51-I-011	
685	DI	YI	13	RO FLUSH TANK INLET VALVE IN REMOTE	RO-V-0013	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-011	
686	DI	YI	102	RO FLUSH PUMP NO 1 IN REMOTE	RO-VFD-0102	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-011	
687	DI	YIR	102	RO FLUSH PUMP NO 1 RUNNING	RO-VFD-0102	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-011	
688	DI	UA	102	RO FLUSH PUMP NO 1 FAIL	RO-VFD-0102	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	51-I-011	
689	DI	YI	202	RO FLUSH PUMP NO 2 IN REMOTE	RO-VFD-0202	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	51-I-011	
690	DI	YIR	202	RO FLUSH PUMP NO 2 RUNNING	RO-VFD-0202	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	51-I-011	
691	DI	UA	202	RO FLUSH PUMP NO 2 FAIL	RO-VFD-0202	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	51-I-011	
692	DO	ZCO	1001	RO UNIT 1 INLET VALVE OPEN CMD	RO-V-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-003	
693	DO	ZCC	1001	RO UNIT 1 INLET VALVE CLOSE CMD	RO-V-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-003	
694	DO	UCR	1001	RO UNIT 1 BOOSTER PUMP RUN CMD	RO-VFD-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-003	
695	DO	UC	1001	RO UNIT 1 BOOSTER PUMP RESET CMD	RO-VFD-1001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RESET CMD	FIELD	YES	51-I-003	
696	DO	ZCO	2001	RO UNIT 2 INLET VALVE OPEN CMD	RO-V-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-004	
697	DO	ZCC	2001	RO UNIT 2 INLET VALVE CLOSE CMD	RO-V-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-004	
698	DO	UCR	2001	RO UNIT 2 BOOSTER PUMP RUN CMD	RO-VFD-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-004	
699	DO	UC	2001	RO UNIT 2 BOOSTER PUMP RESET CMD	RO-VFD-2001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RESET CMD	FIELD	YES	51-I-004	
700	DO	ZCO	3001	RO UNIT 3 INLET VALVE OPEN CMD	RO-V-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-005	
701	DO	ZCC	3001	RO UNIT 3 INLET VALVE CLOSE CMD	RO-V-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-005	
702	DO	UCR	3001	RO UNIT 3 BOOSTER PUMP RUN CMD	RO-VFD-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-005	
703	DO	UC	3001	RO UNIT 3 BOOSTER PUMP RESET CMD	RO-VFD-3001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RESET CMD	FIELD	YES	51-I-005	
704	DO	ZCO	1040	PERMATE FROM RO UNIT 1 VESSELS TO OUTFALL BALANCING TANK VALVE OPEN CMD	RO-V-1040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-006	
705	DO	ZCC	1040	PERMATE FROM RO UNIT 1 VESSELS TO OUTFALL BALANCING TANK VALVE CLOSE CMD	RO-V-1040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-006	
706	DO	ZCO	1042	PERMATE FROM RO UNIT 1 VESSELS TO UV SYSTEM VALVE OPEN CMD	RO-V-1042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-006	
707	DO	ZCC	1042	PERMATE FROM RO UNIT 1 VESSELS TO UV SYSTEM VALVE CLOSE CMD	RO-V-1042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-006	
708	DO	ZCO	1048	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN OPEN CMD	RO-V-1048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-006	
709	DO	ZCC	1048	CONCENTRATE FROM RO UNIT 1 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN CLOSE CMD	RO-V-1048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-006	
710	DO	ZCO	2040	PERMATE FROM RO UNIT 2 VESSELS TO OUTFALL BALANCING TANK VALVE OPEN CMD	RO-V-2040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-007	
711	DO	ZCC	2040	PERMATE FROM RO UNIT 2 VESSELS TO OUTFALL BALANCING TANK VALVE CLOSE CMD	RO-V-2040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-007	
712	DO	ZCO	2042	PERMATE FROM RO UNIT 2 VESSELS TO UV SYSTEM VALVE OPEN CMD	RO-V-2042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-007	
713	DO	ZCC	2042	PERMATE FROM RO UNIT 2 VESSELS TO UV SYSTEM VALVE CLOSE CMD	RO-V-2042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-007	
714	DO	ZCO	2048	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN OPEN CMD	RO-V-2048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-007	
715	DO	ZCC	2048	CONCENTRATE FROM RO UNIT 2 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN CLOSE CMD	RO-V-2048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-007	
716	DO	ZCO	3040	PERMATE FROM RO UNIT 3 VESSELS TO OUTFALL BALANCING TANK VALVE OPEN CMD	RO-V-3040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-008	
717	DO	ZCC	3040	PERMATE FROM RO UNIT 3 VESSELS TO OUTFALL BALANCING TANK VALVE CLOSE CMD	RO-V-3040	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-008	
718	DO	ZCO	3042	PERMATE FROM RO UNIT 3 VESSELS TO UV SYSTEM VALVE OPEN CMD	RO-V-3042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-008	
719	DO	ZCC	3042	PERMATE FROM RO UNIT 3 VESSELS TO UV SYSTEM VALVE CLOSE CMD	RO-V-3042	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-008	
720	DO	ZCO	3048	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN OPEN CMD	RO-V-3048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-008	
721	DO	ZCC	3048	CONCENTRATE FROM RO UNIT 3 VESSELS TO OUTFALL SYSTEM BYPASS VALVE IN CLOSE CMD	RO-V-3048	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-008	
722	DO	UCR	1	NEUTRALIZATION TANK CIP-T-0201 MIXER IN RUN CMD	MCC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-009	
723	DO	ZCO	103	RO PERMEATE (MAKEUP) TO CIP MAKEUP TANK CIP-T-0101 VALVE OPEN CMD	CIP-V-0103	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-009	
724	DO	ZCC	103	RO PERMEATE (MAKEUP) TO CIP MAKEUP TANK CIP-T-0101 VALVE CLOSE CMD	CIP-V-0103	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-009	
725	DO	YC	1	RO CIP PUMP STATION DISCHARGE HEADER EDUCTOR ENABLE	CIP-EDC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	ENABLE	FIELD	YES	51-I-010	
726	DO	YC	1	RO CIP PUMP STATION DISCHARGE HEADER EDUCTOR CIP TANK LWCO	CIP-EDC-0001	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	TANK LWCO	FIELD	YES	51-I-010	
727	DO	UC	101	RO CIP PUMP NO 1 RESET COMMAND	RO-VFD-0101	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RESET CMD	FIELD	YES	51-I-010	
728	DO	UCR	101	RO CIP PUMP NO 1 RUN COMMAND	RO-VFD-0101	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-010	
729	DO	UC	201	RO CIP PUMP NO 2 RESET COMMAND	RO-VFD-0201	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RESET CMD	FIELD	YES	51-I-010	
730	DO	UCR	201	RO CIP PUMP NO 2 RUN COMMAND	RO-VFD-0201	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-010	
731	DO	ZCO	13	RO FLUSH TANK INLET VALVE OPEN COMMAND	RO-V-0013	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	51-I-011	
732	DO	ZCC	13	RO FLUSH TANK INLET VALVE CLOSE COMMAND	RO-V-0013	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	51-I-011	
733	DO	UCR	102	RO FLUSH PUMP NO 1 RUN COMMAND	RO-VFD-0102	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-011	
734	DO	UCR	202	RO FLUSH PUMP NO 2 RUN COMMAND	RO-VFD-0202	51-RO-LCP-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	51-I-011	
735	AI	AI	1	UV SYSTEM INLET TOTAL CHLORINE	UV-AIT-0001	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
736	AI	FI	1	UV SYSTEM OUTLET FLOW	UV-FIT-0001	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
737	AI	AI	2	UV SYSTEM INLET POST CHEM DOSING pH	UV-AIT-0002	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
738	AI	AI	3	UV SYSTEM INLET POST CHEM DOSING TOTAL CHLORINE	UV-AIT-0003	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
739	AI	AI	4	UV SYSTEM UNITS INLET FREE CHLORINE	UV-AIT-0004	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
740	AI	AI	5	UV SYSTEM UNITS INLET UVT	UV-AIT-0005	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
741	AI	AI	6	UV SYSTEM OUTLET UVT	UV-AIT-0006	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
742	AI	AI	7	UV SYSTEM OUTLET pH	UV-AIT-0007	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
743	AI	AI	8	UV SYSTEM OUTLET TOTAL CHLORINE	UV-AIT-0008	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
744	AI	AI	9	UV SYSTEM OUTLET FREE CHLORINE	UV-AIT-0009	52-UV-PLC-0001	4-20 mA		4-WIRE	N/A	N/A	N/A	N/A	52-I-001	
745	DI	ZIO	12	EFFLUENT FLOW TO CALCITE FILTERS VALVE OPENED	UV-V-0012	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	52-I-001	
746	DI	ZIC	12	EFFLUENT FLOW TO CALCITE FILTERS VALVE CLOSED	UV-V-0012	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	52-I-001	
747	DI	YI	12	EFFLUENT FLOW TO CALCITE FILTERS VALVE IN REMOTE	UV-V-0012	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	52-I-001	
748	DI	ZIO	13	EFFLUENT FLOW TO OUTFALL BALANCING TANK VALVE OPENED	UV-V-0013	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	OPENED	PLC	No	52-I-001	
749	DI	ZIC	13	EFFLUENT FLOW TO OUTFALL BALANCING TANK VALVE CLOSED	UV-V-0013	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	CLOSED	PLC	No	52-I-001	
750	DI	YI	13	EFFLUENT FLOW TO OUTFALL BALANCING TANK VALVE IN REMOTE	UV-V-0013	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	52-I-001	
751	DO	ZCO	12	EFFLUENT FLOW TO CALCITE FILTERS VALVE OPEN COMMAND	UV-V-0012	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	52-I-001	
752	DO	ZCC	12	EFFLUENT FLOW TO CALCITE FILTERS VALVE CLOSE COMMAND	UV-V-0012	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	CLOSE MD	FIELD	YES	52-I-001	
753	DO	ZCO	13	EFFLUENT FLOW TO OUTFALL BALANCING TANK VALVE OPEN COMMAND	UV-V-0013	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	OPEN CMD	FIELD	YES	52-I-001	
754	DO	ZCC	13	EFFLUENT FLOW TO OUTFALL BALANCING TANK VALVE CLOSE COMMAND	UV-V-0013	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	CLOSE CMD	FIELD	YES	52-I-001	
755	DO	UCR	103	UV SYSTEM UNIT 1 SAMPLE SOLENOID RUN COMMAND	UV-V-00103	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	52-I-001	
756	DO	UCR	104	UV SYSTEM UNIT 2 SAMPLE SOLENOID RUN COMMAND	UV-V-00104	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	52-I-001	
757	DO	UCR	203	UV SYSTEM UNIT 1 SAMPLE SOLENOID RUN COMMAND	UV-V-00203	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	52-I-001	
758	DO	UCR	204	UV SYSTEM UNIT 2 SAMPLE SOLENOID RUN COMMAND	UV-V-00204	52-UV-PLC-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	52-I-001	
759	AI	SI	1		VFD-0001	64-PLC-001							No	73-I-001	
760	AI	SI	2		VFD-0002	64-PLC-001							No	73-I-001	
761	AI	SI	3		AFD-0001	64-PLC-001							No	73-I-001	
762	AO	SC	1		VFD-0001	64-PLC-001							No	73-I-001	
763	AO	SC	2		VFD-0002	64-PLC-001							No	73-I-001	
764	AO	SC	3		AFD-0001	64-PLC-001							No	73-I-001	
765	DI	YI	1		VFD-0001	64-PLC-001							No	73-I-001	
766	DI	YIR	1		VFD-0001	64-PLC-001							No	73-I-001	
767	DI	YA	1		VFD-0001	64-PLC-001							No	73-I-001	
768	DI	YI	2		VFD-0001	64-PLC-001							No	73-I-001	
769	DI	YIR	2		VFD-0001	64-PLC-001							No	73-I-001	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
770	DI	YA	2		VFD-0001	64-PLC-001							No	73-I-001	
771	DI	YI	3		AFD-0001	64-PLC-001							No	73-I-001	
772	DI	YIR	3		AFD-0001	64-PLC-001							No	73-I-001	
773	DI	YA	3		AFD-0001	64-PLC-001							No	73-I-001	
774	DO	UCR	1		VFD-0001	64-PLC-001							No	73-I-001	
775	DO	UCR	2		VFD-0002	64-PLC-001							No	73-I-001	
776	DO	UCR	3		AFD-0001	64-PLC-001							No	73-I-001	
777	AI	LI	101	SLUDGE HOLDING TANK NO 1 LEVEL	WAS-LT-0101	72-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	71-I-001	
778	AI	AI	101	SLUDGE HOLDING TANK NO 1 DISSOLVED OXEGEN	WAS-AIT-0101	72-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	71-I-001	
779	AI	LI	201	SLUDGE HOLDING TANK NO 2 LEVEL	WAS-LT-0201	72-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	71-I-001	
780	AI	AI	201	SLUDGE HOLDING TANK NO 2 DISSOLVED OXEGEN	WAS-AIT-0201	72-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	71-I-001	
781	AI	LI	1	SAFE DIVERSION BOX LEVEL	WAS-LIT-0001	72-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	71-I-002	
782	AI	PI	102	SLUDGE HOLDING TANK BLOWER NO 1 DISCHARGE PRESSURE	LCP-0101	72-CTRL-RIO-0001	4 - 20 MA		2- WIRE	N/A	N/A	N/A	No	71-I-003	
783	AI	PI	202	SLUDGE HOLDING TANK BLOWER NO 2 DISCHARGE PRESSURE	LCP-0201	72-CTRL-RIO-0001	4 - 20 MA		2- WIRE	N/A	N/A	N/A	No	71-I-003	
784	AI	FI	1	DEWATERING SLUDGE FEED PUMP DISCHARGE FLOW	DWT-FIT-0001	72-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	72-I-001	
785	AI	FI	1	DISK FILTER OVERFLOW EFFLUENT FLOW	FIT-0001	72-CTRL-RIO-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	73-I-001	
786	AI	PI	1	FILTER SOLID WASTE PUMP SUCTION PRESSURE	PIT-0001	72-CTRL-RIO-0001	4 - 20 MA		2 - WIRE	N/A	N/A	N/A	No	73-I-001	
787	AI	PI	2	FILTER BACKWASH WASTE PUMP SUCTION PRESSURE	PIT-0002	72-CTRL-RIO-0001	4 - 20 MA		2 - WIRE	N/A	N/A	N/A	No	73-I-001	
788	DI	YA	101	SLUDGE HOLDING TANK NO 1 DO ANALYZER FAIL	WAS-AIT-0101	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	71-I-001	
789	DI	YA	201	SLUDGE HOLDING TANK NO 2 DO ANALYZER FAIL	WAS-AIT-0201	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	71-I-001	
790	DI	LAHH	1	SAFE DIVERSION BOX HIGH HIGH LEVEL	WAS-LSHH-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI HI LEVEL	PLC	No	71-I-002	
791	DI	YIA	1	DEWATERING SCREW CONVEYOR NO 1 E-STOP	LCP-1001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	E-STOP	PLC	No	72-I-002	
792	DI	SI	1	DEWATERING SCREW CONVEYOR NO 1 ZERO SPEED	LCP-1001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	ZERO SPEED	PLC	No	72-I-002	
793	DI	IA	1	DEWATERING SCREW CONVEYOR NO 1 MOTOR OVERLOAD	LCP-1001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	MOTOR OVERLOAD	PLC	No	72-I-002	
794	DI	YIR	1	DEWATERING SCREW CONVEYOR NO 1 RUNNING	LCP-1001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	72-I-002	
795	DI	YI	1	DEWATERING SCREW CONVEYOR NO 1 IN REMOTE	LCP-1001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	72-I-002	
796	DI	YIR	1	BELT FILTER PRESS RUNNING	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	RUNNING	PLC	No	72-I-002	
797	DI	YA	1	BELT FILTER PRESS FAIL	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	FAIL	PLC	No	72-I-002	
798	DI	UA	1	BELT FILTER PRESS SHUTDOWN ALARM	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	SHUTDOWN ALARM	PLC	No	72-I-002	
799	DI	YIA	1	BELT FILTER PRESS E-STOP	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	E-STOP	PLC	No	72-I-002	
800	DI	PAL	1	BELT FILTER PRESS LOW PRESSURE	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	LOW PRESSURE	PLC	No	72-I-002	
801	DI	YA	1	BELT FILTER PRESS WARNING	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	ETHERNET	WARNING	PLC	No	72-I-002	
802	DI	YIA	2	DEWATERING SCREW CONVEYOR NO 2 E-STOP	LCP-1002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	E-STOP	PLC	No	72-I-002	
803	DI	SI	2	DEWATERING SCREW CONVEYOR NO 2 ZERO SPEED	LCP-1002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	ZERO SPEED	PLC	No	72-I-002	
804	DI	IA	2	DEWATERING SCREW CONVEYOR NO 2 MOTOR OVERLOAD	LCP-1002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	MOTOR OVERLOAD	PLC	No	72-I-002	
805	DI	YIR	2	DEWATERING SCREW CONVEYOR NO 2 RUNNING	LCP-1002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	72-I-002	
806	DI	YI	2	DEWATERING SCREW CONVEYOR NO 2 IN REMOTE	LCP-1002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	72-I-002	
807	DI	YIA	3	DEWATERING SCREW CONVEYOR NO 3 E-STOP	LCP-1003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	E-STOP	PLC	No	72-I-002	
808	DI	SI	3	DEWATERING SCREW CONVEYOR NO 3 ZERO SPEED	LCP-1003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	ZERO SPEED	PLC	No	72-I-002	
809	DI	IA	3	DEWATERING SCREW CONVEYOR NO 3 MOTOR OVERLOAD	LCP-1003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	MOTOR OVERLOAD	PLC	No	72-I-002	
810	DI	YIR	3	DEWATERING SCREW CONVEYOR NO 3 RUNNING	LCP-1003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	72-I-002	
811	DI	YI	3	DEWATERING SCREW CONVEYOR NO 3 IN REMOTE	LCP-1003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	72-I-002	
812	DI	YI	6	BELT FILTER INLET VALVE IN REMOTE	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	72-I-002	
813	DI	ZIO	6	BELT FILTER INLET VALVE OPENED	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	72-I-002	
814	DI	ZIC	6	BELT FILTER INLET VALVE CLOSED	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	72-I-002	
815	DI	YI	101	DEWATERING GATE 1 IN REMOTE	V-0101	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	72-I-002	
816	DI	ZIO	101	DEWATERING GATE 1 OPENED	V-0101	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	72-I-002	
817	DI	ZIC	101	DEWATERING GATE 1 CLOSED	V-0101	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	72-I-002	
818	DI	YI	201	DEWATERING GATE 2 IN REMOTE	V-0201	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	72-I-002	
819	DI	ZIO	201	DEWATERING GATE 2 OPENED	V-0201	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	72-I-002	
820	DI	ZIC	201	DEWATERING GATE 2 CLOSED	V-0201	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	72-I-002	
821	DI	YI	1	DISK FILTER IN REMOTE	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
822	DI	YIR	1	DISK FILTER RUNNING	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	73-I-001	
823	DI	YA	1	DISK FILTER FAIL	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	73-I-001	
824	DI	YI	1	FILTER SOLID WASTE PUMP IN REMOTE	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
825	DI	YIR	1	FILTER SOLID WASTE PUMP RUNNING	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	73-I-001	
826	DI	YA	1	FILTER SOLID WASTE PUMP FAIL	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	73-I-001	
827	DI	YI	1	DISK FILTER INLET GATE IN REMOTE	G-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
828	DI	ZIO	1	DISK FILTER INLET GATE OPENED	G-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
829	DI	ZIC	1	DISK FILTER INLET GATE CLOSED	G-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
830	DI	YI	2	FILTER BACKWASH WASTE PUMP IN REMOTE	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
831	DI	YIR	2	FILTER BACKWASH WASTE PUMP RUNNING	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	73-I-001	
832	DI	YA	2	FILTER BACKWASH WASTE PUMP FAIL	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	73-I-001	
833	DI	YI	2	FILTER SOLID WASTE PUMP SUCTION VALVE IN REMOTE	V-0002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
834	DI	ZIO	2	FILTER SOLID WASTE PUMP SUCTION VALVE OPENED	V-0002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
835	DI	ZIC	2	FILTER SOLID WASTE PUMP SUCTION VALVE CLOSED	V-0002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
836	DI	YI	3	FILTER BACKWASH WASTE VALVE 0003 IN REMOTE	V-0003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
837	DI	ZIO	3	FILTER BACKWASH WASTE VALVE 0003 OPENED	V-0003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
838	DI	ZIC	3	FILTER BACKWASH WASTE VALVE 0003 CLOSED	V-0003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
839	DI	YI	4	FILTER BACKWASH WASTE VALVE 0004 IN REMOTE	V-0004	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
840	DI	ZIO	4	FILTER BACKWASH WASTE VALVE 0004 OPENED	V-0004	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
841	DI	ZIC	4	FILTER BACKWASH WASTE VALVE 0004 CLOSED	V-0004	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
842	DI	YI	5	FILTER BACKWASH WASTE VALVE 0005 IN REMOTE	V-0005	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
843	DI	ZIO	5	FILTER BACKWASH WASTE VALVE 0005 OPENED	V-0005	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
844	DI	ZIC	5	FILTER BACKWASH WASTE VALVE 0005 CLOSED	V-0005	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
845	DI	YI	6	DISK FILTER RECIRCLATION VALVE IN REMOTE	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
846	DI	ZIO	6	DISK FILTER RECIRCLATION VALVE OPENED	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
847	DI	ZIC	6	DISK FILTER RECIRCLATION VALVE CLOSED	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
848	DI	YI	7	DISK FILTER SCUM VALVE IN REMOTE	V-0007	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
849	DI	ZIO	7	DISK FILTER SCUM VALVE OPENED	V-0007	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
850	DI	ZIC	7	DISK FILTER SCUM VALVE CLOSED	V-0007	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
851	DI	YI	11	FILTER SOLIDS WASTE PUMP DISCHARGE VALVE IN REMOTE	V-0011	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
852	DI	ZIO	11	FILTER SOLIDS WASTE PUMP DISCHARGE VALVE OPENED	V-0011	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
853	DI	ZIC	11	FILTER SOLIDS WASTE PUMP DISCHARGE VALVE CLOSED	V-0011	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
854	DI	YI	14	FILTER BACKWASH WASTE PUMP DISCHARGE VALVE IN REMOTE	V-0014	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	73-I-001	
855	DI	ZIO	14	FILTER BACKWASH WASTE PUMP DISCHARGE VALVE OPENED	V-0014	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPENED	PLC	No	73-I-001	
856	DI	ZIC	14	FILTER BACKWASH WASTE PUMP DISCHARGE VALVE CLOSED	V-0014	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSED	PLC	No	73-I-001	
857	DO	UCR	1	DEWATERING SCREW CONVEYOR NO 1 RUN COMMAND	LCP-1001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	72-I-002	
858	DO	UCR	2	DEWATERING SCREW CONVEYOR NO 2 RUN COMMAND	LCP-1002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	72-I-002	
859	DO	UCR	3	DEWATERING SCREW CONVEYOR NO 3 RUN COMMAND	LCP-1003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	72-I-002	
860	DO	ZCO	6	BELT FILTER INLET VALVE OPEN COMMAND	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	72-I-002	
861	DO	ZCC	6	BELT FILTER INLET VALVE CLOSE COMMAND	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	72-I-002	
862	DO	ZCO	101	DEWATERING GATE 1 OPEN COMMAND	V-0101	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	72-I-002	
863	DO	ZCC	101	DEWATERING GATE 1 CLOSE COMMAND	V-0101	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	72-I-002	
864	DO	ZCO	201	DEWATERING GATE 2 OPEN COMMAND	V-0201	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	72-I-002	
865	DO	ZCC	201	DEWATERING GATE 2 CLOSE COMMAND	V-0201	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	72-I-002	
866	DO	UCS	1	DISK FILTER START COMMAND	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	START CMD	PLC	YES	73-I-001	
867	DO	UCS	1	DISK FILTER STOP COMMAND	LCP-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	STOP CMD	PLC	YES	73-I-001	
868	DO	ZCO	1	DISK FILTER INLET GATE OPEN CMD	G-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
869	DO	ZCC	1	DISK FILTER INLET GATE CLOSE CMD	G-0001	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	
870	DO	ZCO	2	FILTER SOLID WASTE PUMP SUCTION VALVE OPEN CMD	V-0002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
871	DO	ZCC	2	FILTER SOLID WASTE PUMP SUCTION VALVE CLOSE CMD	V-0002	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
872	DO	ZCO	3	FILTER BACKWASH WASTE VALVE 0003 OPEN CMD	V-0003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
873	DO	ZCC	3	FILTER BACKWASH WASTE VALVE 0003 CLOSE CMD	V-0003	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	
874	DO	ZCO	4	FILTER BACKWASH WASTE VALVE 0004 OPEN CMD	V-0004	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
875	DO	ZCC	4	FILTER BACKWASH WASTE VALVE 0004 CLOSE CMD	V-0004	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	
876	DO	ZCO	5	FILTER BACKWASH WASTE VALVE 0005 OPEN CMD	V-0005	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
877	DO	ZCC	5	FILTER BACKWASH WASTE VALVE 0005 CLOSE CMD	V-0005	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	
878	DO	ZCO	6	DISK FILTER RECIRCLATION VALVE OPEN CMD	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
879	DO	ZCC	6	DISK FILTER RECIRCLATION VALVE CLOSE CMD	V-0006	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	
880	DO	ZCO	7	DISK FILTER SCUM VALVE OPEN CMD	V-0007	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
881	DO	ZCC	7	DISK FILTER SCUM VALVE CLOSE CMD	V-0007	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	
882	DO	ZCO	11	FILTER SOLIDS WASTE PUMP DISCHARGE VALVE OPEN CMD	V-0011	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
883	DO	ZCC	11	FILTER SOLIDS WASTE PUMP DISCHARGE VALVE CLOSE CMD	V-0011	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	
884	DO	ZCO	14	FILTER BACKWASH WASTE PUMP DISCHARGE VALVE OPEN CMD	V-0014	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	OPEN CMD	PLC	YES	73-I-001	
885	DO	ZCC	14	FILTER BACKWASH WASTE PUMP DISCHARGE VALVE CLOSE CMD	V-0014	72-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	CLOSE CMD	PLC	YES	73-I-001	
886	AI	WI	1	THICKENING POLYMER STORAGE TOTE LEVEL	POLF-WIT-0001	72-CTRL--RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-008	
887	AI	SI	1	THICKENING POLYMER METERING PUMP NO 1 SPEED INDICATION	POLF-LCP-0001	72-CTRL--RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-008	
888	AO	SC	1	THICKENING POLYMER METERING PUMP NO 1 SPEED SET POINT	POLF-LCP-0001	72-CTRL--RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-008	
889	DI	YIR	1	THICKENING POLYMER METERING PUMP NO 1 RUNNING	POLF-LCP-0001	72-CTRL--RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-008	
890	DI	YA	1	THICKENING POLYMER METERING PUMP NO 1 FAIL	POLF-LCP-0001	72-CTRL--RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-008	
891	DI	YI	1	THICKENING POLYMER METERING PUMP NO 1 IN REMOTE	POLF-LCP-0001	72-CTRL--RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-008	
892	DI	FAH	6	THICKENING POLYMER STORAGE AREA EYEWASH ACTIVATED	POLF-FSH-0006	72-CTRL--RIO-0001	N/A	N/A	N/A	24 VDC	EYEWASH ACTIVATED	PLC	No	90-I-008	
893	DO	UCR	1	THICKENING POLYMER METERING PUMP NO 1 RUN COMMAND	POLF-LCP-0001	72-CTRL--RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-008	
894	DI	YIA	2			72-RIO-0001							No	72-I-002	
895	DI	SI	2			72-RIO-0001							No	72-I-002	
896	DI	IA	2			72-RIO-0001							No	72-I-002	
897	DI	YIR	2			72-RIO-0001							No	72-I-002	
898	DI	YI	2			72-RIO-0001							No	72-I-002	
899	DI	YIA	2			72-RIO-0001							No	72-I-002	
900	DI	SI	2			72-RIO-0001							No	72-I-002	
901	DI	IA	2			72-RIO-0001							No	72-I-002	
902	DI	YIR	2			72-RIO-0001							No	72-I-002	
903	DI	YI	2			72-RIO-0001							No	72-I-002	
904	DI	YIR	2			72-RIO-0001							No	72-I-002	
905	DI	YA	2			72-RIO-0001							No	72-I-002	
906	DI	UA	2			72-RIO-0001							No	72-I-002	
907	DI	YIA	2			72-RIO-0001							No	72-I-002	
908	DI	PAL	2			72-RIO-0001							No	72-I-002	
909	DI	YA	2			72-RIO-0001							No	72-I-002	
910	DI	YIA	3			72-RIO-0001							No	72-I-002	
911	DI	SI	3			72-RIO-0001							No	72-I-002	
912	DI	IA	3			72-RIO-0001							No	72-I-002	
913	DI	YIR	3			72-RIO-0001							No	72-I-002	
914	DI	YI	3			72-RIO-0001							No	72-I-002	
915	DI	YIR	3			72-RIO-0001							No	72-I-002	
916	DI	YA	3			72-RIO-0001							No	72-I-002	
917	DI	UA	3			72-RIO-0001							No	72-I-002	
918	DI	YIA	3			72-RIO-0001							No	72-I-002	
919	DI	PAL	3			72-RIO-0001							No	72-I-002	
920	DI	YA	3			72-RIO-0001							No	72-I-002	
921	DO	UCR	2			72-RIO-0001							No	72-I-002	
922	DO	UCR	2			72-RIO-0001							No	72-I-002	
923	DO	UCR	3			72-RIO-0001							No	72-I-002	
924	AI	SI	1001	BASIN 1 MBR FEED PUMP SPEED FEEDBACK	VFD1001	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-001	
925	AI	SI	2001	BASIN 2 MBR FEED PUMP SPEED FEEDBACK	VFD-2001	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-002	
926	AI	SI	1	SCUM PUMP SPEED FEEDBACK	VFD-0001	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-003	
927	AI	SI	1	WAS PUMP SPEED FEEDBACK	VFD-0001	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-003	
928	AI	SI	101	RECYCLED WATER PUMP NO. 1 SPEED FEEDBACK	101	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	34-I-001	
929	AI	SI	201	RECYCLED WATER PUMP NO. 2 SPEED FEEDBACK	201	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	34-I-001	
930	AI	SI	101	SLUDGE HOLDING TANK BLOWER NO 1 SPEED INDICATION	LCP-0101	80-CTRL-PLC-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	71-I-003	
931	AI	II	101	SLUDGE HOLDING TANK BLOWER NO 1 MOTOR CURRENT	LCP-0101	80-CTRL-PLC-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	71-I-003	
932	AI	SI	201	SLUDGE HOLDING TANK BLOWER NO 2 SPEED INDICATION	LCP-0201	80-CTRL-PLC-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	71-I-003	
933	AI	II	201	SLUDGE HOLDING TANK BLOWER NO 2 MOTOR CURRENT	LCP-0201	80-CTRL-PLC-0001	4 - 20 MA		4 - WIRE	N/A	N/A	N/A	No	71-I-003	
934	AI	SI	101	DEWATERING SLUDGE FEED PUMP NO 1 SPEED FEEDBACK	101	80-CTRL-PLC-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	72-I-001	
935	AI	SI	201	DEWATERING SLUDGE FEED PUMP NO 2 SPEED FEEDBACK	201	80-CTRL-PLC-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	72-I-001	
936	AO	SC	1001	BASIN 1 MBR FEED PUMP SPEED SETPT	VFD1001	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-001	
937	AO	SC	2001	BASIN 2 MBR FEED PUMP SPEED SETPT	VFD-2001	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-002	
938	AO	SC	1	SCUM PUMP SPEED SETPT	VFD-0001	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-003	
939	AO	SC	1	WAS PUMP SPEED SETPT	VFD-0001	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	31-I-003	
940	AO	SC	101	RECYCLED WATER PUMP NO. 1 SPEED SETPT	101	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	34-I-001	
941	AO	SC	201	RECYCLED WATER PUMP NO. 2 SPEED SETPT	201	80-CTRL-PLC-0001	4-20 mA		2-WIRE	N/A	N/A	N/A	N/A	34-I-001	
942	AO	SC	101	SLUDGE HOLDING TANK BLOWER NO 1 SPEED SET PT	LCP-0101	80-CTRL-PLC-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	71-I-003	
943	AO	SC	201	SLUDGE HOLDING TANK BLOWER NO 2 SPEED SET PT	LCP-0201	80-CTRL-PLC-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	71-I-003	
944	AO	SC	101	DEWATERING SLUDGE FEED PUMP NO 1 SPEED SET PT	101	80-CTRL-PLC-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	72-I-001	
945	AO	SC	201	DEWATERING SLUDGE FEED PUMP NO 2 SPEED SET PT	201	80-CTRL-PLC-0001	4 - 20 MA	0 - 100 %	4 - WIRE	N/A	N/A	N/A	No	72-I-001	
946	DI	UA	1	RAS DEOX MIXER FAIL	MCC-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-001	
947	DI	YIR	1	RAS DEOX MIXER RUNNING	MCC-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-001	
948	DI	YI	1	RAS DEOX MIXER IN REMOTE	MCC-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-001	
949	DI	YI	1001	BASIN 1 MBR FEED PUMP IN REMOTE	VFD1001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-001	
950	DI	YIR	1001	BASIN 1 MBR FEED PUMP RUNNING	VFD1001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-001	
951	DI	YA	1001	BASIN 1 MBR FEED PUMP FAULT	VFD1001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	31-I-001	
952	DI	YI	2001	BASIN 2 MBR FEED PUMP IN REMOTE	VFD-2001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-002	
953	DI	YIR	2001	BASIN 2 MBR FEED PUMP RUNNING	VFD-2001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-002	
954	DI	YA	2001	BASIN 2 MBR FEED PUMP FAULT	VFD-2001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	31-I-002	
955	DI	YA	1	SCUM PUMP FAULT	VFD-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	31-I-003	
956	DI	YA	1	WAS PUMP SPEED FAULT	VFD-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	FAULT	PLC	No	31-I-003	
957	DI	YI	1	SCUM PUMP IN REMOTE	VFD-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-003	
958	DI	YI	1	WAS PUMP SPEED IN REMOTE	VFD-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-003	
959	DI	YIR	1	SCUM PUMP RUNNING	VFD-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-003	
960	DI	YIR	1	WAS PUMP SPEED RUNNING	VFD-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-003	
961	DI	YI	101	RECYCLED WATER PUMP NO. 1 IN REMOTE	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	34-I-001	
962	DI	YIR	101	RECYCLED WATER PUMP NO. 1 RUNNING	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	34-I-001	
963	DI	UA	101	RECYCLED WATER PUMP NO. 1 FAIL	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	34-I-001	
964	DI	PAH	101	RECYCLED WATER PUMP NO. 1 DISCHARGE PRESSURE HIGH	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	PR. HIGH	PLC	No	34-I-001	
965	DI	PAH	101	RECYCLED WATER PUMP NO. 1 SUCTION PRESSURE LOW	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	PR. LOW	PLC	No	34-I-001	
966	DI	PAL	201	RECYCLED WATER PUMP NO. 2 SUCTION PRESSURE LOW	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	PR. LOW	PLC	No	34-I-001	
967	DI	YI	201	RECYCLED WATER PUMP NO. 2 IN REMOTE	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	34-I-001	
968	DI	YIR	201	RECYCLED WATER PUMP NO. 2 RUNNING	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	34-I-001	
969	DI	UA	201	RECYCLED WATER PUMP NO. 2 FAIL	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	34-I-001	
970	DI	PAH	201	RECYCLED WATER PUMP NO. 2 DISCHARGE PRESSURE HIGH	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	PR. HIGH	PLC	No	34-I-001	
971	DI	YA	2	SLUDGE HOLDING TANK NO 2 MIXER FAIL	MCC-0002	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	71-I-001	
972	DI	YIR	2	SLUDGE HOLDING TANK NO 2 MIXER RUNNING	MCC-0002	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	71-I-001	
973	DI	YI	2	SLUDGE HOLDING TANK NO 2 MIXER IN REMOTE	MCC-0002	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	71-I-001	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
974	DI	YA	101	SLUDGE HOLDING TANK NO 1 MIXER FAIL	MCC-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	71-I-001	
975	DI	YIR	101	SLUDGE HOLDING TANK NO 1 MIXER RUNNING	MCC-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	71-I-001	
976	DI	YI	101	SLUDGE HOLDING TANK NO 1 MIXER IN REMOTE	MCC-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	71-I-001	
977	DI	YA	101	SLUDGE HOLDING TANK BLOWER NO 1 WARNING	LCP-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	WARNING	PLC	No	71-I-003	
978	DI	YI	101	SLUDGE HOLDING TANK BLOWER NO 1 IN REMOTE	LCP-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	71-I-003	
979	DI	YIR	101	SLUDGE HOLDING TANK BLOWER NO 1 RUNNING	LCP-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	71-I-003	
980	DI	YA	101	SLUDGE HOLDING TANK BLOWER NO 1 FAIL	LCP-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	71-I-003	
981	DI	YA	201	SLUDGE HOLDING TANK BLOWER NO 2 WARNING	LCP-0201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	WARNING	PLC	No	71-I-003	
982	DI	YI	201	SLUDGE HOLDING TANK BLOWER NO 2 IN REMOTE	LCP-0201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	71-I-003	
983	DI	YIR	201	SLUDGE HOLDING TANK BLOWER NO 2 RUNNING	LCP-0201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	71-I-003	
984	DI	YA	201	SLUDGE HOLDING TANK BLOWER NO 2 FAIL	LCP-0201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	71-I-003	
985	DI	YI	101	DEWATERING SLUDGE FEED PUMP NO 1 IN REMOTE	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	72-I-001	
986	DI	YIR	101	DEWATERING SLUDGE FEED PUMP NO 1 RUNNING	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	72-I-001	
987	DI	YA	101	DEWATERING SLUDGE FEED PUMP NO 1 FAIL	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	72-I-001	
988	DI	YI	201	DEWATERING SLUDGE FEED PUMP NO 2 IN REMOTE	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	72-I-001	
989	DI	YIR	201	DEWATERING SLUDGE FEED PUMP NO 2 RUNNING	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	72-I-001	
990	DI	YA	201	DEWATERING SLUDGE FEED PUMP NO 2 FAIL	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	72-I-001	
991	DO	UCR	1	RAS DEOX MIXER RUN COMMAND	MCC-0001	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	31-I-001	
992	DO	UCR	101	RECYCLED WATER PUMP NO. 1 RUN CMD	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	34-I-001	
993	DO	UCR	201	RECYCLED WATER PUMP NO. 2 RUN CMD	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	34-I-001	
994	DO	UCR	2	SLUDGE HOLDING TANK NO 2 MIXER RUN COMMAND	MCC-0002	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	71-I-001	
995	DO	UCR	101	SLUDGE HOLDING TANK NO 1 MIXER RUN COMMAND	MCC-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	71-I-001	
996	DO	UCR	101	SLUDGE HOLDING TANK BLOWER NO 1 RUN COMMAND	LCP-0101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	71-I-003	
997	DO	UCR	201	SLUDGE HOLDING TANK BLOWER NO 2 RUN COMMAND	LCP-0201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	71-I-003	
998	DO	UCR	101	DEWATERING SLUDGE FEED PUMP NO 1 RUN COMMAND	101	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	72-I-001	
999	DO	UCR	201	DEWATERING SLUDGE FEED PUMP NO 2 RUN COMMAND	201	80-CTRL-PLC-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	72-I-001	
1000	DI	UA	2001	BASIN 2 ANOXIC MIXER FAIL	MCC-2001	90-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-002	
1001	DI	YIR	2001	BASIN 2 ANOXIC MIXER RUNNING	MCC-2001	90-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-002	
1002	DI	YI	2001	BASIN 2 ANOXIC MIXER IN REMOTE	MCC-2001	90-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-002	
1003	DO	UCR	2001	BASIN 2 ANOXIC MIXER RUN CMD	MCC-2001	90-CTRL-PLC-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	31-I-002	
1004	AI	LI	1	SODIUM HYDROXIDE STORAGE TANK LEVEL	NAOH-LIT-0001	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-003	
1005	AI	SI	101	SODIUM HYDROXIDE METERING PUMP NO 1 SPEED INDICATION	NAOH-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-003	
1006	AI	SI	201	SODIUM HYDROXIDE METERING PUMP NO 2 SPEED INDICATION	NAOH-LCP-0201	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-003	
1007	AI	SI	301	SODIUM HYDROXIDE METERING PUMP NO 3 SPEED INDICATION	NAOH-LCP-0301	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-003	
1008	AI	SI	1	SODIUM BISULFITE METERING PUMP NO 1 SPEED INDICATION	NHS-LCP-0001	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-004	
1009	AI	WI	35	SODIUM BISULFITE STORAGE TOTE LEVEL	NHS-WIT-0035	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-004	
1010	AI	WI	1	ANTISCALANT STORAGE TOTE LEVEL	ANTI-WIT-0001	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-005	
1011	AI	SI	1	ANTISCALANT METERING PUMP NO 1 SPEED INDICATION	ANTI-LCP-0001	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-005	
1012	AI	WI	1	CITRIC ACID STORAGE TOTE LEVEL	CA-WIT-0001	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-006	
1013	AI	SI	101	CITRIC ACID METERING PUMP NO 1 SPEED INDICATION	CA-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-006	
1014	AI	SI	201	CITRIC ACID METERING PUMP NO 2 SPEED INDICATION	CA-LCP-0201	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-006	
1015	AI	WI	1	SULFURIC ACID STORAGE TOTE LEVEL	HSO4-WIT-0001	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1016	AI	TI	1	SULFURIC ACID DILUTION WATER TEMPERATURE	HSO4-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		2 - WIRE	N/A	N/A	N/A	No	90-I-007	
1017	AI	AI	1	SULFURIC ACID DILUTION WATER CONDUCTIVITY	HSO4-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1018	AI	TI	2	SULFURIC ACID DILUTION WATER TEMPERATURE	HSO4-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		2 - WIRE	N/A	N/A	N/A	No	90-I-007	
1019	AI	AI	2	SULFURIC ACID DILUTION WATER CONDUCTIVITY	HSO4-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1020	AI	NI	101	SULFURIC ACID METERING PUMP NO 1 STROKE INDICATION	HSO4-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1021	AI	SI	101	SULFURIC ACID METERING PUMP NO 1 SPEED INDICATION	HSO4-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1022	AI	NI	201	SULFURIC ACID METERING PUMP NO 2 STROKE INDICATION	HSO4-LCP-0201	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1023	AI	SI	201	SULFURIC ACID METERING PUMP NO 2 SPEED INDICATION	HSO4-LCP-0201	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1024	AO	SC	101	SODIUM HYDROXIDE METERING PUMP NO 1 SPEED SET POINT	NAOH-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-003	
1025	AO	SC	201	SODIUM HYDROXIDE METERING PUMP NO 2 SPEED SET POINT	NAOH-LCP-0201	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-003	
1026	AO	SC	301	SODIUM HYDROXIDE METERING PUMP NO 3 SPEED SET POINT	NAOH-LCP-0301	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-003	
1027	AO	SC	1	SODIUM BISULFITE METERING PUMP NO 1 SPEED SET POINT	NHS-LCP-0001	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-004	
1028	AO	SC	1	ANTISCALANT METERING PUMP NO 1 SPEED SET POINT	ANTI-LCP-0001	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-005	
1029	AO	SC	101	CITRIC ACID METERING PUMP NO 1 SPEED SET POINT	CA-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-006	
1030	AO	SC	201	CITRIC ACID METERING PUMP NO 2 SPEED SET POINT	CA-LCP-0201	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-006	
1031	AO	NC	101	SULFURIC ACID METERING PUMP NO 1 STROKE SET POINT	HSO4-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1032	AO	SC	101	SULFURIC ACID METERING PUMP NO 1 SPEED SET POINT	HSO4-LCP-0101	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1033	AO	NC	201	SULFURIC ACID METERING PUMP NO 2 STROKE SET POINT	HSO4-LCP-0201	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1034	AO	SC	201	SULFURIC ACID METERING PUMP NO 2 SPEED SET POINT	HSO4-LCP-0201	90-CTRL-RIO-0001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-007	
1035	DI	UA	1001	BASIN 1 ANOXIC MIXER FAIL	MCC-1001	90-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	FAIL	PLC	No	31-I-001	
1036	DI	YIR	1001	BASIN 1 ANOXIC MIXER RUNNING	MCC-1001	90-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUNNING	PLC	No	31-I-001	
1037	DI	YI	1001	BASIN 1 ANOXIC MIXER IN REMOTE	MCC-1001	90-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	IN REMOTE	PLC	No	31-I-001	
1038	DI	YIR	101	SODIUM HYDROXIDE METERING PUMP NO 1 RUNNING	NAOH-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-003	
1039	DI	YA	101	SODIUM HYDROXIDE METERING PUMP NO 1 FAIL	NAOH-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-003	
1040	DI	YI	101	SODIUM HYDROXIDE METERING PUMP NO 1 IN REMOTE	NAOH-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-003	
1041	DI	PAH	101	SODIUM HYDROXIDE METERING PUMP NO 1 HIGH DISCHARGE PRESSURE	NAOH-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-003	
1042	DI	YIR	201	SODIUM HYDROXIDE METERING PUMP NO 2 RUNNING	NAOH-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-003	
1043	DI	YA	201	SODIUM HYDROXIDE METERING PUMP NO 2 FAIL	NAOH-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-003	
1044	DI	YI	201	SODIUM HYDROXIDE METERING PUMP NO 2 IN REMOTE	NAOH-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-003	
1045	DI	PAH	201	SODIUM HYDROXIDE METERING PUMP NO 2 HIGH DISCHARGE PRESSURE	NAOH-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-003	
1046	DI	YIR	301	SODIUM HYDROXIDE METERING PUMP NO 3 RUNNING	NAOH-LCP-0301	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-003	
1047	DI	YA	301	SODIUM HYDROXIDE METERING PUMP NO 3 FAIL	NAOH-LCP-0301	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-003	
1048	DI	YI	301	SODIUM HYDROXIDE METERING PUMP NO 3 IN REMOTE	NAOH-LCP-0301	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-003	
1049	DI	PAH	301	SODIUM HYDROXIDE METERING PUMP NO 3 HIGH DISCHARGE PRESSURE	NAOH-LCP-0301	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-003	
1050	DI	YIR	1	SODIUM BISULFITE METERING PUMP NO 1 RUNNING	NHS-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-004	
1051	DI	YA	1	SODIUM BISULFITE METERING PUMP NO 1 FAIL	NHS-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-004	
1052	DI	YI	1	SODIUM BISULFITE METERING PUMP NO 1 IN REMOTE	NHS-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-004	
1053	DI	PAH	1	SODIUM BISULFITE METERING PUMP NO 1 DISCHARGE HIGH PRESSURE	NHS-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-004	
1054	DI	FAH	2	SODIUM BISULFITE STORAGE AREA EYEWASH ACTIVATED	NHS-FSH-0002	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	EYEWASH ACTIVATED	PLC	No	90-I-004	
1055	DI	YIR	1	ANTISCALANT METERING PUMP NO 1 RUNNING	ANTI-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-005	
1056	DI	YA	1	ANTISCALANT METERING PUMP NO 1 FAIL	ANTI-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-005	
1057	DI	YI	1	ANTISCALANT METERING PUMP NO 1 IN REMOTE	ANTI-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-005	
1058	DI	PAH	1	ANTISCALANT METERING PUMP NO 1 DISCHARGE HIGH PRESSURE	ANTI-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-005	
1059	DI	FAH	3	ANTISCALANT STORAGE AREA EYEWASH ACTIVATED	ANTI-FSH-0003	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	EYEWASH ACTIVATED	PLC	No	90-I-005	
1060	DI	FAH	4	CITRIC ACID STORAGE AREA EYEWASH ACTIVATED	CA-FSH-0004	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	EYEWASH ACTIVATED	PLC	No	90-I-006	
1061	DI	YIR	101	CITRIC ACID METERING PUMP NO 1 RUNNING	CA-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-006	
1062	DI	YA	101	CITRIC ACID METERING PUMP NO 1 FAIL	CA-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-006	
1063	DI	YI	101	CITRIC ACID METERING PUMP NO 1 IN REMOTE	CA-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-006	
1064	DI	PAH	101	CITRIC ACID METERING PUMP NO 1 DISCHARGE HIGH PRESSURE	CA-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-006	
1065	DI	YIR	201	CITRIC ACID METERING PUMP NO 2 RUNNING	CA-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-006	
1066	DI	YA	201	CITRIC ACID METERING PUMP NO 2 FAIL	CA-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-006	
1067	DI	YI	201	CITRIC ACID METERING PUMP NO 2 IN REMOTE	CA-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-006	
1068	DI	PAH	201	CITRIC ACID METERING PUMP NO 2 DISCHARGE HIGH PRESSURE	CA-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-006	
1069	DI	FAH	5	SULFURIC ACID STORAGE AREA EYEWASH ACTIVATED	HSO4-FSH-0005	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	EYEWASH ACTIVATED	PLC	No	90-I-007	
1070	DI	PAH	101	SULFURIC ACID METERING PUMP NO 1 DISCHARGE HIGH PRESSURE	HSO4-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-007	
1071	DI	MAH	101	SULFURIC ACID METERING PUMP NO 1 HIGH MOISTURE	HSO4-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI MOISTURE	PLC	No	90-I-007	
1072	DI	YA	101	SULFURIC ACID METERING PUMP NO 1 FAIL	HSO4-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-007	
1073	DI	YI	101	SULFURIC ACID METERING PUMP NO 1 IN REMOTE	HSO4-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-007	
1074	DI	YIR	101	SULFURIC ACID METERING PUMP NO 1 RUNNING	HSO4-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-007	
1075	DI	PAH	201	SULFURIC ACID METERING PUMP NO 2 DISCHARGE HIGH PRESSURE	HSO4-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-007	

Item	IO Type	IO Code	Loop Number	Description	Field Device	Controller ID	Analog Signal Type	Analog Range	Analog Power Type	Digitial Signal Type	Digital Close State	Digital Power Source	Digital Interp Relay	P&ID Drawing	Remarks
1076	DI	MAH	201	SULFURIC ACID METERING PUMP NO 2 HIGH MOISTURE	HSO4-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	HI MOISTURE	PLC	No	90-I-007	
1077	DI	YA	201	SULFURIC ACID METERING PUMP NO 2 FAIL	HSO4-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-007	
1078	DI	YI	201	SULFURIC ACID METERING PUMP NO 2 IN REMOTE	HSO4-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-007	
1079	DI	YIR	201	SULFURIC ACID METERING PUMP NO 2 RUNNING	HSO4-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-007	
1080	DO	UCR	1001	BASIN 1 ANOXIC MIXER RUN COMMAND	MCC-1001	90-CTRL-RIO-0001	N/A	N/A	N/A	24VDC	RUN CMD	FIELD	YES	31-I-001	
1081	DO	UCR	101	SODIUM HYDROXIDE METERING PUMP NO 1 RUN COMMAND	NAOH-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-003	
1082	DO	UCR	201	SODIUM HYDROXIDE METERING PUMP NO 2 RUN COMMAND	NAOH-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-003	
1083	DO	UCR	301	SODIUM HYDROXIDE METERING PUMP NO 3 RUN COMMAND	NAOH-LCP-0301	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-003	
1084	DO	UCR	1	SODIUM BISULFITE METERING PUMP NO 1 RUN COMMAND	NHS-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-004	
1085	DO	UCR	1	ANTISCALANT METERING PUMP NO 1 RUN COMMAND	ANTI-LCP-0001	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-005	
1086	DO	UCR	101	CITRIC ACID METERING PUMP NO 1 RUN COMMAND	CA-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-006	
1087	DO	UCR	201	CITRIC ACID METERING PUMP NO 2 RUN COMMAND	CA-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-006	
1088	DO	UCS	101	SULFURIC ACID METERING PUMP NO 1 STOP COMMAND	HSO4-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	STOP CMD	PLC	YES	90-I-007	
1089	DO	UCR	101	SULFURIC ACID METERING PUMP NO 1 RUN COMMAND	HSO4-LCP-0101	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-007	
1090	DO	UCS	201	SULFURIC ACID METERING PUMP NO 2 STOP COMMAND	HSO4-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	STOP CMD	PLC	YES	90-I-007	
1091	DO	UCR	201	SULFURIC ACID METERING PUMP NO 2 RUN COMMAND	HSO4-LCP-0201	90-CTRL-RIO-0001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-007	
1092	AI	LI	1	SODIUM HYPOCHLORITE STORAGE TANK LEVEL	NOCL-LIT-0001	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-001	
1093	AI	SI	101	SODIUM HYPOCHLORITE METERING PUMP NO 1 SPEED INDICATION	NOCL-LCP-0101	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-001	
1094	AI	SI	201	SODIUM HYPOCHLORITE METERING PUMP NO 2 SPEED INDICATION	NOCL-LCP-0201	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-001	
1095	AI	SI	301	SODIUM HYPOCHLORITE METERING PUMP NO 3 SPEED INDICATION	NOCL-LCP-0301	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-001	
1096	AI	SI	401	SODIUM HYPOCHLORITE METERING PUMP NO 4 SPEED INDICATION	NOCL-LCP-0401	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-002	
1097	AI	SI	501	SODIUM HYPOCHLORITE METERING PUMP NO 5 SPEED INDICATION	NOCL-LCP-0501	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-002	
1098	AI	SI	601	SODIUM HYPOCHLORITE METERING PUMP NO 6 SPEED INDICATION	NOCL-LCP-0601	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-002	
1099	AI	SI	701	SODIUM HYPOCHLORITE METERING PUMP NO 7 SPEED INDICATION	NOCL-LCP-0701	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-002	
1100	AO	SC	101	SODIUM HYPOCHLORITE METERING PUMP NO 1 SPEED SET POINT	NOCL-LCP-0101	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-001	
1101	AO	SC	201	SODIUM HYPOCHLORITE METERING PUMP NO 2 SPEED SET POINT	NOCL-LCP-0201	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-001	
1102	AO	SC	301	SODIUM HYPOCHLORITE METERING PUMP NO 3 SPEED SET POINT	NOCL-LCP-0301	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-001	
1103	AO	SC	401	SODIUM HYPOCHLORITE METERING PUMP NO 4 SPEED SET POINT	NOCL-LCP-0401	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-002	
1104	AO	SC	501	SODIUM HYPOCHLORITE METERING PUMP NO 5 SPEED SET POINT	NOCL-LCP-0501	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-002	
1105	AO	SC	601	SODIUM HYPOCHLORITE METERING PUMP NO 6 SPEED SET POINT	NOCL-LCP-0601	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-002	
1106	AO	SC	701	SODIUM HYPOCHLORITE METERING PUMP NO 7 SPEED SET POINT	NOCL-LCP-0701	90-CTRL-RIO-001	4 -20 MA		4 - WIRE	N/A	N/A	N/A	No	90-I-002	
1107	DI	FAH	1	SODIUM HYPOCHLORITE STORAGE AREA EYEWASH ACTIVATED	NOCL-FSH-0001	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	EYEWASH ACTIVATED	PLC	No	90-I-001	
1108	DI	YIR	101	SODIUM HYPOCHLORITE METERING PUMP NO 1 RUNNING	NOCL-LCP-0101	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-001	
1109	DI	YA	101	SODIUM HYPOCHLORITE METERING PUMP NO 1 FAIL	NOCL-LCP-0101	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-001	
1110	DI	YI	101	SODIUM HYPOCHLORITE METERING PUMP NO 1 IN REMOTE	NOCL-LCP-0101	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-001	
1111	DI	PAH	101	SODIUM HYPOCHLORITE METERING PUMP NO 1 DISCHARGE HIGH PRESSURE	NOCL-LCP-0101	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-001	
1112	DI	YIR	201	SODIUM HYPOCHLORITE METERING PUMP NO 2 RUNNING	NOCL-LCP-0201	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-001	
1113	DI	YA	201	SODIUM HYPOCHLORITE METERING PUMP NO 2 FAIL	NOCL-LCP-0201	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-001	
1114	DI	YI	201	SODIUM HYPOCHLORITE METERING PUMP NO 2 IN REMOTE	NOCL-LCP-0201	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-001	
1115	DI	PAH	201	SODIUM HYPOCHLORITE METERING PUMP NO 2 DISCHARGE HIGH PRESSURE	NOCL-LCP-0201	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-001	
1116	DI	YIR	301	SODIUM HYPOCHLORITE METERING PUMP NO 3 RUNNING	NOCL-LCP-0301	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-001	
1117	DI	YA	301	SODIUM HYPOCHLORITE METERING PUMP NO 3 FAIL	NOCL-LCP-0301	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-001	
1118	DI	YI	301	SODIUM HYPOCHLORITE METERING PUMP NO 3 IN REMOTE	NOCL-LCP-0301	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-001	
1119	DI	PAH	301	SODIUM HYPOCHLORITE METERING PUMP NO 3 DISCHARGE HIGH PRESSURE	NOCL-LCP-0301	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-001	
1120	DI	YIR	401	SODIUM HYPOCHLORITE METERING PUMP NO 4 RUNNING	NOCL-LCP-0401	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-002	
1121	DI	YA	401	SODIUM HYPOCHLORITE METERING PUMP NO 4 FAIL	NOCL-LCP-0401	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-002	
1122	DI	YI	401	SODIUM HYPOCHLORITE METERING PUMP NO 4 IN REMOTE	NOCL-LCP-0401	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-002	
1123	DI	PAH	401	SODIUM HYPOCHLORITE METERING PUMP NO 4 DISCHARGE HIGH PRESSURE	NOCL-LCP-0401	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-002	
1124	DI	YIR	501	SODIUM HYPOCHLORITE METERING PUMP NO 5 RUNNING	NOCL-LCP-0501	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-002	
1125	DI	YA	501	SODIUM HYPOCHLORITE METERING PUMP NO 5 FAIL	NOCL-LCP-0501	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-002	
1126	DI	YI	501	SODIUM HYPOCHLORITE METERING PUMP NO 5 IN REMOTE	NOCL-LCP-0501	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-002	
1127	DI	PAH	501	SODIUM HYPOCHLORITE METERING PUMP NO 5 DISCHARGE HIGH PRESSURE	NOCL-LCP-0501	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-002	
1128	DI	YIR	601	SODIUM HYPOCHLORITE METERING PUMP NO 6 RUNNING	NOCL-LCP-0601	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-002	
1129	DI	YA	601	SODIUM HYPOCHLORITE METERING PUMP NO 6 FAIL	NOCL-LCP-0601	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-002	
1130	DI	YI	601	SODIUM HYPOCHLORITE METERING PUMP NO 6 IN REMOTE	NOCL-LCP-0601	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-002	
1131	DI	PAH	601	SODIUM HYPOCHLORITE METERING PUMP NO 6 DISCHARGE HIGH PRESSURE	NOCL-LCP-0601	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-002	
1132	DI	YIR	701	SODIUM HYPOCHLORITE METERING PUMP NO 7 RUNNING	NOCL-LCP-0701	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUNNING	PLC	No	90-I-002	
1133	DI	YA	701	SODIUM HYPOCHLORITE METERING PUMP NO 7 FAIL	NOCL-LCP-0701	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	FAIL	PLC	No	90-I-002	
1134	DI	YI	701	SODIUM HYPOCHLORITE METERING PUMP NO 7 IN REMOTE	NOCL-LCP-0701	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	IN REMOTE	PLC	No	90-I-002	
1135	DI	PAH	701	SODIUM HYPOCHLORITE METERING PUMP NO 7 DISCHARGE HIGH PRESSURE	NOCL-LCP-0701	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	HI PRESSURE	PLC	No	90-I-002	
1136	DO	UCR	101	SODIUM HYPOCHLORITE METERING PUMP NO 1 RUN COMMAND	NOCL-LCP-0101	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-001	
1137	DO	UCR	201	SODIUM HYPOCHLORITE METERING PUMP NO 2 RUN COMMAND	NOCL-LCP-0201	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-001	
1138	DO	UCR	301	SODIUM HYPOCHLORITE METERING PUMP NO 3 RUN COMMAND	NOCL-LCP-0301	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-001	
1139	DO	UCR	401	SODIUM HYPOCHLORITE METERING PUMP NO 4 RUN COMMAND	NOCL-LCP-0401	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-002	
1140	DO	UCR	501	SODIUM HYPOCHLORITE METERING PUMP NO 5 RUN COMMAND	NOCL-LCP-0501	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-002	
1141	DO	UCR	601	SODIUM HYPOCHLORITE METERING PUMP NO 6 RUN COMMAND	NOCL-LCP-0601	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-002	
1142	DO	UCR	701	SODIUM HYPOCHLORITE METERING PUMP NO 7 RUN COMMAND	NOCL-LCP-0701	90-CTRL-RIO-001	N/A	N/A	N/A	24 VDC	RUN CMD	PLC	YES	90-I-002	
END															

Section 40 64 01

VENDOR STANDARD
PROGRAMMABLE LOGIC CONTROLLERS

PART 1 – GENERAL

1-1. SCOPE. This section covers the Equipment Supplier's or Equipment Vendor's standard programmable logic controllers (PLCs) for packaged systems, including associated input/output hardware to control process equipment and serve as the interface to field devices.

1-1.01. Control System. The Instrumentation and Control System section shall apply to all equipment furnished under this section.

1-2. GENERAL. Equipment furnished under this section shall be fabricated, assembled, in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Design-Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Drawings. Supplementing this section, the Drawings and equipment specifications indicate the number and types of PLCs, locations of PLCs, who is providing the PLCs and provide diagrams and schematics regarding connection and interaction with other equipment. All hardware, including power supplies, special cables, and other appurtenant equipment, shall be provided to meet the functional requirements described herein and indicated on the Drawings.

1-2.03. I/O List. An input/output (I/O) field device signal listing is included as an appendix attached to this section.

1-3. SUBMITTALS. Submittals shall be as specified in the Instrumentation and Control System, Submittal Procedures, and Schedule of Submittals sections.

1-4. DELIVERY, STORAGE, AND SHIPPING. Delivery, storage and shipping shall be as specified in the Instrumentation and Control System Section.

1-5. SPARE PARTS. The System Supplier shall provide spare parts per the general Terms and Conditions.

PART 2 - PRODUCTS

2-1. GENERAL. All equipment furnished under this section shall be expressly selected by System Supplier for its superior quality for the intended purpose and shall comply with the following requirements.

2-1.01. Initial, Spare, and Future Memory (RAM). System Supplier shall provide adequate memory for the amount of I/O, control algorithms, and communications in the initial system.

2-1.02. Spare I/O. Each PLC input/output enclosure shall be provided with the System Supplier's standard spare inputs and outputs of each type. Spare I/O shall be installed, wired, and interfaced properly to the terminal strip. In addition, each PLC input/output enclosure shall be capable of accommodating the System Supplier's standard additional input/output capacity of each type as originally assembled, without the need for additional expansion racks, communication adapters, cables, or PLC power supplies.

2-1.03. Expandability. Each PLC processor and associated I/O shall have a future expandability based on the System Supplier's standard design for the provided system.

2-1.04. Acceptable Manufacturers. The PLCs shall be the System Supplier's standard product.

2-1.05. Signal Power Supplies. Regulated dc power supplies shall be provided in each PLC enclosure for analog inputs, digital outputs, digital inputs. Output voltage regulation shall be as required by the instrumentation equipment supplied under another section.

Unless otherwise noted, all field devices will be provided with dry contacts that close to provide an input to the PLC.

2-1.06. Appurtenances. The PLC processor and I/O hardware shall be provided as complete systems, as shown on the control system block diagram drawings. The PLCs shall include all necessary hardware and software for a complete working system. All special rack or panel mounted power supplies, special interconnecting and programming cables, special grounding hardware, or isolation devices shall be furnished for proper operation of the equipment. Signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, intrinsically safe relays and current repeaters, surge suppression devices, and isolation devices shall be furnished and installed for proper operation of the equipment.

2-1.07. PLC Arrangement. The PLCs shall be distributed and arranged as indicated on the Drawings. PLC I/O for duty/standby equipment from separate

process trains shall be connected to separate I/O modules.

2-1.08. Service Conditions. PLCs will be installed in air conditioned rooms, non air conditioned rooms or outdoors where the ambient temperature range is 6-22°C. PLCs shall be furnished with sun shades and air conditioned and heated enclosures.

2-2. LARGE PLC PROCESSOR. The programmable logic controller processor shall be the System Supplier's standard industrial-type rack-mounted unit.

2-2.01. Programming Port. The processor shall include a programming port that is available for programming and monitoring on-line after the system is fully functional, and after all communications, human machine interface (HMI), and network connections have been made. Removal or disruption of network communications, remote I/O communications, and HMIs to allow for on-line programming and monitoring will not be acceptable.

2-2.03. Communications. The processor shall be programmed to operate autonomously, regardless of communications status with other units. Each programmable controller shall be furnished complete with communication modules for local and remote input/output hardware communications, communications with other programmable controllers, and communication with host computers as shown on the block diagram. The PLC shall be provided with any required gateway/bridge mux to facilitate seamless Ethernet-based peer-to-peer communication with the Plant Control System's Modicon M340 and M580 PLCs.

2-2.04. Environment. The processor shall be suitable for operation in the environments specified in another section.

2-2.05. Programming. The processor shall be programmable using the IEC 1131 international programming standards and ladder logic programming. IEC 1131 programming shall include the following:

Functional Block Diagram

Sequential Function Chart.

Instruction List.

Structured Text.

Ladder Diagram.

Ladder logic programming shall include a minimum of the following capabilities:

Contacts, coils, branching.

Data comparisons.

On-delay and off-delay timers.

Counters with comparators.

Floating point Math and Logical instructions.

PID loop control.

Jumps and Subroutine functions.

Master control relay.

Transitional or one-shot outputs.

Standard and user-defined data tables for digital and analog value storage.

Remote I/O capability.

Fault-mode sub-routine.

2-2.06. Programming Capabilities. The processor shall include the following capabilities for programming, debugging of programs, and troubleshooting.

Off-line programming.

On-line programming.

On-line status of coils and registers.

Input/output forcing.

2-2.07. Hardware Configuration. Processors shall be configured for standard rack mounting. Each programmable logic controller processor shall include integral communications ports for the programming device, remote input/output, HMI device, or remote communications interfaces.

2-2.08. Input/Output Hardware. Input/output hardware shall be arranged as indicated on the Drawings. Programmable logic controller systems shall support the following types of input/output modules.

120 volt ac digital input and output.

24 volt dc digital input and output.

4-20 mA dc analog input and output.

Platinum RTD analog input.

All output hardware connected to inductive loads shall be supplied with surge suppression devices and recommended by the PLC manufacturer to prevent damage to output hardware. Combination input/output modules will be acceptable if they meet the following requirements.

2-2.08.01. Wiring Terminals. All input/output modules shall utilize easily removable plug-in or hinged field wiring terminals to allow removal of modules without disconnecting individual wires.

2-2.08.02. I/O Circuit Power Supply. Outputs for motor driven equipment will typically be powered from the driven equipment. Digital outputs for miscellaneous equipment shall be powered either from the controlled equipment or the PLC enclosure as indicated on the Drawings or as coordinated with the controlled equipment supplier. Outputs that control process equipment specified under other sections or provided under other contracts shall be fully isolated or shall operate either interposing relays or relay-type digital output modules in the PLC cabinet.

2-2.08.03. Digital Input Modules. Digital input modules shall sense voltages between 100 and 130 volts ac or 20 and 28 volts dc and shall have LED indicators for each point to display the status of the field contact. Return voltage may be common to the entire input module. Digital input modules shall have multiple inputs.

2-2.08-04. Digital Output Modules. Digital output modules shall control voltages from 100 and 130volts ac or 20 and 28 volts dc. Digital output modules shall have multiple outputs.

2-2.08.05. Relay Digital Output Modules. Where indicated on the PLC input/output listing, digital output modules shall have dry contact relay type outputs suitable to control voltages from 24 to 110 volts dc and 24 to 230 volts ac. Digital outputs for motor driven equipment shall be powered by the driven equipment. Relay digital output modules shall have multiple outputs.

2-2.08.06. Analog Input Modules. Analog input modules shall accept linear 4-20 mA dc signals from field transmitters. Analog input modules shall have multiple inputs.

2-2.08.07. Analog Output Modules. Analog output modules shall transmit linear 4-20 mA dc signals to field devices. Loop power for all analog outputs shall be provided by regulated power supplies in each input/output enclosure. Analog output modules shall have multiple outputs.

2-2.08.08. Panel Terminations. All PLC input/output signals for field connections shall be terminated through panel enclosure terminal strips. Direct connection of field wiring to the I/O module terminals is not acceptable.

2-2.08.09. Interposing Relays. Interposing relays shall be incorporated on all I/O circuits as shown on the PLC input/output listing, where required by the application of isolate foreign power sources, where the continuous output rating of the PLC relay digital or output module is not sufficient to power the connected

device or equipment, or where otherwise required by the System Supplier's equipment. Interposing relays shall be provided for any digital output module output signal that leaves the PLC enclosure. Interposing relays shall be mounted in the PLC enclosure containing the output module that activates the relays.

2-3. MINI PLC PROCESSOR. The programmable logic controller processor shall be the System Supplier's standard industrial type.

2-3.01. Programming Port. The processor shall include a programming port that is available for programming and monitoring on-line after the system is fully functional. Removal or disruption of network communications, remote I/O communications, or HMIs to permit programming and monitoring will not be acceptable.

2-3.02. Communications. The processor shall be programmed to operate autonomously, regardless of communications status with other units. The PLC shall be provided with any required gateway/bridge mux to facilitate seamless Ethernet-based peer-to-peer communication with the Plant Control System's Modicon M340 and M580 PLCs.

2-3.03. Environment. The processor shall be suitable for operation in the environments specified in another section. A key switch shall be provided on the processor to select the operating mode and as a security measure.

2-3.04. Programming. The processor shall be programmable using conventional relay ladder logic, or as required, and shall include the following functions and features.

Contacts, coils, branching.

Data comparisons.

On-delay and off-delay timers.

Counters with comparators.

Floating Point Math and Logical instructions.

Master control relay.

Transitional or one-shot outputs.

Standard and user-defined data tables for digital and analog value storage.

2-3.05. Capabilities. The processor shall include the following capabilities for programming, debug of programs, and troubleshooting.

Off-line programming.

On-line status of coils and registers.

Input/output forcing.

2-3.06. Configuration. Processors shall be configured for standard rack mounting and shall be of plug-in printed circuit board construction. Each programmable logic controller shall include integral communications ports for the programming device, remote input/output, HMI device, or remote communications interfaces as required.

Programmable logic controller systems shall support the following types of input/output.

120 volt ac digital input and output.

24 volt dc digital input and output.

4-20 mA dc analog input and output.

2-3.07. Input/Output Hardware. Input/output hardware shall be supplied in standard modules of 4, 8, 16, or 32 points each for assembly in local and remote input/output enclosures.

All input/output hardware shall be entirely contained within the PLC enclosure.

All output hardware connected to inductive loads shall be supplied with surge suppression devices as required and recommended by the PLC manufacturer to prevent damage to output hardware. Combination input/output modules will be acceptable if they meet all of the requirements in the following subparagraphs.

2-3.07.01. Wiring Terminals. All input/output modules shall utilize easily removable plug-in or hinged field wiring terminals to allow removal of modules without disconnecting individual wires.

2-3.07.02. I/O Circuit Power Supply. Outputs for motor driven equipment will typically be powered from the driven equipment. Digital outputs for miscellaneous equipment shall be powered either from the controlled equipment or the PLC enclosure as indicated on the Drawings or as coordinated with the controlled equipment supplier. Outputs that control process equipment specified under other sections or provided under other contracts shall be fully isolated or shall operate relay-type digital output modules or interposing relays in the PLC cabinet.

2-3.07.03. Digital Input Modules. Digital input modules shall sense voltages between 100 and 130 volts ac or 20 and 28 volts dc and shall have LED indicators for each point to display the status of the field contact.

2-3.07.04. Digital Output Modules. Digital output modules shall control voltages from 100 and 130volts ac or 20 and 28 volts dc.

2-3.07.05. Relay Digital Output Modules. Where indicated on the PLC input/output listing, digital output modules shall control voltages from 24 to 110 volts dc and 24 to 230 volts ac. Digital outputs for motor driven equipment shall be powered by the driven equipment.

2-3.07.06. Analog Input Modules. Analog input modules shall accept linear 4-20 mA dc signals from field transmitters. Input circuitry shall be floating differential type designed to prevent loop grounding. Where analog input signals are grounded outside of the PLC enclosure, isolation shall be provided for the associated analog input point either on the analog input module or through an I/I signal isolator provided in the PLC enclosure.

2-3.07.07. Analog Output Modules. Analog output modules shall transmit linear 4-20 mA dc signals to field devices. Loop power for all analog outputs shall be provided by regulated power supplies in each input/output enclosure.

2-3.07.08. Panel Terminations. All PLC input/output signals for field connections shall be terminated through panel enclosure terminal strips. Direct connection of field wiring to the I/O module terminals is not acceptable.

2-4. COMMUNICATIONS. Each programmable controller system shall be furnished complete with communication hardware modules for local input/output hardware, remote input/output hardware, other programmable controllers, or for host computers.

Communication hardware shall be compatible with the cable, data highway or fiber optic communication media. Ethernet components and cable are specified in other specification sections.

2-4.01. Addressability. Each programmable logic controller shall be individually addressable so that only the selected controller responds when queried. IP addressing shall be used. Designation of a controller's network address may be either a software or hardware function.

2-4.02. Communications Hardware. System Supplier shall provide all necessary communications hardware. Hardware shall be included for, but not be limited to, remote I/O, data highway, host computer, fiber optics and Ethernet.

2-4.02.01. PLC to PLC Communications Hardware. Each PLC shall communicate to other PLCs over a network as shown on the control system block diagram. System Supplier shall include all rack mounted, enclosure mounted, or desktop mounted communications modules required for a complete working system.

2-4.02.02. PLC to Remote I/O Communications Hardware. The master PLC shall communicate with the remote PLC rack over a remote I/O communications

network. System Supplier shall include all rack mounted, enclosure mounted, or desktop mounted communications modules required for a complete working system.

2-4.02.03. PLC to Host Communications Hardware. Each PLC shall communicate to the host computer over a network as shown on the control system block diagram. System Supplier shall include all rack mounted, enclosure mounted, or desktop mounted communications modules required for a complete working system. The computer system hardware is covered in another section.

2-4.03. Communications Media. System Supplier shall provide all necessary cabling for the PLC communications network and PLC remote I/O communications network. Communications cables shall meet the requirements of the manufacturers of the PLCs and communications modules. PLC communications media shall be as specified under the Network Systems section.

2-5. MEDIA CONVERTERS. Not Used.

2-6. TELEPHONE NETWORKS. Not used

2-7. SERIAL NETWORKS. Not Used.

2-8. PROGRAMMING DEVICE HARDWARE. The programming device shall be a portable laptop computer as specified in the Computer System Hardware section. System Supplier shall provide two interconnecting cables to connect the computer to the programmable logic controller. The cables shall be shielded data cable and shall be terminated on both ends with the appropriate connectors. Connectors shall be labeled to identify the connected equipment.

2-8.01. Special Devices. System Supplier shall provide two sets of any special devices (such as null modems, adapter cards, interface converters, etc.) required to establish an operational programming line between the programmable logic controllers and programming device.

2-9. PROGRAMMING SOFTWARE. System Supplier shall furnish one licensed copy of PLC programming software for the Owner and one licensed copy for the Design-Builder. The software shall be suitable for running on a laptop computer running a Windows-based operating system software. A full legal set of programming software documentation shall accompany each copy of the software. Each copy of the programming software shall include all necessary device drivers and add-on software packages.

2-9.01. Standard Product. The programming software shall be personal computer based and a standard product of the PLC manufacturer.

2-9.02. PLC Simulation. Not used .

2-9.03. Programming Software Features. The programming software shall allow off-line development of all PLC-related programming, including user annotation of the program, and creation and printing of application programs and I/O cross-reference lists. Special programming tasks originally provided by System Supplier shall also be included.

On-line features shall include IEC-61131 standards program modification, ladder-logic modification, program language modification, monitoring of real-time ladder-logic execution, monitoring of program execution, monitoring and manipulation of timer and counter preset and present values, monitoring and forcing of physical I/O, and monitoring and manipulation of analog (register) and bit (binary) data table values. PLC and I/O hardware diagnostic and status information shall be accessible using the software in on-line mode.

2-10. SYSTEM ENCLOSURES. Programmable logic controllers and input/output hardware shall be housed in shop-assembled panels as indicated on the Drawings and as described in the Panels, Consoles, and Appurtenances section. Programmable logic controllers and input/output hardware shall be housed in existing panels or panels provided by others.

2-11. OPERATOR INTERFACE TERMINALS. Operator interface terminals (OIT) shall be the System Supplier's standard microprocessor-based flat panel type. The unit shall have data entry capabilities. The unit shall be connected to the PLC and shall display status, alarm, and diagnostic information. The OIT shall be rated NEMA 4X, suitable for panel face.

Terminals shall be suitable for ambient temperatures of +32 to +130°F and a relative humidity of 5 to 95 percent.

One licensed copy of the OIT software used to create the screens shall be turned over to the Owner upon successful startup and commissioning of the system.

The operator interface unit shall be an Eaton PanelMate Power Pro, Allen-Bradley PanelView, or equal.

OIT shall provide graphic screens that shall be used by the operators to access all functions and setpoints necessary for comprehensive control. The equipment vendor supplier shall be responsible for developing and configuring the custom graphic displays. Each piece of major process equipment that is monitored and controlled by the control system shall be displayed on the graphic screens. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. The manufacturer shall use the configuration standards and conventions to be established by direct coordination with the Owner that shall

describe and define such items as proposed graphic display process line colors/representations; color standards for “on”, “off”, “opened”, “closed”, and “alarm” conditions; alarm handling conventions; how items will be selected for control; methods for navigation between displays; address usage/naming conventions; and security setup. The Owner utilizes the stop light standard where green is running and open while red is stopped or closed. Proposed displays shall be submitted to the Design-Builder and Owner for approval.

PART 3 - EXECUTION

3-1. INSTALLATION REQUIREMENTS. PLCs installation requirements are specified in Instrumentation and Control System section except as described herein.

Field check, testing, and training shall be as specified in the Instrumentation and Control System section.

3-2. CONFIGURATION.

3-2.01. PLC Programming and Configuration. Configuration services are specified in the Instrumentation and Control System section.

3-2.02. Communications Configuration. The communications shall be fully configured and installed by System Supplier, and shall be operational before application software configuration by others. Communications shall be configured as shown on the Drawings.

End of Section

Section 40 66 11

NETWORK SYSTEMS

PART 1 - GENERAL

1-1. SCOPE. The Network Systems section covers the furnishing of all hardware and software for network systems for the Instrumentation and Control System. Principal components of the network systems shall be as indicated on the block diagram Drawings and as described below.

System Supplier shall furnish all necessary equipment, interconnecting cables, accessories, and appurtenances for proper network operation and to meet the functional requirements indicated on the Drawings and specified herein. Configuration of all hardware shall be provided by the System Supplier.

Equipment and services provided under the Network section shall be subject to the general requirements specified in the Instrumentation and Control System section. Supplementing this section, network data, special requirements, and options may be indicated on the Drawings.

1-1.01. Control System. The Instrumentation and Control System section shall apply to all systems described herein. All applicable requirements specified in the Instrumentation and Control System section shall apply to equipment and services provided herein.

1-1.02. Network Functional Description. The network system shall provide communications between the operator workstations, servers, and PLCs.

1-2. GENERAL. System Supplier shall select the equipment for its superior quality and the intended performance. The System Supplier shall install all equipment in accordance with the manufacturer's instructions. Equipment and materials used shall be subject to review and shall comply with the following requirements.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Drawings. Supplementing this section, the Drawings indicate locations and arrangement of hardware and enclosures, provide mounting details, and may show other information regarding the connection and interaction with other equipment.

1-2.03. Governing Standards. Governing Standards for network systems shall

be as specified in the Instrumentation and Control System section.

1-2.04. Power and Instrument Signals. Unless otherwise specified, electric power supply to the network equipment will be unregulated 24 volts dc or 120 volts ac.

1-2.05. Appurtenances. Special power supplies, special cable, special grounding, and isolation devices shall be furnished for proper performance of the equipment.

1-2.06. Interchangeability and Appearance. To the extent possible, components used for similar types of functions and services shall be the same brand and model line. Similar components of different network hardware shall be the products of the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

1-2.07. Programming Devices. A programming or system-configuring device, or software required for programming, shall be provided for systems that contain any equipment that requires such a device or software for routine maintenance and troubleshooting. The programming device shall be complete, newly purchased for this project, and shall be in like-new condition when turned over to Owner at completion of startup. Programming software shall be licensed to the Owner.

1-3. SUBMITTALS. Submittals shall be made in accordance with the requirements of the Instrumentation and Control System section and as listed below.

The submittals shall include the following items for the Network Design submittal (to be provided with the First Stage Submittals):

a. A complete network topology diagram, detailing all hardware, cabling and the interconnections between all connected equipment. Interconnections to existing installed equipment and Owner-furnished equipment shall be included in the diagram.

b. A complete listing of IP addresses to be assigned to all equipment furnished under this contract shall be provided. The assignment of IP addresses shall be coordinated with the Owner.

All above documentation shall also be provided in the O&M manuals.

1-4. DELIVERY, SHIPMENT, PROTECTION, AND STORAGE. Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

1-5. CONNECTION TO OWNER NETWORKS. Network hardware and software provided shall be compatible with the Owner's existing network systems wherever a system interconnection is provided. System Supplier shall verify existing systems to ensure compatibility.

All connections to the Owner's existing network shall be fully coordinated between the Owner and the System Supplier. Prior to connecting to the existing network, the System Supplier shall provide a written request to the Owner for an Owner's representative to be available when existing systems are disconnected and at the time of any new connections.

1-6. COORDINATION WITH OWNER. The System Supplier shall coordinate all demolitions, installations and rework on the existing networks with the Owner and the Design-Builder. No work shall be performed without the written consent of the Owner. The System Supplier shall submit a written request to perform work on the existing network, including date, time, scope of work, length of time, and any Owner's support that may be required.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs provide minimum Ethernet network device stipulations.

2-2. NETWORK CABLING SPECIFICATIONS. Individual network equipment and related devices shall be coordinated with items provided in the following sections:

13591 Network Cable

2-3. ETHERNET NETWORK HARDWARE. Ethernet network hardware shall be provided as specified and/or as shown on the Drawings. All specified functionality of provided Ethernet network equipment shall adhere to the IEEE 802 standards. Ethernet Hubs will not be accepted for network systems. Ethernet switches shall be provided to connect multiple network segments together, selectively forwarding traffic between the segments.

2-3.01. Ethernet Switches. Each switch shall include the following functionality:

a. Switch shall support the quantity of 10/100/1000BaseTX ports and 10BaseFL/100BaseFX/1000BaseLX Fiber ports to meet the functionality indicated in this specification and as shown on the Drawings. Switches shall have a minimum of 10/100/1000Base-T, RJ-45 ports. A minimum of 20% spare ports shall be provided for the installed system.

b. Each switch connection shall automatically sense the network speed of

the devices to which it is connected.

c. Path Redundancy: IEEE 802.1w Rapid Spanning Tree Protocol.

d. Prioritization: IEEE 802.1p QoS Support.

e. Support for Optional Redundant Power Supply as required on Drawings.

f. Management: Fully Managed Switch with support for SNMP v.3., and port mirroring.

g. All necessary memory upgrades, software feature sets, and cables needed for proper operation of these switches shall be furnished with each switch.

h. Environmental: Suitable for installation in industrial environments. Operating Temperature Range: 0 to 40C.

Power over Ethernet (POE) switches shall have the following functionality:

a. Power Enabling and standards: IEEE 812.3af

b. Power: 48 VDC, 50 watt minimum power supply for power enabling switch.

c. LED indication of the link activity for each port and power forwarding.

Switches shall be Cisco “Catalyst Series”, Hewlett Packard “Procurve Switch” series, 3Com “SuperStack II” series, or equal.

2-3.02. Industrial (Panel-Mounted) Ethernet Switches. Each switch mounted in process areas shall include the following functionality:

a. Ports: Switch shall support the quantity of 10/100BaseTX ports and 100BaseFX fiber ports to meet the functionality indicated on the Drawings, with a minimum of 20% spare auto-negotiating 10/100Base-T, RJ-45 ports, and two multimode fiber uplink ports. A minimum of four UTP ports shall be provided.

b. Each switch connection shall automatically sense the network speed of the devices to which it is connected.

c. Capable of ring-based media redundancy with 30 ms recovery time.

d. Path Redundancy: IEEE 802.1w Rapid Spanning Tree Protocol.

e. Prioritization: IEEE 802.1p QoS Support.

f. Network Segregation: Port VLAN.

g. Management: SNMPv3 and Browser-based management shall be supported.

h. IGMP snooping supported.

i. LED indication of the link activity for each port.

j. Environmental: Suitable for installation in industrial environments. Operating Temperature Range: 0 to 60C. Optional -40 to 60C rating availability.

k. Redundant 24 VDC power supply inputs

l. Conformal coating option for use in hazardous environments.

m. Mounting: DIN-rail mounted suitable for panel installation.

n. All necessary memory upgrades, software feature sets, and cables needed for proper operation of these switches shall be furnished with each switch.

Power over Ethernet (POE) switches shall have the following functionality:

a. Power Enabling and standards: IEEE 812.3af

b. Power: 48 VDC, 50 watt minimum power supply for power enabling switch.

c. LED indication of the link activity for each port and power forwarding.

Switches shall be GarretCom Magnum 6K Series, Hirschmann RS-20 series, Moxa 508A series, N-Tron 708FX series, SIXNET SL-8MG Series. With POE Injector, or equal.

2-3.03. Network Routers. Routers shall be provided to allow connection of a Wide Area Network (WAN) to the Local Area Network (LAN). These routers shall provide the flexibility to adapt to changing requirements, features and performance to support new WAN services, and integration of multiple network functions to simplify deployment and management operations.

a. LAN Connection: 10/100 Base-T Ethernet Port

b. WAN Connection: At least 2 CSU slots. Provide CSU for a 56K]T1]E1 interface to enable direct connection to the phone company network

c. Management: Browser based, and SNMP v2 or v3.

d. IEEE 802.1p QoS Support.

e. Router Redundancy Functionality (HSRP, VRRP, etc) where required to meet the specified functionality.

f. VLAN Support

g. Rack mounting, where required for proper installation.

Routers shall be Cisco 1800 series Modular Access Routers, 3Com 5000 series Routers, Hewlett Packard ProCurve Routing Switches, or equal.

2-3.04. Network Firewall. Network firewall hardware shall be a dedicated hardware device and provide security and isolation between networks. Firewalls shall have the following functionality:

a. Stateful Packet Inspection and Filtering
b. DHCP and Network Address Translation Services
c. Virtual private networking (VPN) support
d. A minimum of three dedicated or configurable DMZ port.
e. A minimum of five integrated 10/100Base-T ports.
f. Management: Browser based, and SNMP v2 or v3.
g. Logging of all access through the firewall.
h. Rack mounting, where required for proper installation.

Firewalls shall be Cisco ASA 5505 series, or equal. Firewall capability can be provided with a router, provided the above functionality is provided.

2-3.05. Ethernet Connectors. Ethernet wiring connectors shall be RJ-45 male modular plug connectors.

2-3.05.01. Standard RJ45 Connectors. Standard connectors shall be polycarbonate, clear connectors. Connectors shall conform to RJ-45 and ISO 8877 standards. Contacts shall be gold plated with a 0.5A current rating and a -25º to 60º C temperature rating. Connectors shall accept unshielded Cat-5e or Cat-6, AWG 24, solid conductor cable.

2-3.05.02. Industrial RJ45 Connectors. Not used.

2-3.06. Media Converters. Not used.

2-3.07. Frame Relay Routers. Not used.

2-4. ETHERNET NETWORK SOFTWARE. All switches and routers shall be managed from a graphical user interface on a Microsoft Windows operating system computer. Network management software and all network equipment provided by the System Supplier shall be compatible with each other, allowing management of each device from the provided software. Network management software shall be the latest version of Cisco netmanager IP Infrastructure, or equal.

2-3. SPARE PARTS. The System Supplier shall provide spare parts per the general Terms and Conditions.

PART 3 - EXECUTION

3-1. NETWORK INSTALLATION REQUIREMENTS. Additional network installation requirements are specified in the Instrumentation and Control System section. Networks shall be installed and tested in accordance with the following requirements.

3-2. NETWORK CONFIGURATION. The System Supplier shall fully configure all network devices. All device selections shall be fully coordinated with the Owner to ensure compatibility with existing systems and standards.

3-2.01. Ethernet Switches. The System Supplier shall fully configure all Ethernet switches. The following shall be configured:

a. Unused ports shall be disabled for security purposes.

b. Spanning Tree or other appropriate redundancy scheme shall be configured for all redundant links. Trunking or other bandwidth sharing redundancy schemes shall be utilized where available to minimize switching times, and increase available bandwidth.

c. Management Password Security

d. Quality of Service, with any traffic to/from PLCs getting priority over all other traffic.

3-2.02. Routers. The System Supplier shall fully configure all network routers. The routers shall be configured for all network and telephone interfaces.

3-2.03. Firewalls. The System Supplier shall fully configure all network firewalls. The firewall shall be configured for all network connections provided under this contract, and shall be configured to exclude devices not part of the control system network unless otherwise specified. The firewall shall be configured to deny all traffic, except for traffic specifically allowed in the ruleset.

3-2.04. Network Configuration Report. The System Supplier shall provide a configuration report to the Owner detailing all connections, addresses, and port assignments

3-2.05. Management Software. Management software shall be fully configured for all network devices provided.

3-3. NETWORK TESTING. After each network has been installed, a technical representative of System Supplier shall test the network and shall provide a written report for each test.

3-3.01. Field Testing. After each network has been installed, a technical representative of System Supplier shall test the network and shall provide a written report for each test. Specific testing requirements are described in the individual network specification sections.

3-3.02. Systems Check. A technical representative of System Supplier shall participate in the checkout of network systems. Systems check requirements shall be as specified in the Instrumentation and Control System section.

3-3.01. Test Equipment. Unless specified otherwise, all test equipment for the calibration and checking of system components shall be provided by System Supplier for the duration of the testing work and this test equipment will remain the property of System Supplier.

3-3.02.02. Ethernet Network Minimum Test Requirements. The following minimum tests are to be performed by the System Supplier:

a. Verify Link Integrity Status LED is lit on both sides of each link
b. Verify proper operation and failover of each redundant component and redundant link.
c. Verify alarming of each link failure.
d. Verify bandwidth Usage

3-3.02.03. Ethernet Network Test Reports. Upon completion and testing of the installed Ethernet network, the System Supplier shall submit test reports to the Engineer in printed form. Test reports are to show all test results performed by the System Supplier for each port and piece of equipment. Date of calibration of the test equipment is also to be provided.

3-4. NETWORK TROUBLESHOOTING. It is the System Supplier's responsibility to provide trouble-free and reliable networks. The System Supplier shall employ any means necessary to ensure operational networks. The System Supplier shall obtain any needed test equipment, including but not limited to time-domain reflectometers, protocol analyzers and network sniffers, to troubleshoot any problems. The System Supplier shall utilize the services of a trained and certified Network Engineer that is regularly involved in troubleshooting network problems, in the event that operational or reliability problems exist. Acceptable certifications include Cisco CCNP, Cisco CCIE, or Network Professional Association Certified Network Professional (CNP).

3-5. CUSTOMER TRAINING. Training for networks is covered under Network Training in the Instrumentation and Control System section and the Demonstration and Training section.

End of Section

Section 40 66 33

METALLIC AND FIBER OPTIC COMMUNICATION CABLE AND CONNECTORS

PART 1 - GENERAL

1-1. SCOPE. The Metallic and Fiber Optic Communications Cable and Connectors section covers the furnishing and installation of cable systems to provide communications for the Instrumentation and Control System as indicated on the Drawings.

Accessories and appurtenances shall be provided as specified herein to provide a complete and properly operating system.

Equipment and services provided under this section shall be subject to the General Computer Control System Requirements specified in the Instrumentation and Control System section and the Network Systems section. Supplementing the Metallic and Fiber Optic Communications Cable and Connectors section, network data, special requirements, and options are indicated on the Drawings.

1-2. SUBMITTALS. Submittals shall be made as specified in the Instrumentation and Control System section.

1-2.01. Qualifications. The name, address and telephone number of the proposed subcontractor, including specific personnel to perform the work shall be included with the submittals. Provide the experience record of the subcontractor and personnel in performing work similar to that specified. Include the agency, contact person, and telephone number of at least three (3) previous network installation projects completed by the proposed subcontractor. The Design-Builder shall review and approve the network installation subcontractor and personnel prior to any of the related work being performed. This review will be conducted during the project submittal phase, as described below.

1-2.02. Drawings and Data. All material and equipment documentation shall be submitted for review in accordance with the Submittals section. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment.

Product data shall include the following in the Submittals section:

a. Cut sheets and catalog literature for proposed fiber optic cable, and fiber optic cable accessories (pigtails, connectors, etc.)

b. Manufacturer specifications and data that clearly shows that the fiber

optic cable meets all requirement specified herein.

c. Sample of the proposed cable.

d. Physical dimension drawings of all fiber optic accessories.

e. Proposed fiber identification sequence and labeling.

f. Provide off-line maintenance aids and on-line diagnostics to check the performance of the communication links and interfaces of devices on the data highway.

g. Provide a Recommended Spare Parts List (RSPL).

h. Provide a list of recommended special tools for fiber installation testing or maintenance.

1-2.03. Operations and Maintenance Manuals. Operation and Maintenance Manuals shall have the following items included in addition to those items specified in other sections:

a. Description of all components.

b. Methods of connection.

c. Connection diagram.

d. OTDR trace plots for all fibers.

1-3. SHIPMENT, PROTECTION, AND STORAGE. Equipment provided under this section shall be shipped, protected, and stored in accordance with the requirements of the Instrumentation and Control System section.

1-4. QUALIFICATIONS. Due to the specialized nature of installing, splicing, terminating, and testing optical fiber cable, the subcontractor shall utilize personnel who are experienced in such practices. The installing subcontractor or Subcontractor shall have performed similar installation and testing work on at least three projects of similar size and complexity. The personnel assigned to the installation and testing shall also have experience on at least three projects of similar size and complexity.

PART 2 - PRODUCTS

2-1. GENERAL. All fiber optic cable, fiber optic hardware and accessories shall be designed, assembled and connected in accordance with the requirements of these Specifications and the Drawings.

2-2. ETHERNET UNSHIELDED TWISTED PAIR (UTP) CABLE. Ethernet cables and connectors shall be provided for a complete and working system,

and/or as shown on the Drawings. Cable for Ethernet wiring shall be UTP Cat-6 cable. Jacket color coding for cables shall be as follows:

a. Standard Cat-6. Yellow
b. Crossover cables. Red

Cable shall meet the following characteristics:

2-2.01. Category 5e UTP Cable. Not used.

2-2.02. Category 6 UTP Cable. Cat-6 cable shall meet the following requirements:

a. 24 AWG
b. 4 pair solid strand FEP Teflon insulation
c. 100 Ohm impedance
d. 1-250 MHz frequency range
e. Min attenuation 19.9 Db
f. 100 Ohm impedance
g. Min NEXT 44.3dB/100MHz
h. Min PS-NEXT 42.3dB/100MHz
i. Min ELFEXT 27.8dB/100MHz
j. Min PS-ELFEXT 24.8dB/100MHz
k. Min return loss 20.1 dB/100 MHz
l. Max delay skew 45 ns
m. Max propagation delay 540 ns

Plenum rated cable shall have FEP insulation jacketing and FEP insulation for conductors. Non plenum rated cable shall have PVC insulation jacketing and polyethylene insulation for conductors. Cat-6 cable shall be Belden 1872 or equal.

2-2.03. Ethernet Patch Cables. Pre-wired and terminated patch cables with RJ-45 connectors and lever protecting boot shall be furnished for all connections to computers, network equipment, and controller equipment except where physical conditions (i.e. length over 12 ft. or conduit size) require unterminated wire to be installed. Patch cables shall meet the requirements of Cat-6 cable specified in this section. Straight through cables shall be wired using the T568-B standard for both connectors as shown in section 3-1.01. Crossover cables shall be wired

using the T568-A standard for one connector and the T568-B standard for the opposite end.

2-3. FIBER OPTIC CABLE. The fiber optic cable must meet all of the requirements of the following paragraphs.

a. The fiber optic cable must meet the following requirements of the National Electrical Code (NEC) Section 770.

b. Riser Applications – Applicable Flame Test UL 1666.

c. Finished cables shall conform to the applicable performance requirements of Table 8-6 and 8-7 in the Insulated Cable Engineers Association, Inc. (ICEA) Standard for Fiber Optic Premises Distribution Cable (ICEA S-83-596).

d. Every fiber in the cable must be usable and meet required specifications.

e. All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

f. Each optical fiber shall consist of a doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.

g. All optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 100 kpsi.

h. All optical fibers shall be 100 percent attenuation tested. The attenuation shall be measured at 850 nm, and 1300 nm for multimode fibers. The attenuation shall be measured at 1310 nm and 1550 nm for single-mode fibers. The manufacturer shall store these values for a minimum of 5 years. These values shall be available upon request.

i. The storage temperature range for the cable on the original shipping reel shall be –40^{o}C to +70^{o}C. The operating temperature range shall be –40^{o}C to +70^{o}C. Testing shall be in accordance with FOTP-3.

j. The attenuation specification shall be a maximum attenuation for each fiber at 23 $\pm$ 5^{O}C.

k. The attenuation of the cabled fiber shall be uniformly distributed throughout its length such that there are no discontinuities greater than 0.2 dB at 850 nm/1300 nm (multimode) in any one kilometer length of fiber.

l. Required Fiber Grade: Maximum Fiber Attenuation at 850 nm shall be 3.5 dB/km.

m. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be 3.0 mm.

n. The cable shall contain 24 fibers. Each buffer tube shall contain up to 12 fibers.

o. The fibers shall not adhere to the inside of the buffer tube.

p. Each fiber shall be distinguishable from others by means of color coding in accordance with TIA/EIA-598-A, “Optical Fiber Cable Color Coding.”
q. The fibers shall be colored with ultraviolet (UV) curable inks.
r. Buffer tubes containing fibers shall also be color coded with distinct and recognizable colors in accordance with TIA/EIA-598-A, “Optical Fiber Cable Color Coding.”
s. In buffer tubes containing multiple fibers, the colors shall be stable during temperature cycling and not subject to fading or smearing onto each other. Colors shall not cause fibers to stick together.
t. The buffer tubes shall be resistant to kinking.
u. The cable jacket color shall be black.
v. Fibers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fibers shall be placed so that they do not interrupt the consecutive positions of the buffer tubes. In dual layer cables, any fillers shall be placed in the inner layer. Fillers shall be nominally 3.0 nm in outer diameter.
w. The jacket shall be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket shall have a consistent, uniform thickness; jackets extruded under high pressure are not acceptable. The jacket shall be smooth, as consistent with the best commercial practice. The jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.
x. The outer cable jacket shall be marked with the manufacturer’s name or UL file number, date of manufacture, fiber type, flame rating, UL symbol, and sequential length markings every two feet (e.g. “62.5/125 MICRON – TYPE OFNR – (UL) 00001 Feet”). The print color shall be white.
y. The cable shall be all-dielectric.
z. The cable shall be gel-free.
aa. Flammability – All cables shall comply with the requirements of the 1996 NEC Article 770. All cables shall pass UL 1666.

Fiber optic cable shall be as manufactured by Corning Cable Systems, Belden, Commscope, TE Connectivity, or equal.

2-3.01. Multimode Fiber. Multimode fiber shall be 62.5/125µm core diameter or 50/125 µm core diameter cable.

62.5 µm core diameter multimode fiber optic cable shall meet the following requirements:

a. The multimode fiber utilized in the cable specified herein shall meet EIA/TIA-492AAAA-1989, “Detail Specification for 62.5 m Core Diameter/125 m Cladding Diameter Class Ia Multimode, Graded Index

Optical Waveguide Fibers."

b. Core diameter: 62.5 ± 3.0 micrometers.
c. Cladding diameter: 125.0 ± 2.0 micrometers.
d. Core-to-Cladding Offset: ≤ 3.0 micrometers.
e. Cladding non-circularity: ≤ 2.0%. Defined as: [1-(min. cladding dia. + max. cladding dia.)] X 100.
f. Core non-circularity: ≤ 6.0%. Defined as: [1-(min. core dia. + max. core dia.)] X 100.
g. Coating Diameter: 245 ± 10 micrometers.
h. Graded index.
i. Numerical Aperture: 0.275 ± 0.015.
j. Attenuation Uniformity: There shall be no point discontinuities greater than 0.2 dB at either 850 nm or 1300 nm.
k. Minimum Bandwidth Requirement shall be 160/500 MHz-km at 850/1300 nm.

50 µm core diameter multimode fiber optic cable shall meet the following requirements:

a. The multimode fiber utilized in the cable specified herein shall meet EIA/TIA-492AAAA-1989, "Detail Specification for 50 m Core Diameter/125 m Cladding Diameter Class Ia Multimode, Graded Index Optical Waveguide Fibers."
b. Core diameter: 50 ± 3.0 micrometers.
c. Cladding diameter: 125.0 ± 2.0 micrometers.
d. Core-to-Cladding Offset: ≤ 3.0 micrometers.
e. Cladding non-circularity: ≤ 2.0%. Defined as: [1-(min. cladding dia. + max. cladding dia.)] X 100.
f. Core non-circularity: ≤ 6.0%. Defined as: [1-(min. core dia. + max. core dia.)] X 100.
g. Coating Diameter: 245 ± 10 micrometers.
h. Graded index.
i. Numerical Aperture: 0.275 ± 0.015.
j. Attenuation Uniformity: There shall be no point discontinuities greater than 0.2 dB at either 850 nm or 1300 nm.
k. Minimum Bandwidth Requirement shall be 500/500 MHz-km at 850/1300 nm.

2-3.02. Singlemode Fiber. Not used.Singlemode fiber optic cable shall meet the following requirements:

a. The dispersion unshifted single-mode fiber utilized in the cable specified herein shall conform to the specifications herein.

b. Cladding Diameter: 125.0 + 1.0 μm.

c. Core-to-Cladding Offset: < 0.8 μm.

d. Cladding Non-Circuladty: < 1.0%.

e. Coating Diameter: 245 ± 10 μm.

f. Colored Fiber Diameter: nominal 900 μm.

g. Attenuation Uniformity: No point discontinuity greater than 0. 1 0 dB at either 1310 nm or 1550 nm.

h. Attenuation at the Water Peak: The attenuation at 1383 ± 3 nm shall not exceed 2.1 dB/km.

i. Cutoff Wavelength: The cabled fiber cutoff wavelength(λccf,) shall be < 1260 nm.

j. Mode-Field Diameter: 9.30±0.50 μm at 1310 nm 10.50 ± 1.00 micrometers at 1550 nm.

k. Zero Dispersion Wavelength (λo): 1301.5 nm < λo < 1321.5 nm.

l. Zero Dispersion Slope (So): < 0.092 ps/(nm^2 *km).

m. Fiber Polarization Mode Dispersion (PMD): < 0.5 ps/(sq. km)

2-3.03. Fiber optic cable connectors. All optical fibers shall be terminated with connectors that are type ST for multimode cable and type SC for singlemode cable.

2-3.03.01. Epoxy Connectors. Epoxy connectors shall be provided to terminate each fiber in the cable. Connector style, ST, SC, or other, shall be coordinated with the patch panels and field devices that will interface directly with the cable. Connectors shall be compatible with the supplied cable. Connector loss shall be no greater than 0.3 dB. Loss measurement shall be performed at the time of splicing and documentation shall be furnished for each termination. Connectors shall be Corning Cable Systems Connectors, or equal.

2-3.03.02. Crimp Style Connectors. Not used.

2-3.04. Fiber Optic Jumper Cables. Fiber optic jumper cables shall be furnished and installed for equipment interfacing and between termination cabinets. The jumpers shall meet the following requirements:

a. The jumpers shall be 62.5/ 125 microns50/ 125 microns, multimode for operation at 1300 nm. They shall be tight-buffered and be protected by Kevlar-type strength material.

b. The jumpers shall be supplied with connectors on each end. Connector types (ST, SC, LC, etc.) shall be matched to the equipment provided. Jumpers shall be sized to provide a single connection between the fiber optic hardware being connected.

2-4. PLC COMMUNICATIONS MEDIA. Not used.

2-5. INDUSTRIAL COMMUNICATIONS CABLING. Not used.

2-6. ETHERNET CABLE TEST EQUIPMENT. One hand-held network cable tester that is compatible with the provided network cabling shall be provided. The cable tester shall check for open pairs, shorted pairs, crossed pairs, reversed pairs and split pairs for faults up to 100 m. Tester shall be Black Box "Model SOHO Plus Tester", Fluke MicroScanner2 Pro, or equal.

PART 3 - EXECUTION

3-1. INSTALLATION. The System Supplier shall be responsible for the coordination of the installation of all cable furnished hereunder. The System Supplier shall be responsible for the termination of all cable furnished hereunder.

3-1.01. Cable Damage. If the cable becomes damaged during installation, the subcontractor shall stop work and notify the Design-Builder immediately. The Owner and Design-Builder will decide whether to replace the entire reel of cable or to install a splice at the damaged section. If the Owner decides to replace the entire reel of cable, the subcontractor shall begin the installation at the last designated splice point. The damaged cable between these points shall be removed, coiled, tagged, and given to the Owner. Installation of new cable to replace damaged cable shall not be a basis of extra payment or contract completion time. In addition to installation of the new cable, the subcontractor shall reimburse the Owner for the entire cost of the replacement reel of cable. This cost will be withheld from the contract price. If the Owner decides to install a splice at the damaged point, and the cable is damaged a second time, the entire reel of damaged cable (and all subsequent damaged reels) shall be replaced with new reels at the subcontractor's expense.

3-1.02. Ethernet Cable Installation. Straight through cables shall be wired using the T568-B standard for both connectors as shown in the table below (connector pin numbers are left to right with the clip down). Crossover cables shall be wired using the T568-A standard for one connector and the T568B standard for the opposite end as shown in the table below.

Connector Pin	568A Wiring Conductor	568B Wiring Conductor
1 2	White/Green Green	White/Orange Orange
3 6	White/Orange Orange	White/Green Green
4 5	Blue White/Blue	Blue White/Blue
7 8	White/Brown Brown	White/Brown Brown

3-1.03. Fiber Optic Cable Installation. The cable manufacturer shall provide installation procedures and technical support concerning the items contained in this specification. Fiber optic cable installation shall meet the following requirements:

a. All fiber optic cable shall be installed, terminated, and tested by the System Supplier or his fiber subcontractor as specified above.

b. In pulling the cable, strain-release, or other tension limiting devices shall be used to limit the pull tension to less than 600 lbs.

c. Minimum bend radius restrictions shall be satisfied both during and after cable installation.

d. Horizontal, unsupported cable runs shall be supported at continuous distances of 5 feet or less.

e. All conduit and cabinet entrances shall be sealed with RTV or other re-enterable sealant material to prevent ingress of water, dust or other foreign materials.

f. Cable routing within occupied office areas shall conform to Federal, State, and local electrical and fire codes.

g. Any non-terminating (field) splices shall be documented as to the physical location and cable meter mark (prior to stripping). Field splices shall be OTDR-tested and documented prior to final cable acceptance testing.

h. Fiber optic cables shall be installed in accordance with NECA 301-2004, Installing And Testing Fiber Optic Cables.

3-2. CABLE TESTING. After the network cabling has been installed, each network cable shall be tested.

3-2.01. Test Equipment. Unless specified otherwise, all test equipment for the calibration and checking of system components shall be provided by System Supplier for the duration of the testing work and this test equipment will remain the property of System Supplier.

3-2.02. Ethernet UTP Cable Testing. The System Supplier shall utilize the previously specified test equipment, and additional tools as needed to validate the Ethernet UTP cable installation. All test equipment shall bear current calibration certification from a certified calibration laboratory, as appropriate. Each cable shall be tested for open pairs, shorted pairs, crossed pairs, reversed pairs and split pairs. A check off sheet shall be utilized, shall be signed by the technician testing the cables, and shall be submitted for approval. Any identified faults shall be corrected at no additional cost.

3-2.03. Fiber Optic Cable Testing. Acceptance testing of the data highway (fiber and electronic equipment) shall be conducted as a part of integrated system field testing, as specified elsewhere. Prior to such tests, however, the fiber optic cable shall be tested as specified herein.

The System Supplier, or his fiber subcontractor, shall conduct fiber optic cable testing as specified below. All testing following field installation shall be witnessed by the Design-Builder. The subcontractor shall bear the cost for field witnessed testing in accordance with Section 01610, General Equipment Stipulations. A test plan shall be submitted prior to the proposed test dates. The test plan and procedures shall be mutually agreed to prior to conducting the tests.

Each optical fiber of each fiber optic cable shall be OTDR (Optical Time Domain Reflectometer) tested on the reel at the factory, on the reel upon arrival at the jobsite, and after installation and termination. For each fiber, an OTDR (Optical Time Domain Reflectometer) trace soft/hardcopy is required to be provided to the Owner and Design-Builder. OTDR traces shall be provided for each test (at the factory, on the reel at the job-site, and after installation). A 100 foot launch cable shall be spliced to each fiber for each fiber OTDR test, to ensure accurate results. This end-to-end trace shall be performed from BOTH ends of the fiber. Also for each fiber, an end-to-end power attenuation (insertion loss) test shall be performed. The attenuation test shall use a stabilized optical source and an optical power meter calibrated to the appropriate operating wavelength (1300 nm).

For each installed fiber, the power attenuation shall not exceed the following, tested from connector to connector at the respective patch panels:

$$(0.0035)L + (0.25)N + 3.0 \text{ dB}$$

Where L = The length of the fiber optic cable in meters and
N = the number of splices in the fiber.

Any fiber optic cables containing one or more fibers not meeting this performance will not be accepted by the Owner, and shall be repaired or replaced at no additional cost.

Each fiber optic jumper cable shall be tested and must exhibit an end-to-end attenuation of less than 2.0 dB at 1300 nm. Any jumper exceeding this level shall be replaced at no additional cost to the owner. Any damaged cable still on the reel shall be returned to the manufacturer for replacement at no additional cost to the Owner.

All fiber cable testing shall be documented on pre-approved test forms. Three (3) copies of all documentation (including OTDR traces) shall be submitted to the Design-Builder upon successful completion of the testing.

End of Section

Section 40 67 11

PANELS, CONSOLES, AND APPURTENANCES

PART 1 - GENERAL

1-1. SCOPE. The Panels, Consoles and Appurtenances section covers the furnishing of panels, consoles, and appurtenances as indicated on the Drawings.

This section also describes requirements for panels furnished under other sections whose respective specification refers to this section. Panels furnished under other sections are not listed in the attached Equipment Schedules.

1-1.01. Control System. The Instrumentation and Control System section shall apply to all equipment furnished under the Panels, Consoles and Appurtenances section.

1-2. GENERAL. Equipment furnished and installed under this section shall be fabricated and assembled in full conformity with the Drawings, specifications, equipment schedules, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Design-Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Drawings. General dimensions and arrangements are indicated on the Drawings and on the attached equipment schedules. System Supplier shall be responsible for coordinating the console and enclosure sizes and arrangements to accommodate the equipment provided.

1-3. SUBMITTALS. Submittals shall be as specified in the Instrumentation and Control System, Submittal Procedures, and Schedule of Submittals sections.

Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-4. DELIVERY, STORAGE, AND SHIPPING. Delivery, storage and shipping shall be as per The Instrumentation and Control System section.

1-5. SPARE PARTS. The System Supplier shall provide spare parts per the general Terms and Conditions.

PART 2 - PRODUCTS.

2-1. PANEL DESIGN AND FABRICATION FEATURES. All panels furnished shall conform to the stipulations of NEMA ICS-6-1993 (R2001, R2006). Unless indicated otherwise on the Drawings, the following paragraphs describe general fabrication specifications for the PLC cabinets, instrument panels, consoles, enclosures, and subpanels.

2-1.01. Piping. Pneumatic tubing shall be 1/4-inch OD, soft annealed copper with compression fittings. Tubing and fittings shall be as specified in the Miscellaneous Piping section.

2-1.01.01. Fittings. Compression type bulkhead fittings shall be provided near the bottom or the top of the panel for all field connections. Compression nuts and sleeves shall be provided for the field connections. Indicators, recorders, controllers, and other pneumatic devices shall be provided with plugged test connections and shutoff valves for isolation.

2-1.01.02. Valves. All devices shall have separate air supply shutoff valves. Valves and compression fittings shall be as manufactured by Nupro, Parker Hannifin, Swagelock, Tylok, or Whitey.

2-1.02. Power Entrance. The power entrance to each panel shall be provided with a surge protection device. Refer to the Instrumentation and Controls section for surge suppression requirements.

2-1.03. Power Wiring. Power distribution wiring on the line side of panel fuses shall be minimum 12 AWG. Secondary power distribution wiring shall be minimum 14 AWG. Wiring for ac power distribution, dc power distribution, intrinsically safe, and control circuits shall have different colors and shall agree with the color-coding legend on System Supplier's panel wiring diagrams. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, insulated for not less than 600 volts, with a moisture resistant and flame retardant covering rated for not less than 90°C.

2-1.04. Instrument and Control Wiring. All internal panel wiring shall be type MTW stranded copper wiring rated not less than 600 volts. Electronic analog circuits shall be twisted and shielded pairs rated not less than 300 volts. Analog circuits shall be separated from ac power circuits. Intrinsically safe circuits shall be physically separated from other circuits in accordance with applicable codes.

Wires within the panel shall conform to the minimum size as shown in the table below.

Type	Min. Wire Size	Color
AC Control	16 AWG	Red
DC Control	16 AWG	Blue
Analog Circuits	18 AWG Twisted Pair	Yellow

All wiring shall be grouped or cabled and firmly supported inside the panel. Each individual wire in power, control, and instrumentation circuits shall be provided with identification markers at each point of termination. The wire markers shall be positioned to be readily visible for inspection and the identification numbers shall match the identification on the supplier's panel wiring drawings. Wiring shall be bundled in groups and bound with nylon cable ties or routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel, with removable covers, and with space equal to at least 40 percent of the depth of the duct remaining available for future use after completion of installation and field wiring. Sufficient space shall be provided between cable groups or ducts and terminal blocks for easy installation or removal of cables.

2-1.05. Terminal Blocks. Terminal blocks for external connections shall be suitable for 12 AWG wire and shall be rated 30 amperes at not less than 300 volts. Terminal blocks shall be fabricated complete with marking strip, covers, and pressure connectors. Terminals shall be labeled to agree with identification shown on the supplier's submittal drawings. A terminal shall be provided for each conductor of external circuits, plus one ground for each shielded cable. Not less than 8 inches of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.

2-1.06. Backup Power. Power supply to the panels shall be from electrical sources shown on the Drawings, which may be backed by redundant utility feeds, engine generators, or externally mounted uninterruptible power supplies (UPSs) specified in other sections.

Where indicated in the attached equipment schedules, on the Drawings or in the referring equipment specifications, free-standing vertical panels and wall cabinets shall each be provided with an interior-mounted UPS to provide backup power to critical loads upon loss of power supply to the panel. UPS-backed power shall be provided to the programmable logic controller CPU, instrument loops, I/O modules (operating and wetting voltages), all network communications devices, and any other load essential to preventing loss of control system function. Backup power for panel interior lights, heaters, and convenience receptacles is

not required. UPSs for free-standing vertical panels and wall cabinets shall meet the requirements specified below.

Where required within the respective enclosure specification or shown on the Drawings, Data Server Enclosures shall each be furnished with an interior, rack-mounted UPS. UPSs for rack-type enclosures shall meet the requirements specified below.

2-1.06.01. UPS for Free-Standing Vertical Panels and Wall Cabinets. Each UPS shall accept incoming 120 volts ac, 60Hz, single-phase utility power, apply surge protection, and supply power to the connected loads. The UPS shall be a double-conversion ("on-line") type to provide a breakless transfer to backup power. In the event of incoming power failure, the UPS shall provide 120 volts ac, 60 Hz, single-phase power to its connected loads by inverting power stored within integral storage batteries. The UPS shall be contained inside the enclosure and supported by a dedicated shelf attached to the backplane or sidewall. The shelf shall be between 12 and 18 inches from the bottom of the enclosure and shall not be directly above any electronic or electromechanical devices.

The UPS shall have at least two integral NEMA 5-15R receptacles for connection of battery-backed loads. Upon restoration of incoming power, the UPS shall recharge the batteries and return its connected loads to the incoming power source. The factory-installed line cord and plug shall not be altered. The UPS output shall be connected by plug and line cord to terminal blocks as necessary to distribute power to loads not having a power cord and plug; all other loads shall be connected directly to the UPS's integral receptacles or to permanently installed receptacles fed from the UPS output. A schematic showing the integration of the UPS within the enclosure is shown on the Drawings.

The UPS shall maintain a temperature-compensated, float charge voltage on the batteries when utility power is available. Overcurrent protection when utility power is available shall be from a circuit breaker internal to the UPS. The UPS shall be intrinsically current-limiting when the unit is on battery.

The UPS shall meet the following requirements.

Capacity, minimum	1000 VA / 700 watts
Filtering and surge Protection (on utility power)	Meets IEEE/ANSI C62.41 Category B (IEEE 587)
Voltage, output (on battery)	120 volts ±3 percent

Voltage, output (on-line)	Nominal ±3 percent
Frequency and waveform, output (on battery)	60 ± 0.3 Hz, true sine-wave
Efficiency, minimum (on-line)	90 percent
Operating environment	0 to 40ºC; 0 to 95 percent relative humidity, non-condensing
Backup time, minimum at half of rated load	10 minutes
Recharge time, maximum to 90 percent of full charge	12 hours

The UPS shall have spare capacity of at least 30 percent based on actual connected loads. The System Supplier shall advise the Design-Builder if the UPS capacity needs to be higher than specified above to meet this requirement.

The UPS shall have a visual status indicator for low (or faulty) battery and incoming ac power failure. The UPS shall emit an audible signal when the UPS is operating on battery power. A relay shall be installed within the panel and its coil connected across the UPS input power as a means of providing a contact for remote indication of a power failure condition.

The UPS shall be furnished with an Ethernet network card with RJ-45 connector for communicating status and alarm conditions to the Instrumentation and Control System HMI. Communication shall be via 10/100-BaseT Ethernet and shall use HTTP, SMTP, SNMP, Modbus TCP, or other protocol as necessary to transfer the information into the HMI database for display and alarming. Special software or drivers necessary to complete the communications link shall be furnished with the UPS systems. One copy of any special software or drivers necessary to allow monitoring over the network shall be provided for all UPSs furnished under this section.

Batteries shall be sealed maintenance-free, gelled electrolyte lead-acid, or valve-regulated, maintenance-free, lead-acid. Flooded-electrolyte type batteries will not be acceptable.

The UPS shall be APC “Smart-UPS”, Vertiv/Liebert “GXT4”, Toshiba “1000 Series”, or equal.

2-1.06.02. Rack-Mounted Uninterruptible Power Supply (UPS). The UPS shall accept incoming 120 volts ac, 60 Hz, single-phase utility power, apply surge

protection, and supply power to the connected loads. The UPS shall be a double-conversion ("on-line") type. In the event of incoming power failure, the UPS shall provide 120 volts ac, 60 Hz, single phase power to its connected loads by inverting power stored within integral storage batteries. UPS output shall be true sine-wave under both utility and battery operation.

The UPS shall be EIA 19-inch, rackmount-type and shall be furnished with all mounting accessories necessary to install it within the enclosure. The UPS shall have at least four integral NEMA 5-15R receptacles for connection of battery-backed loads. Upon restoration of incoming power, the UPS shall recharge the batteries and return its connected loads to the incoming power source. The factory-installed line cord and plug for input connection shall not be altered.

The UPS shall maintain a temperature-compensated, float charge voltage on the batteries when utility power is available. Overcurrent protection when utility power is available shall be from a circuit breaker internal to the UPS. The UPS shall be intrinsically current-limiting when the unit is on battery.

The UPS shall meet the following requirements.

Capacity, minimum	2000 VA / 1400 watts
Voltage, output (on battery)	120 volts ± 2 percent
Frequency, output (on battery)	60 ± 0.5 Hz
Efficiency, minimum (on-line)	90 percent
Operating environment	0 to 40°C; 0 to 95 percent relative humidity, non-condensing
Backup time, minimum at half of rated load	20 minutes
Recharge time, maximum to 90 percent of full charge	8 hours

The UPS shall have a visual status indicator for low (or faulty) battery, on bypass, UPS fault, and incoming ac power failure.

The UPS shall be furnished with an Ethernet network card with RJ-45 jack for communicating status and alarm conditions to the Instrumentation and Control System HMI. Communication shall be via 10/100-BaseT Ethernet and shall use HTTP, SMTP, SNMP, or other protocol as necessary to transfer the information

into the HMI database for display and alarming. One copy of any special software or drivers necessary to allow monitoring over the network shall be provided for all UPSs furnished under this section.

Batteries shall be sealed maintenance-free, gelled electrolyte lead-acid, or valve-regulated, maintenance-free, lead-acid. Flooded-electrolyte type batteries will not be acceptable. Additional rack-mounted battery modules shall be supplied to meet runtime requirements.

The UPS shall be APC “Smart-UPS RT”, Vertiv/Liebert “GXT4 Rack Mount”, Toshiba “1000 Rack Mount”, or equal.

2-1.07. Device Tag Numbering System. All devices shall be provided with permanent identification tags. The tag numbers shall agree with the Instrument Device Schedule and with the supplier's equipment drawings. All field-mounted transmitters and devices shall have stamped stainless steel identification tags. Panel, subpanel, and rack-mounted devices shall have laminated phenolic identification tags securely fastened to the device. Hand-lettered labels or tape labels will not be permitted.

2-1.08. Nameplates. Nameplates shall be provided on the face of the panel or on the individual device. Panel nameplates shall have legends and approximate dimensions as indicated on the Drawings and shall be made of laminated phenolic material having engraved letters approximately 3/16 inch [5 mm] high extending through the black face into the white layer. Nameplates shall be secured firmly to the panel. Panel face nameplates do not replace the requirement for device identification tags as specified under the Device Tag Numbering System paragraph.

2-1.09. Indicating Light Color Designations. Indicating lights are specified in the Panel Mounted Instruments section. Indicating lights shall be colored as shown in the following table unless indicated otherwise on the Drawings, in other specification sections, or in the instrument device schedule.

Color	Meaning
Red	Associated equipment or device is “running, “ “open,” or is in an “unsafe” state or position
Green	Associated equipment or device is “stopped,” “closed,” or is in a “safe” state or position
Yellow or Amber	Associated equipment or device has “failed” or a process alarm condition is present or imminent.
White	All other conditions not defined above.

2-1.10. Painting. Interior and exterior surfaces of all stainless steel and carbon steel panels shall be thoroughly cleaned and painted with rust inhibitive (universal) primer. The panel interior shall be painted white with the manufacturer's standard coating. All pits and blemishes in the exterior surface shall be filled. Exterior surfaces shall be painted with one or more finish coats of the manufacturer's standard coating. Finish coats shall have a dry film thickness of at least 4 mils. Color shall be ANSI 61 Graywhite. Color samples shall be submitted to Design-Builder for color selection. One quart of touch-up paint shall be furnished with the panels.

2-1.11. Panel-Mounted Instruments. Instruments, power supplies, pilot devices, and appurtenances mounted within or on the face of the panel shall meet the requirements specified in the Panel Mounted Instruments section for those items unless noted otherwise herein, on the Drawings or, if applicable, within the referring equipment specification section.

2-1.12. Factory Test. Panels shall be factory tested electrically and pneumatically by the panel fabricator before shipment.

2-2. FREESTANDING VERTICAL PANELS. The following paragraphs specify the freestanding vertical panels:

2-2.01. Construction. Panel construction shall be an indoor, dusttight, completely enclosed cubicle formed from steel structural members and steel plates. The base shall be formed of steel channels, with flanges extending upwards. The base shall be provided with 1/2 inch diameter holes at 12 inch centers so that the base can be bolted to the concrete equipment base. Welds, seams, and edges on all exposed surfaces shall be ground smooth. Suitable lifting facilities shall be provided for handling and shipment.

2-2.02. Structure. Panel structure shall be suitably braced and of sufficient strength to support all equipment mounted on or within, to withstand handling and shipment, to remain in proper alignment, and to be rigid and freestanding. Top, sides, and back shall be fabricated from USS 10 gage or heavier stainless steel or carbon steel sheets, with stationary back suitable for back to wall installation, or designed for rear access with hinged back doors. Doors shall not be greater than 24 inches wide or spaced not greater than 36 inches center to center. Rear access doors shall be fabricated from USS 14 gage or heavier stainless steel or carbon steel.

2-2.03. Panel Front. The front shall be a hinged door, or doors, with mounted instruments and control devices, fabricated from USS 10 gage stainless steel or carbon steel sheet and suitably braced and supported to maintain alignment. Panels with hinged fronts shall be of sufficient width to permit door opening without interference with rear projection of flush mounted instruments.

2-2.04. Doors. Doors shall be essentially full height, having turned back edges and additional bracing to ensure rigidity and prevent sagging. Doors shall be mounted with strong, continuous, piano type hinges. Positive latches, acting from a common door handle, shall hold doors securely compressed at top, side, and bottom against rubber gaskets.

2-2.05. Mounted Instruments. The front shall be stationary, with mounted instruments and control devices, fabricated from 3/16 inch steel or carbon steel plate. Panel fronts shall be suitably reinforced between mounting cutouts and drilling to support instruments and devices without deformation and shall be free from waves and other imperfections. Panel fronts shall be recessed at the base. Adjoining panel sections shall be accurately shop fitted to assure satisfactory assembly in the field.

2-2.05.01. Instrument Arrangement. Panel instruments and control devices shall be arranged in a logical configuration for the plant operators. The centerline of recorders shall be within 3 feet and 5'-9" above the base of the panel for convenient reading and chart replacement. Control switches shall be within 6 feet and 2'-6" above the base of the panel. Indicators may be located within 2'-6" and 6'-6" above the base of the panels.

2-2.06. Conduit Entrance. Not used.

2-2.07. Size and Arrangement. Panel dimensions and general instrument arrangement shall be as indicated on the Drawings or in the attached equipment schedules.

2-2.08. Interior Lighting. Illumination of panel interiors shall be provided by ceiling mounted lamp fixtures spaced at approximately 2'-6" and near the door. Fixtures shall be nominal 40-watt LED/fluorescent tube type, with a common "On-Off" switch near each end door. Duplex-grounded receptacles shall be provided for service and maintenance tools at spacing not greater than 5 feet throughout the length of a panel. The lighting and receptacle circuit shall be fused separately from the instrumentation systems.

2-3. FILTER CONSOLES. Not used.

2-4. WALL-MOUNTED CABINETS. Cabinets, which contain the system components indicated on the Drawings, shall be suitable for wall mounting and shall meet the NEMA enclosure rating as indicated on the Drawings or, if applicable, in the attached equipment schedules or the referring equipment specification section. The enclosures shall be fabricated from USS 14 gage, or heavier, carbon steel or stainless steel. Cabinets shall be equipped with full size gasketed doors with hinges and a chromium-plated or stainless steel three-point latch. The door shall be lockable with a key. A screened vent shall be provided in the bottom of enclosures that contain pneumatic devices.

Floor stands shall be provided to support cabinets not fastened to a wall or other support. Floor stands shall be full-depth and shall have a minimum height of 12 inches. Floor stand material and finish shall match the cabinet.

All wall-mounted cabinets shall meet the requirements of the panel fabrication paragraph of this section.

Outdoor cabinets shall be provided with sunshades as indicated on the Drawings or, if applicable, in the attached equipment schedules or the referring equipment specification section.

2-5. FIBER OPTIC PATCH PANELS. Fiber optic patch panels (also referred to as fiber termination cabinets) shall be furnished to terminate fibers at the fiber optic modules, and any other data highway attached equipment. The cabinets shall meet the following requirements:

a. The patch panels shall be the wall rack mounted type, having provisions for terminating multiple fiber optic cables. Splice trays, strain relief cable attachment points, fiber organizers and bend radius hardware shall be furnished with each termination cabinet.

b. Panel size shall be suited to the number of fibers to be terminated within the cabinet. Bayonet/flanged couplings shall be furnished and mounted for each fiber to be terminated.

c. Fiber terminations shall be spliced to pigtail cables (specified below) having ST connectors. The pigtails shall be terminated in an orderly method.

Fiber optic patch panels shall be OFS Technologies “LGX”, Corning Cable Systems “WCH Series”, or equal.

2-6. FREESTANDING EIA 19-INCH RACK ENCLOSURES. Not used.

2-7. DATA SERVER ENCLOSURES. An enclosed equipment distribution rack shall be provided for mounting network equipment provided as rack-mounted, including switches, firewalls, routers, and patch panels. The rack shall be black painted steel or painted aluminum construction with fully tapped, standard 18.3 inch hole-to-hole centers and shall include all hardware and accessories including frame, shelves, and raceways as specified and as shown on Drawings. Rack enclosures shall be as manufactured by Amco Engineering, Hoffman, or equal.

Each data server enclosure shall be furnished with a rack-mounted uninterruptible power supply (UPS) to provide backup power to all enclosed loads. Rack-mounted UPSs are specified elsewhere in this section.

2-8. WALL MOUNTED INSTRUMENT SUBPANELS. Instrument subpanels shall be constructed from 1/8 inch thick stainless steel or carbon steel and shall be reinforced and braced to form a rigid assembly. Panels designed for wall mounting shall have 1 inch turned back edges and a minimum 2 inch air space between the panel and the wall surface. All components on wall-mounted panels shall be mounted so as to be easily removable without requiring rear access to the subpanel.

2-9. CONTROL SYSTEM CONSOLES AND ENCLOSURES. A main control system console and printer enclosure and printer stand shall be provided as indicated on the Drawings.

2-9.01. Control System Console. The control system console shall be a modular system consisting of straight, angular, and corner sections to provide an arrangement as indicated on the Drawings. Console sub-structure shall consist of a welded steel frame and extruded aluminum horizontal supports. Structural arrangement shall allow connection of modular sections to produce a seamless equipment mounting enclosure.

2-9.01.01. Internal Wiring. Integral wireways and surge-protected receptacles shall be provided throughout the console structure. SYSTEM SUPPLIER shall coordinate the receptacle spacing and number to ensure adequate power connections are available for the equipment to be located in the console. SYSTEM SUPPLIER shall coordinate with the CCTV, Security, Intercom, and Radio Suppliers and install receptacles for powering the associated equipment.

2-9.01.02. Equipment Mounting. Equipment mounting kits shall be provided to support the equipment items to be located in the console. This shall include, but not be limited to, operator workstation monitors, operator workstation computers, workstation servers, historical/data collection components, and printers. Kits shall be provided for CCTV, security, intercom, and radio equipment. Monitor support shelves shall be adjustable to allow monitors of various sizes to be centered in the front panel. Central processing unit (CPU) support shelves shall be of the slideout type.

2-9.01.03. Exterior Panels. Console exterior panels shall be attached to the console structure with concealed hardware and shall be removable without the need for tools. Where indicated on the Drawings, hinged access panels shall be provided. Exterior panels shall be constructed of rift cut domestic red oak veneer over composite coreplastic laminate over composite coreformed, painted metal.

2-9.01.04. Work Surface. Work surface shall be 1 inch core, with high-pressure laminate surface and backing. Work surface nosing and edge shall be solid oak, finished to match the exterior panelsshall be soft urethane with plastic laminate edges. Base trim shall be high-pressure laminate over composite core to match work surface.

2-9.01.05. Console Front. The front surfaces of the console shall be oak veneerplastic laminate over composite coreformed, painted metal with window cutout sized to accommodate the monitors provided. Hinged, glare control glass and shall be provided for access to the monitor. Continuous task lighting shall be provided along the length of the monitor mounting area valance or retractable task lights shall be provided on each end section of the console.

2-9.01.06. Color Samples. System Supplier shall submit color samples for all exterior panel, work surface, equipment front, and edge surfaces to Design-Builder for color selection.

2-9.01.07. Manufacturers. The console shall be Evans “Strategy Series” or "Identity Series" or Tresco Consoles “3600”.

2-9.01.08. Printer Enclosures. Printer enclosures shall be of a noise buffering type, furnished in the quantities indicated on the Drawings. The printer enclosure shall be of the same general construction and finish as the control system console. The enclosure shall be provided with a hinged glass cover with pneumatic supports to hold the cover in the raised position. The enclosure shall have a support shelf with paper access slot for the printer provided. Under shelf storage space shall be sufficient to store a standard carton of 11x14 inch [279 by 356 mm] computer paper. The paper storage area shall be accessible through hinged access doors on the enclosure front.

2-9.01.09. Printer Stands. Printer stands shall be an open shelf design, sized to support the report printer provided. The stand shall be provided with shelved storage space under the printer-mounting surface. Access to the storage space will be through lockable doors. The cabinet shall be constructed of materials to match the control system console exterior panels. Printer mounting surface height shall be approximately the same as the work surface of the control console. The printer stand shall be provided by the control console manufacturer.

2-9.01.10. Task Lighting. Task lighting shall consist of a continuous bank of lighting.Task lighting shall consist of three articulating lamps mounted on brackets.

2-10. CONTROL SYSTEM FURNITURE. Not used.A control system desk and printer enclosuresprinter stands shall be provided as indicated on the Drawings.

2-10.01. Control System Desk. The control system desk shall be a freestanding desk-based system consisting of linked work surfaces on pedestals in the general arrangement indicated on the Drawings. System Supplier shall coordinate the types and quantities of console components required, and shall

furnish and install all additional components, including supports and connecting brackets.

2-10.02. Work Surfaces. Work surfaces shall of be high-pressure plastic laminate over a high-density wood composite and shall be 1-1/4 inches thick, 30 inches wide, and of the length required. Special corner work surfaces shall be provided where required. Back panels at least 19 inches high shall be provided for all work surfaces. Work surface dimensions shall be coordinated with the pedestals to ensure proper stability and access to wireways. Where indicated on the Drawings, work surfaces shall be provided with hinged corner access channels for wire and cables.

2-10.03. Pedestals. Pedestals shall be provided as indicated on the Drawings to support the work surface arrangement. Pedestals shall be of painted steel, with integral, double-walled desk drawers.

2-10.04. Internal Wiring. The console shall be provided with a concealed wireway system, mounted near the back edge of the work surface and accessible from the console back without the use of special tools. An integral power raceway system shall be provided to distribute power to the control system components. The power system shall consist of sufficient receptacles and wiring to accommodate the control system components and task lighting.

2-10.05. Task Lighting. Task lighting for work surfaces shall be installed along the back panels. Lighting shall consist of continuous track lighting or articulating lamps mounted on brackets.

2-10.06. CPU Mounting. Not used.Mounting kits shall be provided for installing CPUs under the work surfaces. The numbers and locations of the CPUs are indicated on the Drawings.

2-10.07. Color Samples. System Supplier shall submit color samples for all work surfaces, back panels, and pedestals to the Design-Builder for color selection.

2-10.08. Manufacturers. The console shall be as manufactured by Allsteel or equal.

2-10.09. Printer Stands. Printer stands shall be of open shelf design, with lockable doors, sized to support the report, alarm, or color printer furnished, and with shelved storage space under the mounting surface. The control console manufacturer shall provide the printer stands.

2-10.10. Printer Enclosure. Printer enclosures shall be constructed of materials to match the control system console exterior panels. Printer mounting surface shall be of approximately the same height as the work surface of the control console.

PART 3 - EXECUTION

3-1. GENERAL INSTALLATION REQUIREMENTS. Installation requirements are specified in the Instrumentation and Control System section. In addition, equipment furnished under this section shall conform to the following manufacturing stipulations.

3-1.01. Piping. All tubing shall be run in horizontal and vertical planes and shall be rigidly supported to withstand handling and shipment. Flexible polyethylene tubing shall be used to connect devices mounted on hinged doors.

3-1.02. Wiring. All wiring shall be grouped or cabled and firmly supported inside the panel. Wiring shall be bundled in groups and routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel with removable covers and shall have a space of at least 40 percent of the depth of the duct available for future use after installation is complete and all field wiring installed. Sufficient space shall be provided between cable groups or ducts and terminal blocks for easy installation or removal of cables.

3-1.03. More Than One Panel. Where signal or loop wiring must be routed to more than one panel or device, the required circuit routing shall be as indicated on the one-line diagrams. The panel fabricator shall provide such additional circuits as may be indicated on the electrical schematic Drawings.

End of Section

Equipment Schedule 40 67 11-S01

FREESTANDING VERTICAL PANELS

1.000	**General**					
1.010	Specification Section 40 67 11					
2.000	**Freestanding Vertical Panels**					
2.010	Tag Number/Panel ID					
2.020	NEMA Enclosure Rating					
	12					
	4					
	4X					
2.030	Materials of construction					
	Carbon steel					
	316 Stainless steel					
	Fiberglass polyester					
2.040	Environmental provisions					
	Sunshade and drip shield					
	Cooling fan					
	Air conditioner					
2.050	Door Arrangements					
	Hinged rear doors					
	Hinged front door with instruments					
	Hinged front door without instruments					
	Fixed front					
	Recessed base					
2.060	Dimensions (min. L x W x H)					
2.070	Panel interior-mounted UPS					
2.080	Conduit entrance					
	Bottom open					
	Removable top plates					
3.000	**Exceptions, Clarifications, and Comments**					
3.010	None					

Equipment Schedule 40 67 11-S02

WALL-MOUNTED CABINETS

1.000	**General**					
1.010	Specification Section 40 67 11					
2.000	**Wall Mounted Cabinets**					
2.010	Tag Number/Panel ID					
2.020	NEMA Enclosure Rating					
	12					
	3R					
	4					
	4X					
2.030	Materials of construction					
	Carbon steel					
	316 Stainless steel					
	Fiberglass polyester					
2.040	Environmental provisions					
	Sun shade					
	Cooling fan					
	Air conditioner					
2.050	Dimensions (min. L x W x H)					
3.000	**Exceptions, Clarifications, and Comments**					
3.010	None					

Equipment Schedule 40 67 11-S03

NETWORK RACKS

1.000	General		
1.010	Specification Section 40 67 11		
2.000	**Network Racks**		
2.010	Tag Number/Panel ID		
2.020	Rack Features		
	Open Frame		
	Enclosed		
	Wall Mounted		
	Floor Mounted		
	Doors with Windows		
2.030	Materials		
	Carbon steel		
	Stainless steel		
	Fiberglass polyester		
2.040	Optional Accessories		
	Internal UPS		
	Vertical Cable Management		
	Horizontal Cable Management		
	Light		
	Power Distribution Unit		
3.000	**Exceptions, Clarifications, and Comments**		
	Exterior dimensions (H x W x D), minimum		

Section 40 68 16

COMPUTER SYSTEM SOFTWARE

PART 1 – GENERAL

1-1. SCOPE. This section covers computer system software to be furnished and installed by System Supplier on computer hardware specified in another section.

System Supplier shall furnish standard, field proven, fully debugged and supported software packages for this application with a minimum of additions or changes. Customized or specially written software shall be furnished only if required to meet all functional requirements specified herein.

Software is described in functional categories. System Supplier shall furnish a complete software package including the functional requirements specified, along with any additional software required for proper and efficient operation of the system.

No attempt has been made to list all software or all characteristics of software required by System Supplier to meet the functional requirements specified, nor to determine the location of the software modules within the system.

The computer control software shall meet the design conditions and performance.

1-1.01. Control System. The Instrumentation and Control System section shall apply to all software furnished under this section. Additional software requirements are indicated in the Software Control Block Descriptions section. Software configuration programming standards shall be as discussed in the Instrumentation and Control System section.

1-2. GENERAL. Software packages shall control computer system level activities as well as higher level process control activities, allowing the process to be monitored and controlled through an interactive operator interface.

1-2.01. Interface. Users shall be able to interface to all process control activities through fully interactive software modules initiated and operated using easily recognized icons or custom symbols or driven by full-screen and pull-down menus. Selection of icons or menus shall be through pointing devices and shall not normally require the use of an alphanumeric keyboard. Systems that require the use of typed commands to move from module to module or from display to display are not acceptable.

1-2.02. Execution. Throughout the execution of all software modules, the operator shall be presented with all command or operation choices available at that point in the program to make the choices self-explanatory and unambiguous. Question-and-answer or fill-in-the-blank requests are acceptable only where file names, tag names, or other unique text or numerical information is required.

1-2.03. Configuration. All programs shall be self-configuring to obtain the size and configuration of the system from parameters contained in the various files created during system generation. No parameters related to the hardware configuration shall be hard coded into any of the software.

1-2.04. Version. All programs shall be the latest version commercially available at the time the system is delivered to Owner. Superseded versions, revisions, or releases are not acceptable.

1-2.05. Drawings. Supplementing this section, the Drawings indicate locations and arrangement of computer enclosures and provide one-line and block diagrams regarding the connection and interaction with other equipment.

1-3. SUBMITTALS. In addition to the requirements of the Instrumentation and Control System section, a complete description of the software packages and modules shall be submitted to verify compliance with this section.

1-4. DELIVERY AND SHIPPING. Delivery and shipping shall be as in the Instrumentation and Control System section.

PART 2 - PRODUCTS

2-1. OPERATING SYSTEM SOFTWARE. Operating system software shall be MS Windows Server 2016 for servers and MS Windows 10 for workstations, without exception, and shall include a complete and unmodified operating system that provides system level functions.

2-2. PROCESS CONTROL SYSTEM APPLICATION SOFTWARE. Process control software shall enable the operator to monitor and control field devices connected to PLCs or other input/output hardware. The process control system application software shall meet the following minimum requirements and shall exceed these requirements where necessary to comply with the functional requirements of the project.

A license shall be issued for each machine loaded with process control software.

2-2.01. Approved Software. The process control system application software shall be GE Digital iFIX, without exception.

A dual network shall be provided to insure LAN redundancy.

The control system hardware is specified in another section.

2-2.02. Password Protection. Operator access within the control system software shall be controllable through a password-based security scheme. Operators shall be assigned their own user account and password. Nine levels of security protection shall be provided. Each system display, database block, control action, and software module shall be assigned its own security levels and shall be inaccessible to users without proper security clearance. After initial creation, passwords shall be field alterable, but only by the assigned user or a system administrator.

2-2.03. System Response. All responses to the operator shall be clear, unambiguous, and complete. Every operator menu, target selection, or request shall generate a response providing the range of choices for the next step in the process, or indicating that the request or chosen operation has been completed, is being processed, or cannot be performed. Every operator menu or target pick shall generate a graphic or text message response, even if it is a negative one.

2-2.04. Interactive Software Commands. The software's interactive command structures, user interface, menu organization, and procedures shall be consistent and predictable for all software modules throughout the system. Similar operations shall be performed in a similar manner, so that an operator will not need to learn different techniques for initiating the same operation in different software modules.

2-2.05. Operator Commands. The software shall accept each operator command or selection, decode it, and check its validity and correctness in the sequence of data and operations previously presented. Invalid or incorrect commands or menu selections shall not be processed; instead, a message shall be generated which explains why the command or menu selection is invalid. When a command or selection is canceled prior to being fully processed, the software shall clear all pending sequences and shall not initiate any system control commands.

2-2.06. Database. The software shall include a comprehensive interactive database system for creating, sorting, editing, and monitoring all process inputs and outputs and internally used variables and control blocks. The system shall request, receive, process, and store all real-time data according to the information contained in the database. Database points shall be enabled or disabled individually at any time by an operator working at the proper security level. All internal database point information shall be accessible to other external database software applications through ODBC, export of comma separated value or direct SQL commands.

2-2.07. Interactive Database Editor. An interactive database editor software module shall be provided for creation, inspection, and modification of database entries. Modification, addition, or deletion of database information shall not require direct changes to the program source code. Changes made in the database contents or formatting shall automatically update all locations at which the information is stored or used.

2-2.08. Custom Algorithms. The software shall enable the users to create their own custom algorithms or command sequences through accessing database points, internal pseudo-point variables, math and logic comparisons, and standard system functions. Each algorithm and command sequence shall run independently and shall be configurable to be executed on demand, based upon an event or condition, on a timed-interval, or at a set time of day.

2-2.09. Programming Language. A programming-type language or environment shall be considered acceptable if it is integrated into the base control system software product; if any compilers, linkers, and other necessary software modules are either included with the base software or supplied and configured by System Supplier; if technical support is provided directly by the control software vendor; and if all control system database points and variables are accessible to the programmer.

2-2.10. Alarm Processing. Alarm processing software shall be provided to recognize and report alarms to the operator in an organized, unambiguous, clear, and convenient manner. Alarms shall be classified into at least five priority levels and at least two independent classes. System events shall be considered alarms classified by their own specific priority or class.

2-2.10.01. Alarms. Alarm processing software shall generate alarms for at least the following conditions.

Discrete input or output change of state if defined as an alarm in the database.

Analog value exceeding the alarm limits defined in the database.

Analog rate of change exceeding the limits defined in the database.

Failure of any process input/output hardware, communications link, or other major hardware component.

2-2.10.02. Acknowledgment. Alarms shall be generated as they occur and shall not be cleared until they have been acknowledged and conditions have returned to normal. Alarms shall clear from each operator workstation once they have been acknowledged from any workstation.

2-2.10.03. Alarm Summary Display. An alarm summary display shall be provided which lists at least 100 of the most recent alarms in all classes, with the

most recent alarm listed first. Alarms shall appear flashing or in a unique color until they are acknowledged by the operator. Alarms of different priorities shall be easily distinguished on all alarm displays through the use of unique colors or similar methods.

2-2.10.04. Alarm Logging. Alarm logs shall constitute a hard-copy record and a soft-copy record saved in the historical database of all alarms, events, and significant operator actions. Alarm displays and alarm log entries shall include the date and time that the alarm was detected, the tag name and description of the alarmed point, and an entry describing the nature of the alarm. Alarms shall be logged on an alarm and event printer and saved in the historical database as they occur.

2-2.10.05. Responses to Alarms. An audible alarm shall sound at the operator's console at each occurrence of a new alarm event. The audible alarm shall be silenced when it is acknowledged by the operator.

Voice annunciation shall be used to annunciate alarm events.

The audible alarm shall use an external sound system, such as a sound card and external speakers.

2-2.10.06. Alarm Enabling. Alarms originating from database entries such as discrete change of state or analog limit violations shall be enabled or disabled on a point-by-point basis.

Alarms shall be capable of being shelved for an operator-entered period of time. After the alarm shelving time period has elapsed, the shelved alarm shall become active again.

2-2.10.07. Alarm Notification Software. An external or integral alarm notification software package shall be provided to generate alarms for paging, texting, voice call, or email systems. Two licensed copies of the software shall be provided. External software packages shall be Win911 or SCADAlarm, or equal. Integral software packages shall be equivalent to the listed external software packages.

2-2.11. Operator Interface. System software shall be suitable for creation and modification of alphanumeric and graphic displays and linking of dynamic fields to database variables.

2-2.12. System Storage. The system shall be capable of storing and utilizing 300 full-screen user displays and pop-up windows, each containing any number of the following components.

Static and dynamic alphanumeric information.

Static and dynamic or object-based graphics.

Dynamic bar graph displays.

Dynamic analog real-time and historical trends displays.

Static and dynamic bitmap (Windows .BMP compatible) graphics.

2-2.13. Component and Configuration Information. The software shall enable the user to reuse components and configuration information from any screen or pop-up window with or without modification. All configuration information shall be displayed in any of 256 colors, flashing or non-flashing. Dynamic fields shall change color or from flashing to non-flashing and back in response to a change in value, state, or alarm condition of the linked variable. Dynamic objects linked to process inputs and outputs shall be capable of displaying at least three equipment states, such as on/off/alarm for pumps, or open/close/transition for valves.

2-2.14. Communications. System software shall support communications among computers and PLCs as indicated on the Drawings and as specified herein. System Supplier shall be responsible for any device driver development required to support the communications indicated.

2-2.14.01. Data Retrieval and Transmission. The software shall retrieve and send data from and to all remote field devices indicated on the Drawings. The software shall perform all required error checking to ensure the validity of all data transactions and proper completion of the scan sequence. All communication system malfunctions, including "no response", shall be reported to the system as alarms. Re-transmission shall be utilized to correct or overcome communication errors.

2-2.14.02. Communications Driver. The software shall be supplied with communications drivers capable of communicating with any existing remote field devices indicated on the Drawings as well as all software input/output drivers required to communicate with all field devices and system hardware that are furnished as part of the control system.

Network communications drivers shall be provided for notification and alarming of SNMP compliant devices, such switches and routers. Drivers shall be OPC to SNMP drivers. Generic OPC drivers shall be provided for the HMI software as required. Drivers shall be Kepware, Matrikon or equal.

2-2.15. Historical Data Storage.
The software shall include modules for historical data gathering, data reduction, and reporting. Real-time analog signal values shall be collected and stored in the historical database based on a user defined time interval of 1 second to 1 day, or on a change of state deadband configured for each database point. Alarms and events shall be collected and stored in the historical database as they occur. The historian shall support the following features.

The historical database shall be a real-time relational database. The database shall be an extension of Microsoft SQL Server. The historical database shall acquire point information from the graphical user database.

Access to data shall be by any SQL or ODBC compliant software package, such as Crystal Reports, Oracle database applications, Microsoft Excel, or Microsoft Access.

Database shall allow the use of a separate I/O server for data from the programmable logic controller system.

2-2.15.01. Data Reduction Capabilities. Data reduction capabilities shall be provided to average and reduce data to hourly records, and the hourly records to daily records. Entries for all hourly and daily averaged records shall include sample, average, minimum and maximum values as defined by Owner. Both hourly and daily averages for each day shall be stored in the historical database.

2-2.15.02. Retrieval Software. Data retrieval software shall be provided to allow access to historical data files for the following uses:

Tools shall be provided for remote trending and display of the data on all user workstations. Trend displays shall allow up to eight tags to be graphed in the window. Graphs shall allow stacking or separate display of each tag. Displays shall allow save functions for retrieval from the computer hard drive. Trends shall display real-time data, or display data from the history files. The trend display shall show the time frame of stored data.

Import/export of data from/to ASCII files.

Inclusion in user-generated reports.

Tools for Microsoft Excel display of data shall be included. Tools shall allow the retrieval and display of real-time data, or historical data.

2-2.16. Reports. Report logs shall constitute a hard-copy summary of user-selected process data. At least 30 report formats shall be available in the system. Report printing software shall include a user-interactive, on-line report editor to allow the operator to select the following parameters for each report.

Data consisting of measured variables, calculated variables, and manually entered data.

Starting and ending time of data to be included in the report.

Print format for each variable.

Titles and subtitles to appear on each page of the report, including report name, current time, and date.

Paper width (from 8 to 14 inches).

Print pitch (from 5 to 16.5 characters per inch).

Number of columns on each page.

Number of lines per page and number of pages per report.

2-2.16.01. Database Points. All database points in the system, including all input/output points, manually entered points, and calculated points, shall be available for use in reports. Reports shall include sample, average, minimum, and maximum values for analog variables and the time of occurrence for minimum and maximum values. Information printable for discrete variables shall include running time, state, and transition count.

2-2.16.02. Report Formats. Report logs shall constitute a file or a hard-copy summary of user-selected process data. All historical data for points in the history database shall be available for reporting from an SQL and ODBC compliant database. Reporting software shall have the following features:

Creation and modification of report formats or content shall not require direct modification of system source code. Reports shall have the ability to be created in third party software packages such as Microsoft Excel and Microsoft Access.

Report format spreadsheet package shall be Excel.

2-2.17. Off-line Storage Software. The software shall include provisions for copying to backup media any or all of the historical data currently stored on the hard drive. The software shall support archival of data to any backup devices specified in the Computer System Hardware section. Archival of data shall be intuitive and the archival software shall guide an operator through the backup process.

2-2.17.01. Backup Data. Once historical data is copied to back-up media, the software shall allow the operator to delete it without negative consequences to free space on the hard drive. Archived historical data shall be re-loadable and usable in all the same ways as historical data that has not been removed from the local hard drive.

2-2.17.02. Logical Disk Drive. If the backup device is on-line and addressable by a logical disk drive letter (e.g., an optical disk drive defined as "D:"), historical data archived to that device shall be accessible directly without restoration to a local hard drive.

2-2.17.03. Internet/Intranet Connectivity. The software shall include provisions for making connections to the process data through the existing corporate Intranet or through a connection made on the Internet. This “thin client” solution

shall provide authorized users access to all displays and process information by utilizing any standard Internet browser.

The application software shall include software for development for web browser based interface. Features shall include the following:

The software shall allow access to the real-time process operations through any web browser without special software on the computer.

The software shall provide security to prevent unauthorized use.

The software shall allow the user to view alarms through the browser.

The software shall allow the user to view historical data through the browser.

2-3. SOFTWARE DOCUMENTATION. System Supplier shall relinquish all documentation supplied with the software furnished, such as user manuals, programmer guides, reference cards or keyboard templates, and related materials. In addition, System Supplier shall generate and submit to Owner and Engineer written documentation of any configuration work, modifications of the system, or setup of software done before or after installation of equipment on the site. Documentation shall be electronic. This includes any and all information on the development of any standard “objects,” “wizards,” or “scripts” created for the use in this project.

2-4. PLC SOFTWARE. The requirements for PLC software are specified in the Programmable Logic Controller section.

2-5. EXTENDED SUPPORT OR WARRANTY. The process control system software shall include the extended or comprehensive support service of the manufacturer. The service shall include all software updates and phone and personal support when needed. The service shall be for a period of one year after final acceptance and shall cover all software packages supplied under this contract.

2-6. TRAINING SERVICES. Training requirements are specified in the Instrumentation And Control System section.

PART 3 - EXECUTION

3-1. INSTALLATION REQUIREMENTS. The System Supplier shall install the process control software on the control system hardware specified in another section.

3-1.01. Configuration. System Supplier shall install and properly configure any supplemental programs, modules, and software packages necessary to meet the

functional requirements of the project as described in the Instrumentation and Control System and Software Control Block Description sections.

3-1.02. Quantity. The System Supplier shall install one full development software package(s) on the control system server(s) and a runtime software packages, on each of the operator workstations.

End of Section

Section 40 69 13

UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1-1. SCOPE. The Uninterruptible Power Supply section covers the furnishing of a complete on-line uninterruptible power supply (UPS) as indicated on the Drawings.

The system shall convert incoming single phase, 60 Hz, power into dc power, maintain and charge backup batteries and reconvert outgoing power into a sinusoidal single phase, 60 Hz, ac power source. The system shall consist of a rectifier, battery charger, batteries, inverter, integral static bypass switch, and maintenance bypass switch as required.

Additional accessories and appurtenances shall be provided as specified herein to provide a complete and properly operating system.

1-1.01. Control System. The Instrumentation and Control System section shall apply to all equipment furnished under the Uninterruptible Power Supply section.

1-1.02. Control System Loads. The UPS shall supply the Control System and other loads located in or external to the control room and server room as indicated on the Drawings.

1-2. GENERAL. Equipment furnished under the Uninterruptible Power Supply section shall be fabricated and assembled in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Drawings. Supplementing this section, the Drawings indicate locations and arrangement of enclosures and provide one-line diagrams regarding the connection and interaction with other equipment.

1-2.03. Nameplates. Each UPS shall be identified with a suitable engraved nameplate mounted on the top front. A nameplate shall also be provided for each of the external manual bypass switches. The nameplates shall be made of laminated black and white plastic. The lettering shall be bold, not less than

1/4 inch square, engraved by cutting through the black outside layer so that the letters appear white.

1-3. SUBMITTALS. In addition to the Instrumentation and Control System section, all material and equipment documentation shall be submitted for review as specified in the Submittals Procedures section. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment as follows:

a. Equipment and materials descriptive literature and drawings shall show the specification paragraph for which equipment applies.

b. Sheets or drawings showing items not applicable to this system, or not requiring review, shall contain clear indication as to which section or sections require review.

c. Functional line diagrams showing all major system components and external connection diagrams for all electrical equipment shall be submitted for review. A manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted, unless it is clearly marked to show the intended connections.

d. A report certifying that the UPS will provide the required backup time at the specified UPS loading and UPS ambient temperature. The report shall include anticipated continuous electrical load calculations, backup time calculations and shall indicate the battery end-voltage used in the analysis.

1-4. DELIVERY, STORAGE, AND SHIPPING. Delivery, storage and shipping shall be as specified in the Instrumentation and Control System section.

1-5. SPARE PARTS. The System Supplier shall provide spare parts per the general Terms and Conditions.

PART 2 - PRODUCTS

2-1. GENERAL. All equipment, enclosures, and accessories shall be designed, assembled and connected in accordance with the requirements of these Specifications and the Drawings. Enclosures shall be NEMA Type 1.

2-1.01. System Design Requirements. The UPS system(s) have the following capacity and rated for the following voltages.

Capacity	2 kW
Input voltage at 60 Hz, +10 to -	120

15 percent	
Output voltage at 60 Hz single phase	120
Minimum Back up time required (minutes)	10

The UPS system(s) shall ratings and features.

Capacity, peak (minimum)	150 percent of continuous power rating for 10 seconds.
Frequency stability, battery mode	± 0.5 percent.
Harmonic distortion (max)	5 percent.
Efficiency, overall on-line	75 percent minimum.
Operating temperature-humidity	0 to 40°C; 0 to 95 percent relative humidity, non-condensing.
Recharge time (max)	4 hours.

2-1.02. Acceptable Manufacturers. All systems supplied under this contract shall be of the same manufacturer. The uninterruptible power supply systems shall be as manufactured by MGE, Powerware, Liebert, or equal.

2-1.03. Terminal Blocks. Wiring for external circuits, including all alarm contacts, shall be brought to grouped terminal blocks located for convenient connection. Provisions shall include suitable marked terminal blocks for connection of No. 12 AWG control wiring and for input/output power conductors as sized on the Drawings. Terminal designations shall agree with manufacturer's wiring diagram.

2-2. BATTERY CHARGER/RECTIFIER AND BATTERIES. The battery charger and the rectifier shall have the following characteristics:

a. The rectifier shall convert the incoming ac power to dc power to energize the static inverter.

b. The battery charger shall supply a float current to the batteries to maintain them at a fully charged state while incoming power is being provided. The charging voltage shall be temperature-compensated over the entire operating temperature range to avoid overcharging or undercharging the batteries. The battery charger shall automatically apply an elevated voltage (equalization charge)

to the batteries if and as required by the battery manufacturer.

c. The battery shall provide backup power for the UPS when incoming commercial power is not available. The battery cells shall be valve-regulated or gelled-electrolyte lead-acid type. The battery shall be integral to the UPS. Battery shall have capacity to supply the dc power to the UPS while operating at full load for a period of not less than as required at 25°C. The battery shall have an expected life of 5 years and shall carry a one-year warranty.

2-3. STATIC INVERTER. The solid-state inverter shall employ silicon-controlled rectifiers (SCRs) and other devices for converting direct current power to essentially sinusoidal alternating current power. The static inverter shall conform to the following characteristics and requirements.

a. Automatic Synchronization: During normal operation, the inverter shall provide power to critical loads. The utility electric system will act as an alternate supply. Inverter equipment shall include stable solid-state devices designed to automatically maintain inverter output in phase with the utility electric system.

b. Overload, Short Circuit, and Load Loss: The inverter shall have input and output fuses and other equipment necessary to protect from overload, short circuit, and 100 percent loss of load. Current limiting features shall also be provided.

c. Loss of Supply Voltages: The inverter shall include protective devices to prevent damage resulting from excursion, loss, or restoration of its synchronization voltage and its dc input voltage and any inrush current occurrences associated with such conditions.

2-4. STATIC TRANSFER SWITCH. The static transfer switch shall use SCRs and other static devices to automatically transfer loads from the off-line (bypass) to the on-line operating condition and back again. In off-line mode, the static transfer switch shall connect clean filtered power to the load. The primary ac line shall be monitored and the load shall be transferred to the inverter if the voltage drops below 85 percent. During on-line mode operation, any inverter problem shall cause an instantaneous transfer to the bypass mode.

2-5. MAINTENANCE BYPASS SWITCH. A maintenance bypass switch shall be provided so maintenance can be performed on the UPS without disrupting control system operation. The bypass switch shall be independent of the UPS electronics. The bypass switch shall be external to the UPS.

2-6. OUTPUT RECEPTACLE PANEL. An output receptacle panel with a variety of NEMA 5, 6, L5, and/or L6 receptacles shall be furnished on the rear of the UPS and connected to the distribution panel furnished under the Electrical

section. The System Supplier shall coordinate the size, number, and type of the receptacles with the equipment as indicated on the Drawings.

2-7. CONTROL, INDICATION AND ALARM. Controls, indicators and alarms shall be provided as a part of the UPS. Control buttons and LED indicators shall be provided on the UPS panel and shall be permanently labeled.

2-7.01. Controls. A dc battery circuit breaker, a mode selector switch, and system "ON" and "OFF" buttons shall be provided.

2-7.02. Indication. A digital display for selection and indication of input, output, and battery voltages shall be provided.

LED indicators for inverter ready, frequency, battery voltage, overload, over temperature, and impending shutdown conditions shall be provided.

LED indicators for bypass ready, bypass mode, and on-line mode shall be provided.

2-7.03. Remote Alarms. The UPS shall have the following provisions for remote alarms.

2-7.03.01. General Alarm. For units 5 kW and larger, a common, isolated, dry, alarm contact rated 3 amperes at 120 volts ac shall be provided with the UPS for indication of general alarm. The contact shall close under any UPS fault condition.

2-7.03.02. Power Failure. For units 5 kW and larger, an isolated, dry, alarm contact rated 3 amperes at 120 volts ac shall be provided with the UPS for remote indication of power failure. The contact shall open upon loss of commercial power to the UPS. For units smaller than 5 kW, a relay shall be provided and connected across the incoming power as the means of providing a contact for indication of a power failure condition.

PART 3 - EXECUTION

3-1. INSTALLATION REQUIREMENTS. Installation requirements are specified in the Instrumentation and Control System section.

3-2. OWNER TRAINING. System Supplier shall provide a qualified representative at the jobsite to train Owner's personnel in operating, maintaining, and repairing the equipment. The training shall be in accordance with the Demonstration and Training section.

End of Section

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Section 40 71 00

FLOW INSTRUMENTS

PART 1 - GENERAL

1-1. SCOPE. The Flow Instrument Section covers the furnishing of flow instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings or the Instrument Device Schedule.

1-2. DESIGN CRITERIA. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Design-Builder.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or in the Instrument Device Schedule.

Where possible, each instrument shall be factory wet flow calibrated to the full scale flow range of the sensors or calibration ranges indicated on the Drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration and configuration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings or Instrument Device Schedule.

1-3. SUBMITTALS. Submittals shall be made as specified in the Instrumentation and Control System section.

1-4. SHIPMENT, PROTECTION, AND STORAGE. Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as specified in the Instrumentation and Control System section.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs provide minimum device requirements. The Drawings or Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. Interconnecting Cable. For instruments where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of three meters or as indicated on the Drawings or in the Instrument Device Schedule. The interconnecting cable shall be provided in the length necessary for installation. Splices shall not be allowed in the installed cable.

2-1.02. Programming Device. For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.03. Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. As a minimum, an appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under the Windows 10 operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

2-2. FLOW INSTRUMENTATION.

2-2.01. Differential Pressure Flow Transmitters. Not used.

2-2.02. Magnetic Flowmeters, Signal Converters, and Accessories.

2-2.02.01. Magnetic Flowmeter. The magnetic flowmeter shall be a completely obstructionless, in-line flowmeter with no constrictions in the flow of fluid through the meter. The meter shall consist of a metallic tube with flanged ends and with grounding rings. Flange diameter and bolt drilling pattern shall comply with ANSI/ASME B16.5 for line sizes from one-half inch to 24 inches or AWWA C207 for line sizes larger than 24 inches. Flange class ratings and meter maximum pressure ratings shall be compatible with the adjoining piping. Flangeless wafer insert style meters may be used for pipe sizes up to 6 inches, where compatible with adjacent piping flanges. Self-cleaning electrodes shall be provided for all meters used for sludge metering. Electrode and liner materials shall be fully compatible with the process fluid as approved by the Design-Builder and shall comply with the requirements specified in the Instrument Device Schedule. Each meter shall be factory wet flow calibrated to the sensors full flow capacity, at a facility, which is traceable to NIST or other standard acceptable to Engineer, and a copy of the calibration, report shall be submitted as part of the operation and maintenance manual submittal.

The meter shall be capable of standing empty for extended periods of time without damage to any components.

The meter housing shall be of a splash-proof and drip-proof design, unless indicated on the Drawings or in the Instrument Device Schedule to be submersible. Where required to be submersible, the meter housing shall withstand submergence in 30 feet of water for 48 hours without damage.

Where indicated on the Drawings or in the Instrument Device Schedule, the meter shall be suitable for use in a Class I, Division 2, hazardous area.

Meters shall be manufactured by ABB, Siemens, Rosemount, Endress+Hauser, or equal.

2-2.02.02. Magnetic Flowmeter Signal Converters. Separately mounted, microprocessor-based signal converters shall be provided for the magnetic flowmeters. The signal converters shall include output damping, self-testing, built-in calibration capability, and an "empty pipe zero" contact input. The overall accuracy of the magnetic flowmeter transmitter and signal converter shall be ±1 percent of actual flow rate between 10% and 100% of full-scale. Repeatability shall be 0.25% of full scale. The meter manufacturer shall furnish the signal cable between the converter and the magnetic flowmeter. Signal cable shall be continuous and not spliced between the meter and the signal converter. The signal converter shall be housed in a corrosion-resistant, weatherproof NEMA Type 4X housing and shall be suitable for operation over an ambient temperature range of -30 to +140°F [-34 to +60°C], and relative humidity of 10 to 100 percent. The converter shall have an analog output of 4-20 mA dc. Where indicate on the Drawings or in the Instrument Device Schedule, the converter shall have a pulse

output designed to operate a remote seven-digit totalizer and scaled so that the totalizer will operate for 60 days at 100 percent flow without repeating. Scaling factors shall be field adjustable and shall be selected to provide a totalizer multiplier of a power of 10. Transmitters tagged on the Drawings or specified to be of the indicating type shall contain a local indicator with a minimum four digit LCD type display, scaled to read in engineering units of flow.

Magnetic flowmeter systems shall provide zero flow stability by means of automatic zero adjustment of a DC excited metering circuit. Converters shall be capable of bi-directional flow measurement. Signal converters shall be of the same brand as the magnetic flowmeters.

Where indicated on the Drawings or in the Instrument Device Schedule, the signal converter shall have a non-reset seven-digit totalizer on the face of the enclosure.

The signal converter shall be diagnosed and recalibrated with the use of a hand-held communicator/calibrator device. One device shall be furnished for all converters provided by a single manufacturer.

2-2.03. Open Channel Ultrasonic Flow meters. Not used.

2-2.04. Open Channel Admittance Probe Flowmeters. Not used.

2-2.05. Doppler Ultrasonic Flowmeters. Not used.

2-2.06. In-Line Type Ultrasonic Flowmeters (Single Path). Not used.

2-2.07. In-Line Type Ultrasonic Flowmeters (Multi-Path). Not used.

2-2.08. Averaging Pitot Type Flow Elements. Not used.

2-2.09. Thermal Dispersion Flowmeters. Each flowmeter shall utilize a thermal dispersion type, explosion-proof, and stainless steel or Hastelloy C sensing element installed in the process piping. The insertion length of the element shall be approximately one-half of the pipe diameter, and all mounting accessories shall be provided. The sensor shall have a 1 inch MNPT mounting connection, and an isolation valve and packing gland that allows insertion and removal while the piping is under pressure.

The electronic transmitter shall be remotely mounted within 30 feet of the sensor with interconnecting cable provided, as indicated on the Drawings or in the Instrument Device Schedule. The transmitter shall be of the ac-powered type. The unit shall be housed in a NEMA Type 4 enclosure or an explosion-proof enclosure suitable for hazardous locations, as indicated on the Drawings or in the Instrument Device Schedule. The transmitter shall have a 4-20 mA dc analog

output and a local indicator with a multi-line LCD display calibrated in engineering units of flow. The transmitter shall also display a totalized flow value and the temperature of the process fluid.

Accuracy of the flowmeter shall be 1 percent of full scale over a 20-to-1 operating range. The flowmeter shall be Fluid Components International insertion-type, or equal.

2-2.10. Propeller Flowmeters. Not used.

2-2.11. Turbine Flowmeters. Not used.

2-2.12. Orifice Plates. Not used.

2-2.13. Differential Pressure Flow Indicators. Not used.

2-2.14. Gas Service Rotameters. Rotameters shall be all metal variable area type utilizing an integral orifice plate and conical float. Float position shall be magnetically transmitted to an external indicating unit that linearizes and displays the flow in the engineering units indicated in the instrument data sheets. Flowmeter components shall be compatible with the measured process. Where the process is not defined, flowmeter wetted components shall be AISI Type 316 stainless steel. Flowmeter connections shall be 150 lb ANSI flanges. Flowmeter assemblies shall be rated NEMA Type 4.

Where indicated in the Drawings or Instrument Device Schedule, flowmeters shall be provided with an adjustable, magnetic actuated switch. The switch shall actuate at the flow value listed in the Drawings or the Instrument Device Schedule. Switches shall be rated 5 amp [A] at 120 V ac.

Each rotameter shall be provided with all required mounting hardware to securely mount the unit according to the mounting requirements indicated in the Drawings or the Instrument Device Schedule.

Mounting and installation hardware shall be AISI Type 316L stainless steel. Gas service rotameters shall be ABB, Brooks Instrument, Krohne, or equal.

2-2.15. Liquid Service Rotameters. Rotameters shall be all metal variable area type utilizing an integral orifice plate and conical float. Float position shall be directly visible through a sealed glass or plexiglass viewing window. Flow scale shall be engraved on the viewing window. Flowmeter components shall be in accordance with the Material Class Sheets. Where not covered by the Material Class Sheets, flowmeter wetted components shall be AISI Type 316 stainless steel. Float viewing window materials shall be compatible with the measured process, as indicated in the Instrument Data Sheets. Flowmeter connections shall be 150-lb ANSI flanges.

Where indicated in the Instrument Data Sheets or Instrument Device Schedule, flowmeters shall be provided with an adjustable, magnetic actuated switch. The switch shall actuate at the flow value listed in the Instrument Data Sheet. Switches shall be rated 5A at 120 volts ac.

Each rotameter shall be provided with all required mounting hardware to securely mount the unit according to the mounting requirements indicated in the Instrument Data Sheet or Instrument Device Schedule.

Mounting and installation hardware shall be AISI Type 316L stainless steel. Liquid service rotameters shall be ABB or equal.

2-2.16. Target-Type Flow Switches. Not used.

2-2.17. Coriolis Mass Flowmeters. Not used.

PART 3 - EXECUTION

3-1. FIELD SERVICES. Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

Section 40 72 00

PRESSURE AND LEVEL INSTRUMENTS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of pressure and level instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings or the Instrument Device Schedule.

1-2. DESIGN CRITERIA. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Design-Builder.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or in the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated in the Drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings and/or Instrument Device Schedule.

1-3. SUBMITTALS. Submittals shall be made as specified in the Instrumentation and Control System section.

1-4. SHIPMENT, PROTECTION, AND STORAGE. Equipment provided under this section shall be shipped, protected, and stored in accordance with the requirements of the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs provide minimum device stipulations. The Drawings or Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. Interconnecting Cable. For systems where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of three meters or as indicated in the Drawings or Instrument Device Schedule.

2-1.02. Programming Device. For systems that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section.) The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.03. Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under Microsoft's Windows 10 operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

2-2. PRESSURE AND LEVEL INSTRUMENTATION.

2-2.01. Pressure and Pressure Sensing Level Transmitters. Transmitters shall be an all solid state electronic two-wire device that does not require a direct power connection to the transmitter. Process fluid shall be isolated from the sensing elements by AISI Type 316 stainless steel, Hastelloy-C, ceramic, or

cobalt-chromium-nickel alloy diaphragms, and the transducer may use a silicone oil fluid fill. Transmitters shall have self-diagnostics and electronically adjustable span, zero, and damping. Transmitters shall be enclosed in a NEMA Type 4X housing and shall be suitable for operation at temperatures from 0° to 180°F [-17° to +82°C], and relative humidity of 5 to 100 percent. All parts shall be cadmium-plated carbon steel, stainless steel, or other corrosion-resistant materials. Transmitters shall have over-range protection to maximum line pressure. Accuracy of the transmitter shall be 0.1 percent of span, and transmitter output shall be 4-20 mA dc without the need for external load adjustment. Transmitters shall not be damaged by reverse polarity. Transmitters shall have an elevated or suppressed zero . For calibrated spans of less than 8 psig a differential pressure type transmitter with side vents shall be utilized. Transmitters in absolute pressure applications shall be provided with a 316 stainless steel, three-valve manifold and a mounting bracket for calibration/testing and tapping point for pressure gauge. Manifolds shall have test ports on the instrument side of the valves and shall be Anderson-Greenwood "M4T". Transmitters in chemical applications shall include isolation diaphragm seals. Transmitters shall be provided with brackets for wall and pipe-stand mounting.

Transmitters shall be factory calibrated to the required range and provided with the manufacturer's standard hand-held communications/calibration device. One device shall be furnished for all transmitters provided by a single manufacturer.

Transmitters tagged on the Drawings or specified to be indicating type shall be furnished with LCD type digital indicators.

Transmitters will have a turndown ratio of 30:1, or more.

Transmitters shall be ABB “Model 264GS”, Siemens “SITRANS P”, Rosemount “Model 2051”, Endress+Hauser “Cerabar S”, or equal.

2-2.02. Premium Accuracy Pressure and Pressure Sensing Level Transmitters. Not used.

2-2.03. Differential Pressure Transmitters. Transmitters shall be an all solid state electronic two-wire device that does not require a direct power connection to the transmitter. Process fluid shall be isolated from the sensing elements by AISI Type 316 stainless steel, Hastelloy-C, ceramic, or cobalt-chromium-nickel alloy diaphragms, and the transducer may use a silicone oil fluid fill. Transmitters shall be enclosed in a NEMA Type 4X housing and shall be suitable for operation at temperatures from 0° to 180°F [-17° to +82°C], with relative humidity of 5 to 100 percent. All parts shall be cadmium- plated carbon steel, stainless steel, or other corrosion-resistant materials. Vents shall be provided on the sides of the diaphragm housing body. Transmitters shall have positive over-range protection. Accuracy of the transmitters shall be 0.1 percent of span, and the effect on

accuracy caused by static pressure changes shall be negligible. Transmitter output shall be 4-20 mA dc without the need for external load adjustment. Transmitters shall not be damaged by reverse polarity. Each transmitter shall be provided with a 316 stainless steel, three-valve manifold and a mounting bracket for calibration/testing and tapping point for pressure gauge. Manifolds shall have test ports on the instrument side of the valves and shall be Anderson-Greenwood "M4T". Transmitters in chemical applications shall include isolation diaphragm seals.

Transmitters shall be factory calibrated to the required range and provided with the manufacturer's standard hand-held communications/calibration device. One device shall be furnished for all transmitters provided by a single manufacturer.

Transmitters tagged on the Drawings or specified to be the indicating type shall be furnished with LCD type digital indicators.

Transmitters will have a turndown ratio of 30:1.

Transmitters shall be ABB “Model 264DS”, Siemens “SITRANS P DS III”, Rosemount “Model 2051”, Endress+Hauser “Deltabar S Series”, or equal.

2-2.04. Premium Accuracy Differential Pressure Transmitters. Not used.

2-2.05. Flange-Mounted Pressure Sensing Level Transmitters. Not used.

2-2.06. Ultrasonic Level Transmitters. Each ultrasonic level transmitter shall be a microprocessor-based electronic unit consisting of a sensor assembly, a signal converter/transmitter, and an interconnecting cable. The sensor shall be encapsulated in a chemical and corrosion-resistant material such as kynar or CPVC, and shall be suitable for operation over a temperature range of -20° to +150°F [-28° to +66°C] and a relative humidity of 10 to 100 percent. The sensor shall be compatible with the process media being measured. Where indicated on the Drawings or in the Instrument Device Schedule, the sensor shall be an explosion-proof or intrinsically safe design suitable for use in all hazardous areas. Sensors mounted in areas subject to freezing shall be provided with special transducers or protected against icing by heaters. Sensors mounted in direct sunlight shall be provided with sunshades.

The supplier shall coordinate the sensor mounting requirements and furnish drawings complete with dimensions and elevations. General installation requirements are indicated on the Drawings.

The ultrasonic level transmitter shall have automatic compensation for changes in air temperature at the sensor location. If separate temperature sensing probes are provided, they shall be mounted with or adjacent to the ultrasonic sensor, as recommended by the manufacturer. The transmitter shall have a four-digit LCD

display scaled to read in engineering units. Digit height shall be approximately 1/2 inch. The transmitter shall be designed to ignore momentary level spikes, false targets, or momentary loss-of-echo. A loss-of-echo condition shall be indicated on the transmitter unit and shall be available as an alarm contact output. The transmitter output shall be an isolated 4-20 mA dc signal linearly proportional to the measured level range, or where indicated on the Drawings or in the Instrument Device Schedule, shall be characterized to be proportional to the tank volume. Calibration parameters shall be entered through a keypad on the unit and shall be stored in nonvolatile EEPROM memory. Measurement resolution of the transmitted signal shall be 0.1 inch or less. Accuracy of the transmitted signal shall be ±0.25 percent of the level range greater than 3.3 feet. Measurement range of the transmitted signal shall be 0% through 100%.

Where indicated on the Drawings or in the Instrument Device Schedule, the transmitter shall be a differential level-sensing unit that accepts inputs from two ultrasonic level sensors. The transmitter output shall be proportional to the difference in level. The differential value shall be displayed on the unit. An adjustable alarm contact, actuated by differential level, shall be provided.

Where indicated on the Drawings or in the Instrument Device Schedule, the transmitter shall contain four independently adjustable level alarm contact outputs. Contacts shall be single-pole, single-throw, or double pole where indicated in the device schedule, rated not less than 5 amperes at 120 V ac.

A sufficient length of sensor-to-transmitter signal cable shall be furnished with the instrument to locate the sensor 25 to 200 feet from the signal converter.

For indoor installation, the signal converter electronics shall be housed in a NEMA Type 12 enclosure suitable for wall or pipe-stand mounting and for operating temperatures of +30° to +120°F [-1° to +49°C].

For outdoor installation, the signal converter electronics shall be housed in a weatherproof, corrosion-resistant NEMA Type 4 enclosure suitable for wall or pipestand mounting and for operating temperatures of -5° to +122°F [-20° to +50°C] and a relative humidity of 10 to 100 percent. A thermostatically controlled strip heater shall be provided in the signal converter enclosure.

The signal converter shall be of the ac-powered type. The ultrasonic level transmitter shall be ABB, Siemens “HydroRanger 200”, Rosemount, Endress+Hauser “Prosonic”, or equal

2-2.07. Admittance Probe Level Transmitters. Not used.

2-2.08. Submersible Pressure Sensing Level Transmitters. Not used.

2-2.09. Bubbler System Components. Not used.

2-2.10. Fixed-Mount Float Type Level Switches. Switches shall be of the floating ball type, with a nominal 5-1/2 inch diameter, coated stainless steel float ball that contains a sealed non-mercury switch assembly. The float shall be supported with a flexible synthetic rubber hinge fastened to an adjustable mounting bracket. The hinge shall also act as a housing for the lead wires from the alarm switch. The lead wire shall be a waterproof cable of such length that no splice or junction box is required in the wet well. Stainless steel mounting accessories shall be furnished. The switch contacts shall be single-pole-single-throw rated 1-amp [A] at 120 V ac. Switches shall be Magnetrol, Kari, ITT/Flygt or equal.

2-2.11. Weighted Float Type Level Switches. Each level switch shall consist of a single-pole, double-throw non-mercury switch, rated not less than 3 amp [A] ac, sealed and housed in a chemical-resistant polypropylene casing. The switch assembly shall be weighted and suspended on a waterproof, three-conductor, synthetic covered flexible cable with19 AWG conductors and of such length that no splice or junction box is required in the wet well. Switches shall be suitable for operation at up to 150 V ac within an ambient temperature range of 0 to 60°C. Switches shall be suitable for use in a sanitary wastewater wet well. Adjustable mounting hardware shall be provided for supporting each level switch. Switches shall be Magnetrol, Kari, ITT/Flygt or equal.

2-2.12. Adjustable Deadband Float Type Level Switches. Not used.

2-2.13. Electrode/Conductance Relay Level Switches. Not used.

2-2.14. Flange-Mounted Displacement Float Type Level Switches. Not used.

2-2.15. Flood Level Switches. The flood detecting level switches shall be float actuated and shall be suitable for wall bracket or sump mounting, as indicated on the Drawings or in the Instrument Device Schedule. The switch float mechanism shall actuate when the water level rises to 1 inch [25 mm] above the bottom of the housing. The switch contacts shall be hermetically sealed, rated for 0.1 amp [A] at 120 V ac, and shall be field changeable from normally open to normally closed. Flood switches shall be Contegra "Model FS 202".

2-2.16. Ultrasonic Level Switches. Not used.

2-2.17. Pressure Switches. Pressure switches shall be diaphragm actuated type switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line pressure. Switches mounted inside panels shall have NEMA Type1 housings. All other switches shall have weatherproof housings. Switches shall be differential type where indicated in the Instrument Device Schedule. Switch wetted parts shall be compatible with the process fluid.

Where the process is not defined, all wetted parts shall be Teflon-coated or viton and the connection port shall be stainless steel.

Panel-mounted and surface-mounted switches shall be provided with 1/4 inch NPT connections. All stem-mounted switches shall be provided with 1/2 inch NPT connections.

All pressure switches shall be ranged in psi [kPa] and all vacuum switches in inches of water. Unless otherwise indicated, switches shall have a fixed deadband and shall be auto-reset type. As a minimum, switches shall be SPDT, rated 10 amp [A] at 120 V ac.

Each switch shall be provided with a threaded end, ball-type shutoff valve. Shutoff valve materials shall be compatible with the process fluid. Where the process is not specified, valves shall have AISI Type 316 stainless steel wetted parts and Teflon seals. Multi-port valves shall have all unused ports plugged. Shutoff valve construction shall be as detailed in the Miscellaneous Instruments section.

Where indicated on the Drawings or in the Instrument Device Schedule, the switch shall be provided with a pressure snubber. Each snubber shall be of a size and pressure range compatible with the switch served. Snubbers shall be Ashcroft "Pulsation Dampers", or approved equal.

Where indicated on the Drawings or in the Instrument Device Schedule, a diaphragm seal shall be provided for the respective switch. Diaphragm seals shall be thread-attached type with removable AISI Type 316 stainless steel diaphragm, zinc or cadmium plated carbon steel upper housing, and stainless steel lower housing. The upper housing shall be contoured to fit and provide a seat and seal for the diaphragm and shall be designed to permit removal of the switch with the system under pressure. The lower housing shall be provided with a tapped and plugged 1/4 inch [6 mm] NPT flushing connection. Each diaphragm seal and the switch served shall be factory assembled, filled with a suitable fluid, and calibrated as a unit.

Switches shall be installed at the locations indicated on the Drawings, with installation conforming to the installation details. All switches, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation of the switch or diaphragm seal.

Switches shall be manufactured by Ashcroft, or equal.

2-2.18. Radar Level Transmitters. Not used.

2.2.19. Guided Wave Level Transmitters. Not used.

2-2.20. Field-Mount Pressure Gauges. Not used.

2-2.21. Annular Type Pressure Sensors. Pressure sensors shall be of the wafer type, designed to fit between standard class 150 and class 300 pipeline flanges. Flange material shall be the same as the surrounding pipeline. Sensor shall be flow through design with flexible elastomer sensing ring around the full circumference. The elastomer sensing ring shall be rigidly clamped between metal end cover flanges, and no part of the elastomeric sensing ring shall be exposed to the external face of the sensor. There shall be no dead ends or crevices, and flow passage shall make the sensor self-cleaning.

The pressure-sensing ring shall measure pressure for 360° around the full inside circumference of the pipeline. Flexible sensing ring shall have a cavity behind the ring filled with fluid to transfer pressure to the gauge. Sensing ring material shall be compatible with the process. Fill fluid shall be suitable for use with the process temperatures.

Annular pressure sensors shall be Red-Valve “Series 48 ” or equal.

PART 3 - EXECUTION

3-1. FIELD SERVICES. Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

Section 40 73 12

PRESSURE GAUGES

PART 1 - GENERAL

1-1. SCOPE. This section covers analog dial-type gauges and accessories to be furnished and installed at the locations indicated on the Drawings and as specified in the Gauge Schedule at the end of this section.

Gauges to be furnished by an equipment supplier, either with an item of equipment or as a component of an equipment package, shall be selected by the supplier in accordance with this specification unless covered in the other equipment specifications.

Gauge piping and fittings are covered in other sections.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Governing Standard. Except as modified or supplemented herein, all gauges shall conform to the requirements of ANSI/ASME B40.1.

1-2.03. Accuracy Grade. Unless otherwise specified, gauge accuracy shall be ANSI Grade 2A or better. Overall accuracy for diaphragm seal protected and liquid-filled gauges shall be ANSI Grade A or better.

1-3. SUBMITTALS. Complete drawings or catalog cuts, together with detailed specifications and data covering materials used, shall be submitted in accordance with the Submittals Procedures section.

PART 2 - PRODUCTS

2-1. GAUGE CONSTRUCTION. Unless otherwise specified, gauges shall be indicating dial type, with C-type phosphor bronze Bourdon tube; stainless steel rotary geared movement; phenolic or polypropylene solid front turret case; adjustable pointer; stainless steel, phenolic, or polypropylene ring; and acrylic plastic or shatterproof glass window.

The dial shall be 4-1/2 inches in diameter, with white background and black markings. The units of measurement shall be indicated on the dial face. Subdivisions of the scale shall conform to the requirements of the governing standard. Pointer travel shall be not less than 200 degrees nor more than 270 degrees of arc.

Unless otherwise indicated, pressure gauges shall measure in psig and vacuum gauges shall measure in inches Hg vacuum. All gauges shall have a suitable range to give mid-scale readings under normal conditions

Flush-mounted and surface-mounted gauges shall be provided with 1/4 inch NPT connections. All stem-mounted gauges shall be provided with 1/2 inch NPT connections.

The units of measurement, range, and mounting configuration of each gauge shall be as indicated in the Gauge Schedule.

2-2. GAUGE ACCESSORIES.

2-2.01. Isolation Valves. Each gauge shall be provided with a threaded end ball-type shutoff valve as specified in the Miscellaneous Ball Valves section.

2-2.02. Snubbers. Unless otherwise indicated in the Gauge Schedule, each pressure and compound pressure/vacuum gauge shall be provided with a pressure snubber. Each snubber shall be of internal or external design, fabricated of stainless steel, and of a size and pressure range compatible with the gauge served. Pressure snubbers shall be Operating and Maintenance Specialties "Ray Snubbers", Ashcroft "Pulsation Dampers", Weksler "Piston Type Pressure Snubbers", or Trerice "Pulsation Dampeners".

2-2.03. Gauge Isolators.

2-2.03.01. Pipe-mounted Diaphragm Seals. Pipe-mounted diaphragm seals shall be provided where indicated on the Drawings or in the Gauge Schedule. Diaphragm seals shall be thread-attached type with removable or cleanout AISI Type 316 stainless steel diaphragm, zinc or cadmium plated carbon steel upper housing, and PVC, bronze , brass, carbon steel, or stainless steel lower housing. The diaphragm seal shall be of "continuous" design to safely contain the process fluid in the event of gauge breakage or removal with the system under pressure. The lower housing shall be provided with a tapped 1/4 inch NPT flushing connection and an MxF stainless steel needle valve.

Each diaphragm seal and the gauge served shall be factory assembled, filled with a suitable fluid, and calibrated as a unit.

2-2.03.02. In-line Diaphragm Seals. In-line, flow-through type diaphragm seals shall be provided where indicated on the Drawings or in the Gauge Schedule.

For in-line diaphragm seals in pipe less than 4 inches, ends shall be flanged, threaded, or welding type to fit the piping system in which the unit is installed. Flanges shall be flat faced, with ANSI/ASME B16.5, Class 150 diameter and drilling. Threaded ends shall conform to ANSI/ASME B1.20.1, NPT. Each diaphragm seal shall be provided with a removable or cleanout stainless steel diaphragm and shall be tapped for a 1/2 inch NPT gauge connection.

For in-line diaphragm seals in pipe 4 inches and larger, flange type gauge isolators shall be provided. Each unit shall consist of a carbon steel housing, carbon steel assembly flanges, and Buna-N flexible cylinder, and shall be filled with silicone oil. Each isolator shall be a Moyno "RKL Series W Pressure Sensor/Isolator", Ronningen-Petter "Iso-Ring", or Red Valve "Series 40 Flanged Sensor", suitable for installation between two flat faced ANSI/ASME B16.1, Class 125 cast iron pipe flanges, and tapped for a 1/2 inch NPT gauge connection.

Each diaphragm seal and the gauge served shall be factory assembled, filled with a suitable fluid, and calibrated as a unit.

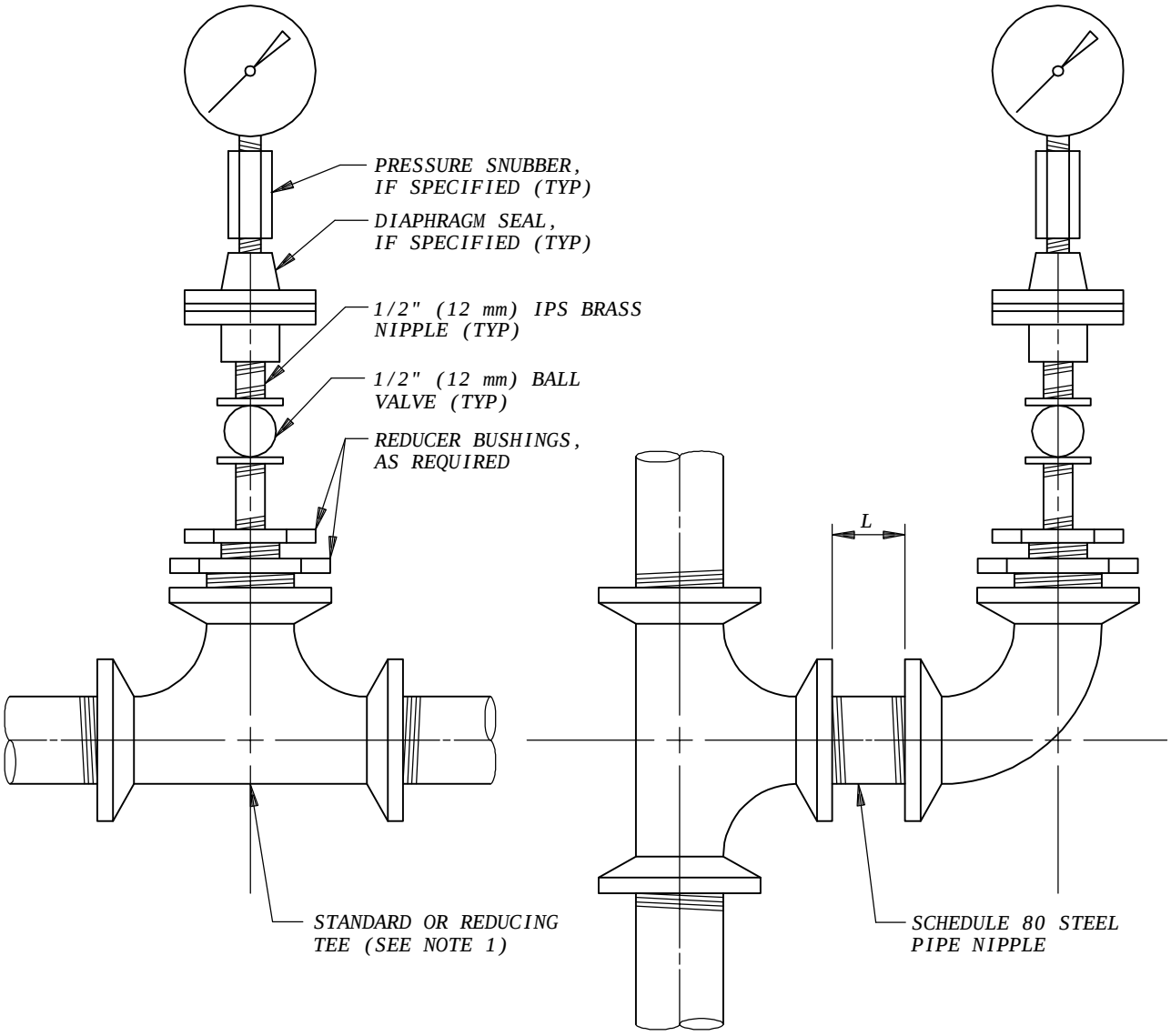
PART 3 - EXECUTION

3-1. INSTALLATION. Gauges shall be installed at the locations indicated on the Drawings. Installation configurations shall conform to the requirements of the Gauge Installation Details.

All gauges, snubbers and diaphragm seals shall be installed in the vertical upright position. Threaded connections shall be assembled using Teflon thread tape or Teflon thread sealer, as specified in the Miscellaneous Piping and Accessories Installation section. Teflon thread sealer shall not be used for liquid oxygen or oxygen gas piping. All connections shall be free from leaks.

Lines shall be purged of trapped air at gauge locations prior to installation of the gauge or diaphragm seal.

End of Section



HORIZONTAL RUN
NO SCALE

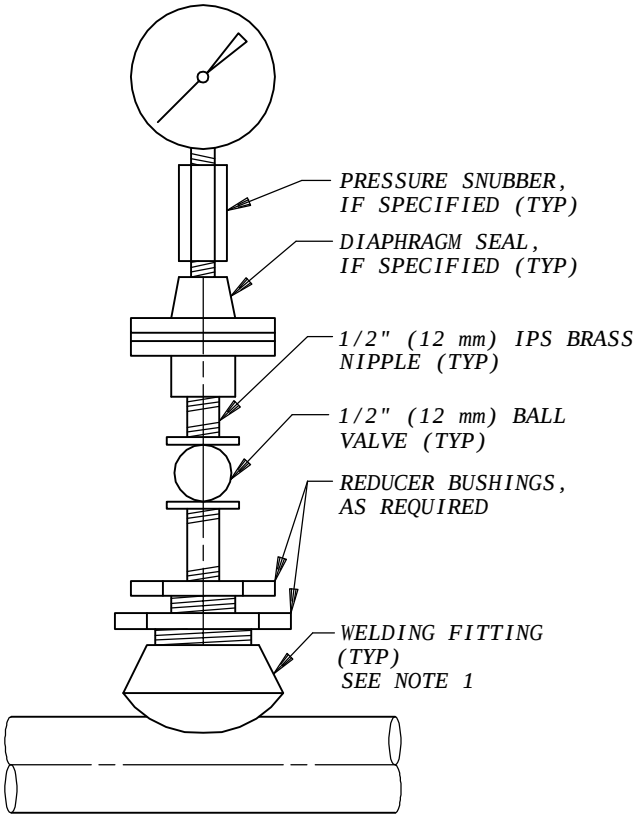
VERTICAL RUN
NO SCALE

NOTES:
1. WHERE SPECIFIED IN THE GAUGE SCHEDULE, PROVIDE IN-LINE FLOW-THROUGH DIAPHRAGM SEAL AND DELETE TEE, REDUCER BUSHINGS, AND THREAD-ATTACHED DIAPHRAGM SEAL.

2. DIMENSION "L" SHALL BE SUFFICIENT TO PREVENT CONTACT BETWEEN THE GAUGE CASE, DIAPHRAGM SEAL HOUSING, OR VALVE OPERATING LEVER AND ADJACENT PIPING OR INSULATION BUT SHALL NOT EXCEED 4 INCHES (100 mm) UNLESS OTHERWISE PERMITTED BY THE ENGINEER.

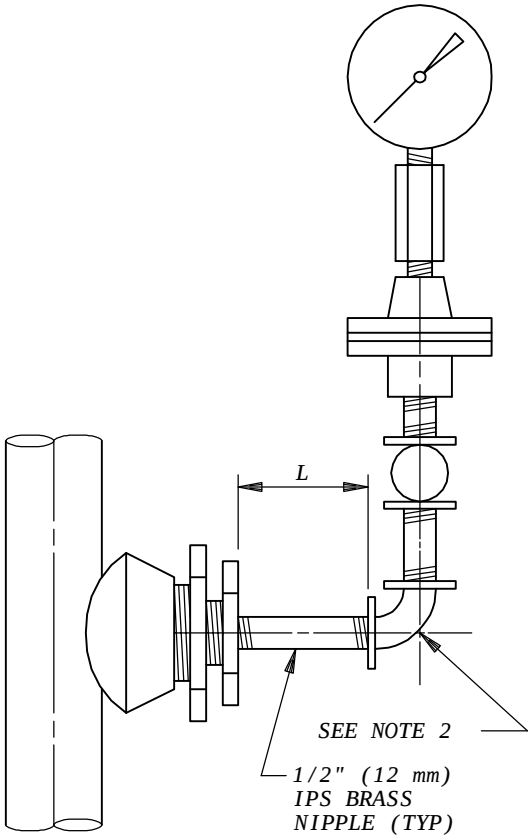
GAUGE INSTALLATION DETAILS

BLACK & VEATCH	STEEL PIPE 2 inch (50 mm) and smaller	FIG 1 - 407312



HORIZONTAL RUN

NO SCALE



VERTICAL RUN

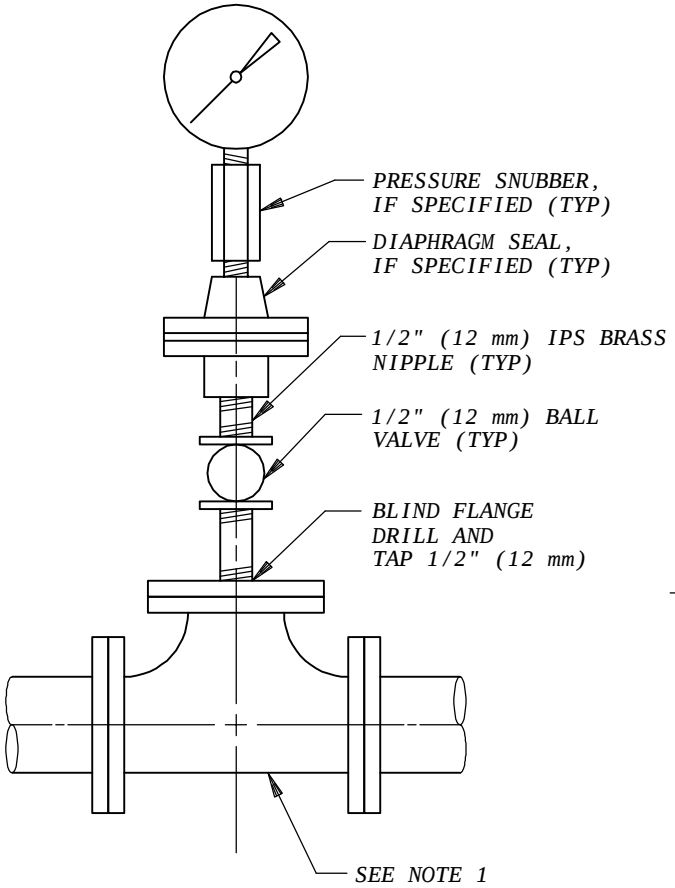
NO SCALE

NOTES:

1. WELDING FITTING SHALL BE BONNEY FORGE "THREDOLETS", PORTER "W-S TEELETS", OR VOGT "WELD COUPLETS".
2. ANSI B16.15, CLASS 125 BRONZE THREADED FITTING.
3. DIMENSION "L" SHALL BE SUFFICIENT TO PREVENT CONTACT BETWEEN THE GAUGE CASE, DIAPHRAGM SEAL HOUSING, OR VALVE OPERATING LEVER AND ADJACENT PIPING OR INSULATION BUT SHALL NOT EXCEED 4 INCHES (100 mm) UNLESS OTHERWISE PERMITTED BY THE ENGINEER.

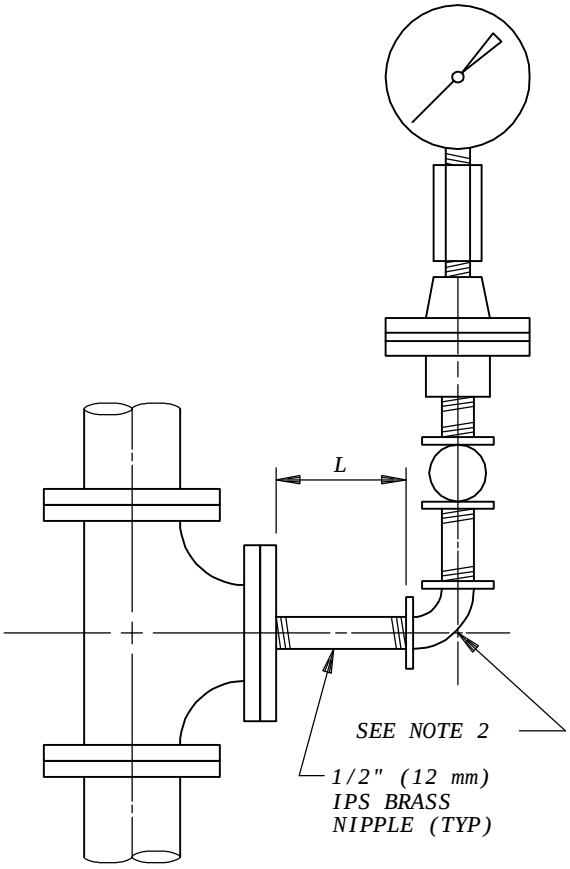
GAUGE INSTALLATION DETAILS

BLACK & VEATCH	STEEL PIPE 2-1/2 inch (62 mm) and larger	FIG 2-40 73 12



HORIZONTAL RUN

NO SCALE



VERTICAL RUN

NO SCALE

NOTES:

1. EXCEPT FOR GLASS LINED CAST IRON PIPE, A TAPPING SADDLE CONFORMING TO THE REQUIREMENTS OF THE CAST IRON PIPE SECTION MAY BE USED INSTEAD OF THE TEE INDICATED.

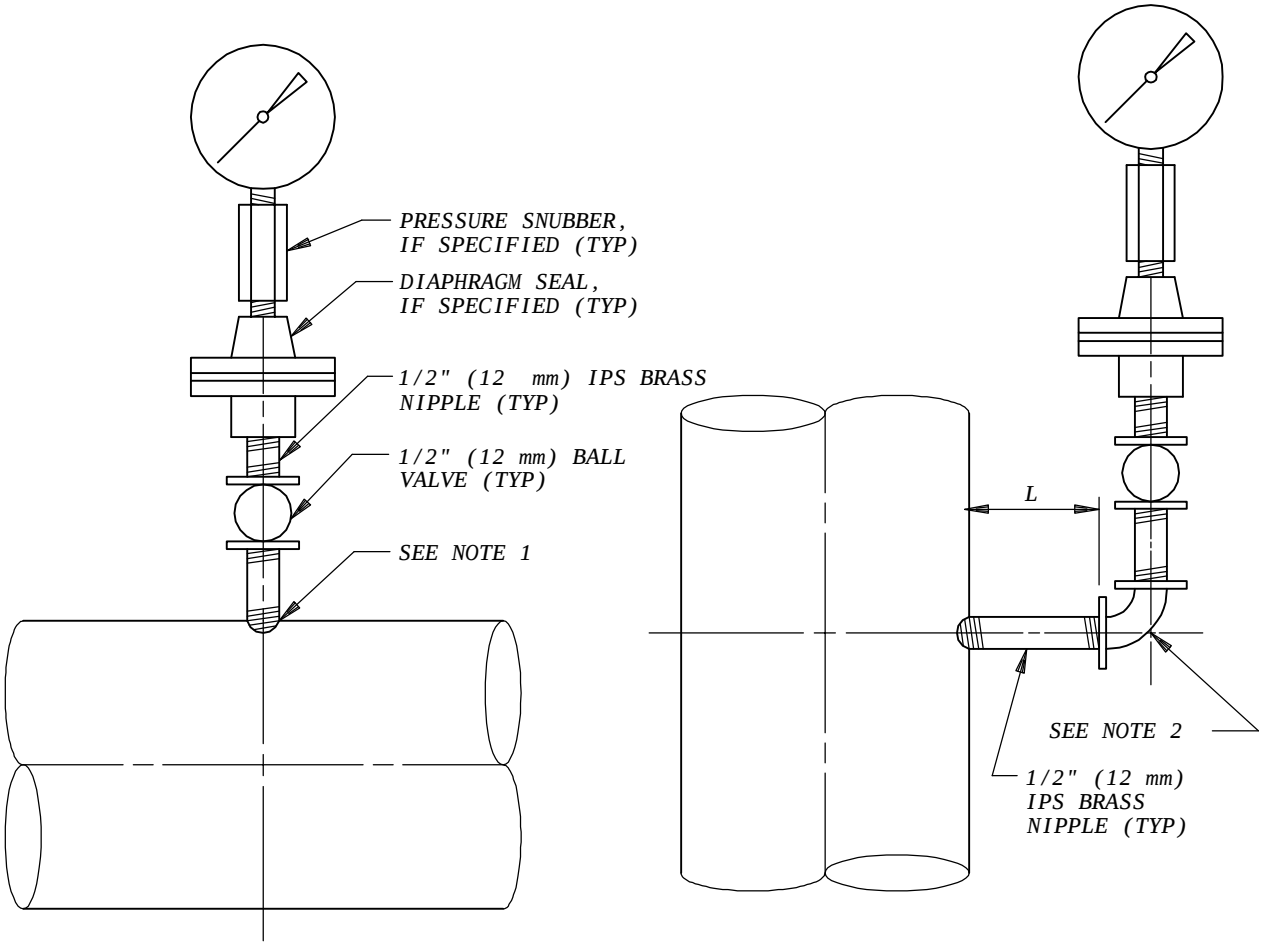
2. ANSI B16.15, CLASS 125 BRONZE THREADED FITTING.

3. WHEN AN IN-LINE FLOW-THROUGH DIAPHRAGM SEAL IS SPECIFIED IN THE GAUGE SCHEDULE, THE TEE OR TAPPING SADDLE AND THREAD-ATTACHED DIAPHRAGM SEAL INDICATED WILL NOT BE REQUIRED.

4. DIMENSION "L" SHALL BE SUFFICIENT TO PREVENT CONTACT BETWEEN THE GAUGE CASE, DIAPHRAGM SEAL HOUSING, OR VALVE OPERATING LEVER AND ADJACENT PIPING OR INSULATION BUT SHALL NOT EXCEED 4 INCHES (100 mm) UNLESS OTHERWISE PERMITTED BY THE ENGINEER.

GAUGE INSTALLATION DETAILS

BLACK & VEATCH	DUCTILE IRON PIPE 6 inch (150 mm) and smaller	FIG 3- 40 73 12



HORIZONTAL RUN

NO SCALE

VERTICAL RUN

NO SCALE

NOTES:

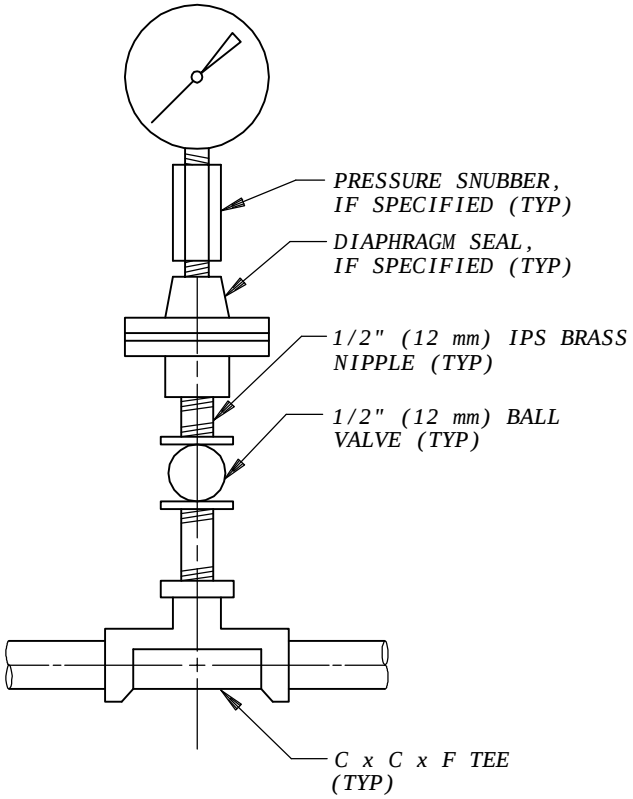
1. A TAPPING SADDLE CONFORMING TO THE REQUIREMENTS OF THE CAST IRON PIPE SECTION SHALL BE PROVIDED INSTEAD OF DIRECT TAPPING IF PIPE THICKNESS CLASS DOES NOT EQUAL OR EXCEED THE MINIMUM REQUIRED THICKNESS CLASS SPECIFIED.

2. ANSI B16.15, CLASS 125 BRONZE THREADED FITTING.

3. DIMENSION "L" SHALL BE SUFFICIENT TO PREVENT CONTACT BETWEEN THE GAUGE CASE, DIAPHRAGM SEAL HOUSING, OR VALVE OPERATING LEVER AND ADJACENT PIPING OR INSULATION BUT SHALL NOT EXCEED 4 INCHES (100 mm) UNLESS OTHERWISE PERMITTED BY THE ENGINEER.

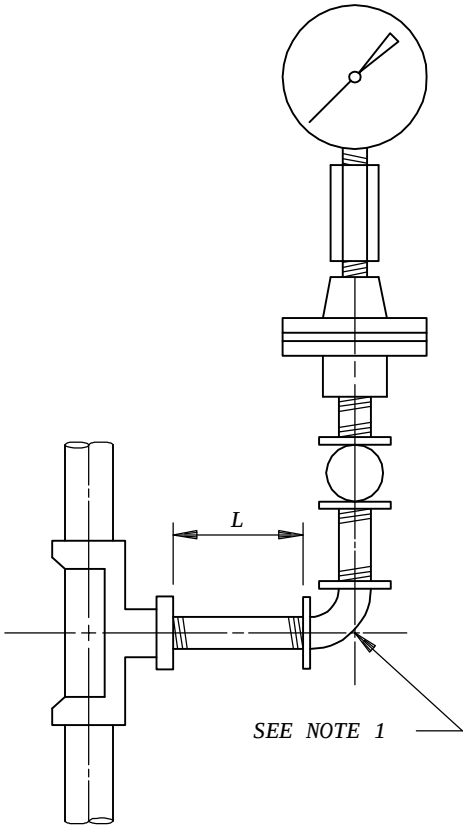
GAUGE INSTALLATION DETAILS

BLACK & VEATCH	DUCTILE IRON PIPE 8 inch (200 mm) and larger	FIG 4-40 73 12



HORIZONTAL RUN

NO SCALE



VERTICAL RUN

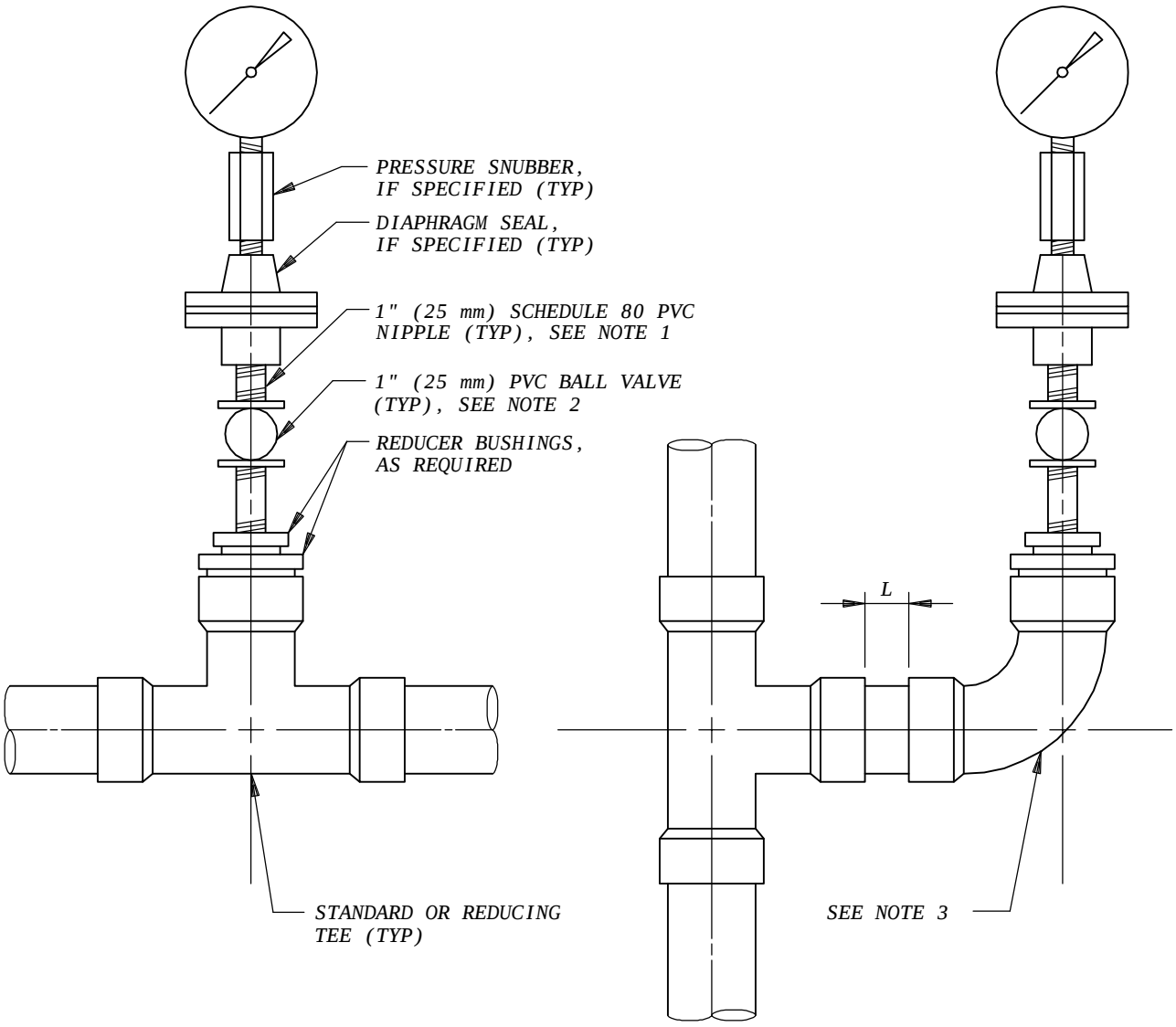
NO SCALE

NOTES:

1. ANSI B16.15, CLASS 125 BRONZE THREADED FITTING.
2. DIMENSION "L" SHALL BE SUFFICIENT TO PREVENT CONTACT BETWEEN THE GAUGE CASE, DIAPHRAGM SEAL HOUSING, OR VALVE OPERATING LEVER AND ADJACENT PIPING OR INSULATION BUT SHALL NOT EXCEED 4 INCHES (100 mm) UNLESS OTHERWISE PERMITTED BY THE ENGINEER.

GAUGE INSTALLATION DETAILS

BLACK & VEATCH	RIGID COPPER TUBING	FIG 5-40 73 12



HORIZONTAL RUN
NO SCALE

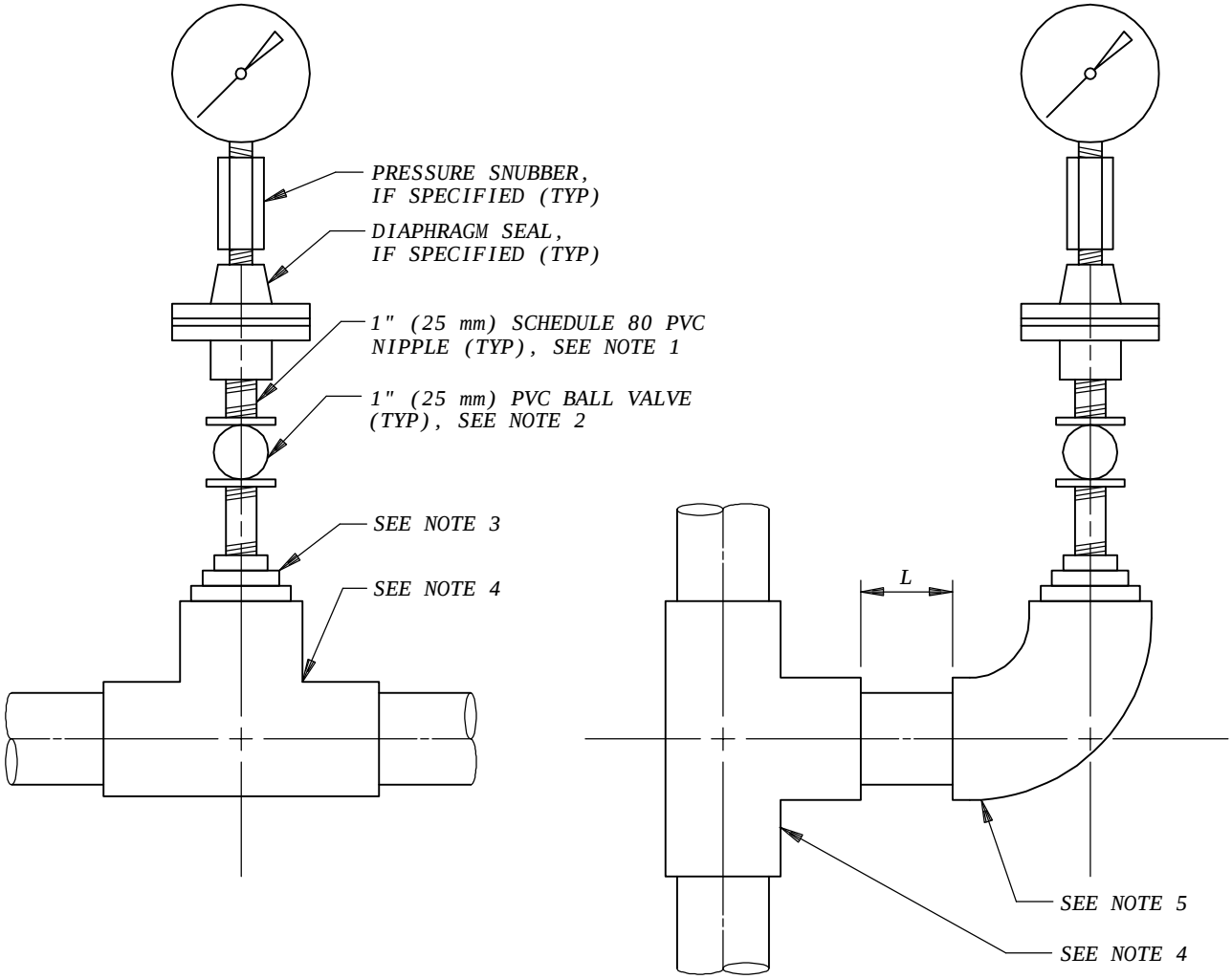
VERTICAL RUN
NO SCALE

NOTES:

1. PVC NIPPLES SHALL BE FACTORY FABRICATED AND SHALL NOT BE THREADED IN THE FIELD.
2. BALL VALVE SHALL BE DELETED FOR GAUGES INSTALLED IN CHEMICAL SERVICE LINES.
3. 90 DEGREE ELBOW, 1-1/2 INCH (37 mm) OR LARGER.
4. DIMENSION "L" SHALL BE SUFFICIENT TO PREVENT CONTACT BETWEEN THE GAUGE CASE, DIAPHRAGM SEAL HOUSING, OR VALVE OPERATING LEVER AND ADJACENT PIPING OR INSULATION BUT SHALL NOT EXCEED 4 INCHES (100 mm) UNLESS OTHERWISE PERMITTED BY THE ENGINEER.

GAUGE INSTALLATION DETAILS

BLACK & VEATCH	PVC PIPE	FIG 6-40 73 12



HORIZONTAL RUN
NO SCALE

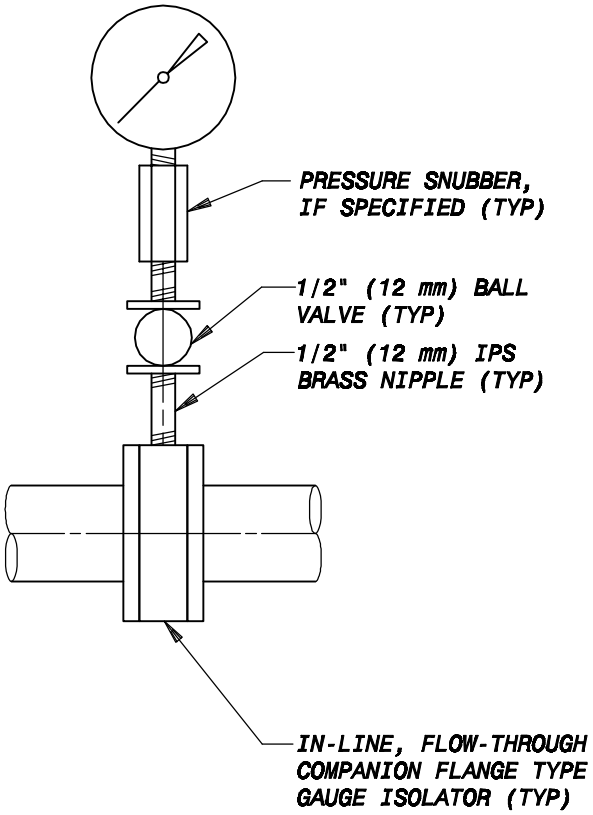
VERTICAL RUN
NO SCALE

NOTES:

1. PVC NIPPLES SHALL BE FACTORY FABRICATED AND SHALL NOT BE THREADED IN THE FIELD.
2. BALL VALVE SHALL BE DELETED FOR GAUGES INSTALLED IN CHEMICAL SERVICE LINES.
3. ADAPTER AND/OR REDUCER BUSHINGS COMPATIBLE WITH TEE AND GAUGE PIPING PROVIDED.
4. STANDARD OR REDUCER TEE.
5. STANDARD OR REDUCER ELBOW.
6. DIMENSION "L" SHALL BE SUFFICIENT TO PREVENT CONTACT BETWEEN THE GAUGE CASE, DIAPHRAGM SEAL HOUSING, OR VALVE OPERATING LEVER AND ADJACENT PIPING OR INSULATION BUT SHALL NOT EXCEED 4 INCHES (100 mm) UNLESS OTHERWISE PERMITTED BY THE ENGINEER.

GAUGE INSTALLATION DETAILS

BLACK & VEATCH	FRP PIPE 4 inch (100 mm) and smaller	FIG 7- 40 73 12



SEE NOTE BELOW

HORIZONTAL RUN
NO SCALE

VERTICAL RUN
NO SCALE

NOTE:
DO NOT INSTALL THIS TYPE OF GAUGE ISOLATOR IN VERTICAL PIPING.

GAUGE INSTALLATION DETAILS

BLACK & VEATCH	GAUGE ISOLATOR	FIG 10-40 73 12

Section 40 74 00

TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of all temperature instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the drawings or the Instrument Device Schedule.

When multiple temperature instruments of a particular type are indicated, and each requires different selectable features, the required features are described on the Drawings or in Instrument Device Schedule.

1-2. DESIGN CRITERIA. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by System Supplier.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Instrument Device Schedule.

1-3 SUBMITTALS. Submittals shall be made as specified in Instrumentation and Control System section.

1-4 SHIPMENT, PROTECTION, AND STORAGE. Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs provide minimum device stipulations. The Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. Interconnecting Cable. For systems where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of three meters or as indicated in the Instrument Device Schedule.

2-1.02. Programming Device. For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.03. Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under Microsoft's Windows 10 operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

2-2. TEMPERATURE INSTRUMENTS.

2-2.01. Resistance Temperature Detectors. Each temperature detector shall be a nominal 100 ohm, three or four wire, hermetically sealed, platinum resistance element. The sensing element shall be enclosed in an AISI Type 316 stainless steel outer sheath. Accuracy shall be ± 1°F over the specified operating range.

Each temperature detector shall be provided with a thermowell. Unless otherwise indicated in the Drawings or Instrument Device Schedule, thermowells shall be weld mount style. Thermowell materials shall be compatible with the process fluid. Where the process fluid is not defined, thermowells shall be AISI Type 316 stainless steel. The approximate process insertion length of the thermowell shall be as indicated on the Drawings or in the Instrument Device Schedule. The temperature element shall be spring-loaded in the thermowell. Appropriate temperature head hardware shall be provided with the assembly.

2-2.02. Resistance Temperature Transmitters. Each transmitter shall be an all solid state electronic two-wire device that does not require a direct power connection to the transmitter. The transmitter shall be designed for a resistance temperature detector input and shall have a 4-20 mA dc output.

The transmitter shall be of the sensor lead wire compensated type with linearized output to provide an accuracy of ± 0.2 percent of temperature span. The transmitter shall be housed in a weatherproof enclosure designed for mounting directly on or near the thermowell. Shielded lead wire shall be provided as needed between the transmitter and the temperature detector. Each transmitter shall be coordinated with the sensor and thermowell. Transmitters shall be manufactured by ABB, Siemens, Rosemount, Endress+Hauser, or equal.

Transmitters shall be factory calibrated to the required range and provided with the manufacturer's standard hand-held communications/calibration device. One device shall be furnished for all transmitters provided by a single manufacturer.

Transmitters tagged on the Drawings or specified to be the indicating type shall be furnished with LCD type digital indicators.

2-2.03. Temperature Switches. Temperature switches shall be ambient compensated, filled type, with integral sensor and thermowell. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual temperature. Switches shall be housed in EEMAC Type 4 enclosures. Switch wetted parts shall be compatible with the process fluid. Where the process fluid is not defined, the switch shall be provided with an AISI Type 316 stainless steel sensing element and an AISI Type 316 stainless steel thermowell.

All temperature switches shall be ranged in degrees Fahrenheit. Unless otherwise indicated, switches shall have a fixed deadband and shall be auto-reset type. As a minimum, switches shall be SPDT, rated 10 amp at 120 V ac.

Each switch shall be provided with a thermowell. Unless otherwise indicated in the Drawings or Instrument Device Schedule, thermowells shall be weld mount style. Thermowell materials shall be compatible with the process fluid. Where the process fluid is not defined, thermowells shall be AISI Type 316 stainless

steel. The approximate process insertion length of the thermowell shall be as indicated on the Drawings or in the Instrument Device Schedule.

Switches shall be installed at the locations indicated on the Drawings, with installation conforming to the installation standards. All switches shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation.

Each switch shall be provided with all required mounting hardware to securely mount the unit according to the mounting requirements indicated in the Drawings or Instrument Device Schedule.

Unless otherwise indicated, mounting and installation hardware shall be AISI Type 316L stainless steel.

Temperature switches shall be Ashcroft, Allen-Bradley, or equal.

2-2.04. Temperature Gauges. Temperature gauges shall be of the indicating dial type, with a stainless steel bimetal thermometer and a stainless steel thermowell; stainless steel rotary geared movement; phenolic or polypropylene open front turret case; adjustable pointer; stainless steel, phenolic, or polypropylene ring; and acrylic plastic or shatterproof glass window.

Gauge dial shall be minimum 4-1/2 inch size, with white background and black markings. The units of measurement shall be indicated on the dial face. Subdivisions of the scale shall conform to the requirements of the governing standard. Pointer travel shall be not less than 200 degrees or more than 270 degrees of arc.

Panel-mounted and surface-mounted gauges shall be provided with 1/4 inch NPT connections. All stem-mounted gauges shall be provided with 1/2 inch NPT connections. Where indicated on the Drawings or the Instrument Device Schedule, stem mounted gauges shall have an adjustable viewing angle to allow the gauge to be positioned for optimum viewing.

All temperature gauges shall measure in degrees Fahrenheit. All gauges shall have a suitable range to give mid-scale readings under normal conditions. Gauge accuracy shall be 1 percent of scale range.

Each gauge shall be provided with a thermowell. Unless otherwise indicated in the Drawings or Instrument Device Schedule, thermowells shall be weld mount style. Thermowell materials shall be compatible with the process fluid. Where the process fluid is not defined, thermowells shall be AISI Type 316 stainless steel.

Gauges shall be installed at the locations indicated on the Drawings, with installation conforming to the installation standards. All gauges shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at gauge locations prior to installation.

Each gauge shall be provided with all required mounting hardware to securely mount the unit according to the mounting requirements indicated on the Drawings or the Instrument Device Schedule.

Unless otherwise indicated, mounting and installation hardware shall be AISI Type 316L stainless steel.

Temperature gauges shall be Ashcroft “EL Series, Code 60”, or equal.

PART 3 - EXECUTION

3-1. FIELD SERVICES. Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

Section 40 75 00

PROCESS ANALYTICAL INSTRUMENTS

PART 1 - GENERAL.

1-1. SCOPE. This section covers the furnishing of all process analytical instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings or the Instrument Device Schedule.

1-2. DESIGN CRITERIA. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Design-Builder.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges on the Drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings or in the Instrument Device Schedule.

1-3. SUBMITTALS. Submittals shall be made as specified in the Instrumentation and Control System Section

1-4. SHIPMENT, PROTECTION, AND STORAGE. Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as described in as specified in the Instrumentation and Control System section.

1-4.01. Cleaning. Instruments indicated to be utilized in oxygen, ozone, or similar service shall be cleaned for oxygen service, labeled appropriately, and bagged or packaged as necessary to ensure the instrument will remain suitable for insertion in the process during installation. Any special mounting or installation requirements associated with such instruments shall be detailed on tags attached to the instrument.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs provide minimum device stipulations. The Drawings and/or Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. Interconnecting Cable. For instruments where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of three meters or as indicated in the Drawings.

2-1.02. Programming Device. For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.03. Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under Microsoft's Windows 10 operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

2-2. PROCESS LIQUID ANALYTICAL INSTRUMENTATION.

2-2.01. Low Range Turbidity Analyzers. Analyzers shall operate with a continuous flow of sample through the sample cell to drain. A Class 1 650 nm laser light source shall be passed through the sample and the amount of light scattered by the turbidity particles shall be measured. The analyzer shall utilize an US EPA approved method of turbidity analysis.

Sample flow rate shall be approximately 0.2 gpm. The sample cell shall be constructed of all corrosion-resistant materials and shall have an integral bubble trap. Accessories shall be provided to allow for a field calibration check of the analyzer. The secondary calibration standard shall be an optical glass calibration cube that has a known NTU value. One secondary calibration device shall be provided for each four analyzers. A one-year supply of consumables, including a primary standard formazin calibration kit, shall be provided with each analyzer.

The analyzer shall have a master indicator mounted near the sample cell and connected to the sample cell with a special cable. The unit shall have an auto-ranging three or four-digit display that indicates turbidity within a range of 0.001 to 100 nephelometric turbidity units (NTU). The analyzer accuracy shall be a maximum of 2% of NTU reading. The analyzer repeatability shall be a maximum of 1% of NTU reading. The master indicator shall be housed in a NEMA Type 12 moisture-resistant enclosure and shall be of the ac-powered type.

The master indicator shall have a linear 4-20 mA dc output signal that corresponds to a pre-selected turbidity range (typically 0 to 1 NTU). Each turbidity sensor shall be provided with an automatic cleaning module.

Turbidity analyzers shall be Hach Company TU5300 with SC200 Controller or equal.

2-2.02. Surface Scatter Turbidity Analyzers. Analyzers shall operate with a continuous sample flow of approximately 0.3 gpm [0.01 L/s] through the analyzer to drain. The analyzer shall utilize a light beam that is focused on the liquid surface of the sample at an acute angle. The suspended particles in the sample will scatter the light, and a photocell mounted above the liquid surface shall detect the reflected light. The light and photocell sensor shall not come in contact with the sample liquid. The analyzer shall have an auto-ranging four-digit display that can indicate from 0.01 to 9999 NTU. The analyzer accuracy shall be a maximum of 2% of NTU reading. The analyzer repeatability shall be a maximum of 1% of NTU reading. The analyzer shall be housed in a NEMA Type 4X enclosure and shall be suitable for operation in an ambient temperature range of 0 to 40°C. The analyzer shall be of the ac powered type.

The analyzer shall have an essentially linear 4-20 mA dc output signal that corresponds to a pre-selected turbidity range.

Alarm points shall be conveniently set on the front of the analyzer. Alarm conditions shall be locally indicated on the face of the analyzer unit.

The turbidity analyzer shall be Hach Chemical Company "Surface Scatter 7" with SC200 Controller or equal.

A bubble trap shall be provided on the sample inlet line to the analyzer. The bubble trap shall be of corrosion-resistant PVC construction and shall be specifically designed for use with the above analyzer.

2-2.03. pH and ORP Analyzers. The pH or ORP sensor and analyzer/transmitter shall be products of the same manufacturer. The cable between the sensor and the transmitter shall be provided by the manufacturer. The sensor shall consist of a kynar, PVC, polypropylene, or other chemical-resistant electrode housing containing a glass pH electrode and a fouling-resistant reference electrode, or gold/platinum ORP electrodes. The pH reference electrode shall be self-contained and shall not require an external electrolyte reservoir. The sensor shall have automatic temperature compensation, and shall be the flow-through type unless indicated on the Drawings or in the Instrument Device Schedule to be submersion type.

Flow-through type sensors, shall have 3/4 or 1 inch NPT process connections and shall be suitable for a working pressure of 1 to 100 psig at 140°F [60°C], with a sample flow rate of 0.5 gpm [0.03 L/s].

Submersion type sensors, shall be suitable for submersion in 30 feet of water at temperatures of 32 to 140°F [0 to 60°C]. A protection shroud shall be provided to protect the electrode. The cable and cable entrance to the sensor shall be suitable for submersible applications.

Each pH sensor assembly shall be provided with a maintenance kit that shall include a spare pH electrode, a spare reference electrode, and other spare parts as recommended by the manufacturer.

The transmitter shall be enclosed in a cast aluminum or fiberglass reinforced plastic NEMA Type 4 housing. The transmitter shall be microprocessor based, with integral diagnostics, and with non-volatile memory. The transmitter shall be suitable for ambient temperatures of -30 to +60°C and a relative humidity of 0 to 100 percent. The transmitter shall have an isolated 4-20 mA dc output linearly proportional to the measured range, with an accuracy of ± 0.5 percent of reading. The analyzer repeatability shall be a maximum of 0.2% of reading. The transmitter shall have a 32 character alphanumeric multiline LCD display that is menu driven. Transmitter range shall be as indicated. The transmitter shall have automatic temperature compensation over a range of 0 to 50°C. The transmitter

shall be of the ac-powered type. The transmitter shall be supplied with an appropriate length of signal cable for connecting the transmitter to the sensor.

The pH analyzer shall be manufactured by Hach Chemical Company or equal.

2-2.04. Dissolved Oxygen Analyzers. An optical type dissolve oxygen analyzer shall be provided. The principle of operation shall be based on the time measured from excitation of a luminescent material by a light source to the time light is emitted by the material. The luminescent material shall be mounted to an oxygen permeable replaceable cap fitted over the end of the probe. The probe shall be submersible and supplied with 30 ft of cable or a length of cable as otherwise indicate in the Instrument Device Schedule. The probe shall be provided with an automatic air blast cleaning system, complete with all required accessories and a compressor system contained in NEMA 4X enclosure. The compressor motor shall be 120 volt, single phase.

The transmitter shall be enclosed in a NEMA Type 4X enclosure with mounting brackets for surface or pipe mounting. The transmitter shall be of the ac-powered type. The transmitter shall have a local LCD display calibrated to read 0 to 20 ppm [mg/L], and shall have a corresponding 4-20 mA dc output signal capable of driving a 0 to 600 ohm external load. The transmitter and probe shall be furnished with all mounting hardware. The probe shall be the Hach Chemical Company LDO Model 2 probe with SC200 controller.

A membrane type analyzer shall be provided, having a galvanic or polarographic type (Ross or Clark principle) dissolved oxygen sensor. The sensor shall include a field replaceable cartridge assembly with pre-installed membrane, electrolyte, and electrodes that is disposable. The electrode chamber shall be isolated from the process by an oxygen-permeable (liquid-impermeable) membrane. A one-year supply of replacement membranes and electrolyte shall be provided. The sensor probe assembly shall be immersion type, with integral automatic temperature compensation over a range of 0 to 122°F. The sensor shall be insensitive to varying hydraulic heads up to a depth of 100 ft. The sensor shall be provided with an automatic air blast cleaning system, with compressor system contained in NEMA 4X enclosure. The compressor motor shall be 120 volt, single phase.

The dissolved oxygen transmitter shall be of the microprocessor type, with non-volatile memory, and built in diagnostics. The transmitter shall display the reading on an integral indicator and shall transmit an isolated 4-20 mA dc signal proportional to the amount of dissolved oxygen. The transmitter shall be of the ac-powered type. The transmitter shall be housed in a NEMA Type 4X enclosure and shall be suitable for surface or pipe mounting. The ambient temperature rating shall be -4°F [-20°C] to 140°F [60°C], with integral heater.

The dissolved oxygen analyzer shall be manufactured by Hach Chemical Company or equal.

2-2.05. Streaming Current Analyzers. Not used.Streaming

2-2.06. Suspended Solids Analyzers. Analyzers shall utilize a light beam that is focused on the liquid surface of the sample at an acute angle. The suspended particles in the sample will scatter the light and a photocell mounted above the liquid surface shall detect the reflected light. The light and photocell sensor shall not come in direct contact with the sample liquid. The analyzer shall have an auto-ranging display that indicates from 0.01 to 50,000 mg/l. The analyzer transmitter shall be housed in a NEMA Type 12 enclosure and shall be suitable for operation in an ambient temperature range of 0 to 104°F [40°C]. The analyzer transmitter shall be of the ac-powered type.

The analyzer shall have an essentially linear 4-20 mA dc output signal that corresponds to a pre-selected suspended solids range. The analyzer shall have adjustable high and low alarm contacts rated 24 V dc. Alarm points shall be conveniently set from the front of the analyzer. Alarm conditions shall be locally indicated on the face of the analyzer unit.

The suspended solids analyzer shall be Hach Chemical Company SOLITAX with sc200 controller or equal.

2-2.07. Particle Counters. Not used.

2-2.08. Chlorine Residual Analyzers. Chlorine residual analyzers shall be the amperometric, colorimetric, or gas stripping type and shall be provided with all required appurtenances shall be provided. For each type of analyzer supplied, a chlorine analyzer cleaning kit shall be provided. A one year supply of all consumables shall be provided along with the cleaning kit. Chlorine analyzers shall measure the total or free chlorine residual in a continuous flow sample as indicated on the Drawings or in the Instrument Device Schedule.

2-2.08.01. Sample Conditioning Panel. A sample conditioning panel shall be furnished and installed upstream of each chlorine residual analyzer as indicated on the Drawings.

Each sample conditioning panel shall be provided with an enclosure with a mini programmable logic controller (PLC) or timer for automatic sequential solenoid valve control. The PLC program or timer shall open the two-way solenoid flush valve for an adjustable time (5 minutes initially) to provide a high volume flow rate through the strainer. After an adjustable time duration (3.5 minutes initially) during the high volume flow rate, the three-way solenoid valve shall be energized for an adjustable time duration (1.5 minutes initially) to flush the analyzer sample control needle valve. When the flush valve and needle valve timers have

expired, both solenoid flush valves shall close and return the analyzer sampling to normal.

Each strainer shall be transparent PVC bodied Y-pattern with 30-mesh screen, Viton O-ring seals, and socket ends. The blowoff from the strainer shall be equipped with the minimum 1/4" inch threaded connection and ball valve for bypassing excess sample flow to drain and for adjusting the pressure in the sample flow to the analyzer. The strainer shall be an Asahi/America Sediment Strainer or approved equal.

Solenoid valves type and construction shall be as follows:

Service	Water
Type	2-Way and 3-Way, pilot operated
Body/Bonnet	Brass or bronze
Trim	
Seals	Buna-N or Teflon
Disc	Buna-N or Teflon
Stem	Manufacturer's standard
Bonnet Gasket	Manufacturer's standard
Spring	Manufacturer's standard
End Connection	Threaded
Temp. Limitations	32 to 104°F
Valve Operator	Integral
Manufacturers	ASCO "8210 Series" 2-Way and "8300 Series" 3-Way

Solenoid valves shall have packless construction without packing box or sliding seal.

Solenoid coils for ac service shall be encapsulated, Class F, for continuous duty at rated voltage ± 10 percent and 40°C ambient, in a NEMA Type 4 enclosure with a conduit knockout.

2-2.08.02. Amperometric Chlorine Residual Analyzers and Titrator. Amperometric chlorine residual analyzers shall be furnished to measure the total or free chlorine residual in a continuous flow sample.

The analyzers shall be of the amperometric or amperometric/polarographic type, with automatic sample temperature compensator, sample flow control, and self-

cleaning electrode assembly for operation over an adjustable range between 0 to 50 or 0 to 20 mg/L of chlorine. Each analyzer shall consist of three electrodes which will generate electric current and constant potential for accurate readings.

Each analyzer shall operate with the following conditions:

Chlorine range, mg/L of chlorine	0 to 50 or 0 to 20
Analyzer accuracy	Residual levels below 20 mg/L: ±2% of reading or 0.001 mg/L of chlorine, whichever is greater
	Residual levels below 60 mg/L: ±5% of reading or 0.002 mg/L of chlorine, whichever is greater
Analyzer repeatability	0.2% of reading
Minimum required detection limit, mg/L chlorine	0.001
Sample water flow	Capital Controls: 2.4 gph
	Wallace & Tiernan: 1-2 gpm (potable); 3 to 5 gpm (wastewater)
Sample water pressure, psi	Capital Controls: 5 to 10 Wallace & Tiernan: 0 to 5

Each analyzer shall be furnished with the following accessories:

Sample filter.

Integral indicator calibrated 0 to 50 mg/L of chlorine.

A 1 year supply of chemicals and expendable materials.

Drain and overflow hose to bell-up.

Each analyzer instrument shall include a transmitter having a minimum of one 4-20 mA dc signal output. The analyzer shall be equipped with a minimum of three programmable relays to signal alarms. The analyzer shall operate using a 120 VAC, 60 Hz, single phase power supply.

The analyzer and electronics shall be installed in a wall panel for mounting. The electronics shall be enclosed in a NEMA 4X cabinet for protection. The analyzer dimensions shall not exceed 19 inches tall by 22 inches wide by 11 inches deep.

One amperometric titrator for measuring total or free residual shall be furnished for calibration of the chlorine residual analyzers. The titrator shall be complete with sample container, titrator solution bottle, pipettes, instruction book,

chemicals, and other items required for proper operation. The titrator shall operate using a 120 volt, 60 Hz, single phase power supply.

The analyzer shall be De Nora Water Technologies/Capital Controls “Series CL1000”, ATI Model “Q46H/79PR”, or Evoqua Water Technologies/Wallace & Tiernan “Micro/2000”. The titrator shall be De Nora Water Technologies/Capital Controls “Series 17T2000” or Evoqua Water Technologies/Wallace & Tiernan “Series A-790”, or equal.

2-2.08.03. Colorimetric Chlorine Residual Analyzers. Colorimetric chlorine residual analyzers shall be furnished to measure the total or free chlorine residual in a continuous flow sample.

The analyzers shall be of the colorimeterc type for operation over a range of 0 to 5 mg/L of chlorine. The assembly shall consist of a sample chamber where the sample and reagents shall be thoroughly mixed with a self-cleaning stir bar. Each analyzer shall use reagents to color the sample. Light shall then be passed though the sample and a detector will measure its intensity to obtain a residual reading. Each analyzer shall be factory calibrated for accurate measurements.

Each analyzer shall operate with the following conditions:

Chlorine range, mg/L of chlorine	0 to 5
Analyzer accuracy	±5% of reading or 0.035 mg/L of chlorine, whichever is greater
Analyzer repeatability	0.2% of reading
Minimum required detection limit, mg/L chlorine	0.035
Sample water flow, gph	3.1 to 8.0
Sample water pressure, psig	1 to 5

Each analyzer shall complete a sample analysis every 2 minutes and 30 seconds. The use of chemical indicator and buffer shall not exceed 475 milliliters each over 30 days.

Each analyzer shall be furnished with the following accessories:

Sample conditioning kit.

Instrument factory calibrated 0 to 5 mg/L chlorine.

A 30 day supply of chemicals and expendable materials.

Drain and overflow hose to bell-up.

Each sample conditioning kit shall be installed upstream of the analyzer and shall be able to accommodate pressures up to 70 psi. Each kit shall include the required valves, filter, fittings, and tubing required for proper analyzer operating conditions.

Each analyzer instrument shall include a transmitter having a programmable 4-20 mA dc signal output. The analyzer shall be equipped with two selectable alarms. The choices of alarms shall include high/low sample concentration, analyzer system warning to indicate a not-critical instrument malfunction, and analyzer system alarm to sound during analyzer failure. The analyzer shall operate using a 115 VAC, 60 Hz power supply.

The analyzer shall be installed in an enclosure for wall mounting. The analyzer dimensions shall not exceed 17 inches tall by 13 inches wide by 7 inches deep.

One colorimetric verification kit for measuring total or free residual shall be furnished for calibration of the chlorine residual analyzers. The verification kit shall be complete with 3 – way valve, bottle cap, pressurization apparatus, calibration standards set, instruction book, chemicals, and other items required for proper operation.

The analyzer shall be Hach “CL17 Chlorine Analyzer” or equal. The verification kit shall be Hach “CL17 CAL/Verification Kit”.

2-2.08.04. Gas Stripped Chlorine Residual Analyzers. Gas stripping chlorine residual analyzers shall be furnished to measure the total or free chlorine residual in a continuous flow sample.

The analyzers shall be of the gas stripping type for operation over a range of 0 to 2 or 0 to 20 ppm of chlorine. The assembly shall use peristaltic pumps to mix the sample, buffer reagents, and potassium iodide reagent. The mixture shall then enter the stripping chamber where it will mix with air from the internal air diaphragm pump. The air/iodine shall proceed to the sensing chamber where the membrane iodine sensor shall measure the iodine concentration and determine the chlorine residual.

Each peristaltic pump shall have quick-load pump heads for simple tube changing procedures. Tubes shall be constructed of materials compatible to the pumped chemical and shall be sized as recommended by the manufacturer. The airflow diaphragm pump shall be internal to the analyzer. A precision metering valve shall control the flow rate and an internal rotameter shall be used for flow indication. The airflow diaphragm pump, precision metering valve, and rotameter shall be properly sized for the analyzer as recommended by the manufacturer.

Each analyzer shall operate with the following conditions:

Chlorine range, mg/L of chlorine	0 to 2 or 0 to 20
Analyzer accuracy	±0.5% of reading or ±0.02 ppm of chlorine
Analyzer repeatability	0.2% of reading
Minimum detection limit, ppm chlorine	0.003
Sample water flow, gph	10 to 20
Sample water pressure, psig	Nominal 1 PSIG

Each analyzer shall complete a sample analysis every 30 seconds.

Each analyzer shall be furnished with the following accessories:

Integral indicator calibrated 0 to 2 or 0 to 20 ppm.

A 1 year supply of chemicals and expendable materials.

Drain and overflow hose to bell-up.

Each analyzer instrument shall include a programmable 4-20 mA dc analog output signal. The analyzer shall be equipped with two alarms. The analyzer shall operate using a 120 VAC, 60 Hz power supply.

The analyzer shall be installed in an enclosure for wall or panel mounting. The analyzer dimensions shall not exceed 33 inches tall by 18 inches wide.

One amperometric titrator for measuring total or free residual shall be furnished for calibration of the chlorine residual analyzers. The titrator shall be complete with sample container, titating solution bottle, pipettes, instruction book, chemicals, and other items required for proper operation. The titrator shall operate using a 120 volt, 60 Hz, single phase power supply.

The analyzer shall be Analytical Technology, Inc. (ATI) “Model A15/79”. The titrator shall be Capital Controls “Series 17T2000” or Wallace & Tiernan “Series A-790” or equal.

2-2.09. Dissolved Ozone Analyzers. Not used.

2-2.10. Nuclear Sludge Density Meters. Not used.

2-2.11. Conductivity Analyzers – Electrode Type. The conductivity sensor and analyzer/transmitter shall be products of the same manufacturer. The cable between the sensor and the transmitter shall be provided by the manufacturer. The sensor electrodes shall be titanium or 316 SST. The sensor shall have automatic temperature compensation.

Submersion type sensors, shall be suitable for submersion in 30 feet of water at temperatures 32 to 140ºF. A protection shroud shall be provided to protect the electrode. The cable and cable entrance to the sensor shall be suitable for submersible applications.

Each conductivity sensor assembly shall be provided with a maintenance kit that shall include a spare conductivity electrode and other spare parts as recommended by the manufacturer. Accessories shall be provided to allow for a field calibration check of the analyzer.

The transmitter shall be enclosed in a cast aluminum or fiberglass reinforced plastic NEMA Type 4 housing. The transmitter shall be microprocessor based, with integral diagnostics, and with non-volatile memory. The transmitter shall be suitable for ambient temperatures of -22 to +140°F and a relative humidity of 0 to 100 percent. The transmitter shall have an isolated 4-20 mA dc output linearly proportional to the measured range, with an accuracy of ± 3 percent of reading. Repeatability shall be 0.2% of reading. The transmitter shall have a multiline LCD display that is menu driven. Transmitter range shall be as indicated. The transmitter shall be of the dc-powered type. The transmitter shall be supplied with an appropriate length of signal cable for connecting the transmitter to the sensor.

The conductivity analyzer shall be manufactured by Rosemount or equal.

2-2.12. Conductivity Analyzers – Electrodeless Type. The instrument shall measure conductivity of the process by use of an inductive principle of measurement and employ a toroidal (electrodeless) conductivity sensor.

The toroidal conductivity sensor shall consist of a large bore sensor encapsulated in PEEK, polypropylene, PVDF, or Teflon suitable for applications containing high levels of suspended solids. The sensor shall be suitable for insertion or submersion service. The sensor shall measure conductivity from 50 μS/cm to at least 1000 mS/cm. The sensor shall have a threaded process connection suitable for end-of-pipe or flange mounting and it shall be furnished with an integral cable of sufficient length to provide an un-spliced connection to the analyzer. The sensor shall have an embedded RTD to sense process temperature for use by the analyzer.

The conductivity sensor shall be Hach “ 3700 Series” or equal.

The analyzer shall be of the same manufacturer as the sensor and it shall measure over the full range of the conductivity sensor furnished. The analyzer shall be housed in a NEMA Type 4X (IP65), flame-retardant enclosure suitable for panel, pipe, or wall mounting. All analyzer functions shall be accessible through a front panel membrane keyboard. Settings may be protected against

accidental or unauthorized changes by a user selectable security code. The analyzer display shall indicate the measured conductivity and process temperature values in engineering units and it shall indicate fault conditions. Engineering units shall be selectable between mS/cm and solution percent concentration for conductivity and between degrees Fahrenheit and degrees Celsius for temperature. Displayed accuracy shall be ±3 percent of reading for conductivity. Repeatability shall be 0.2% of reading for conductivity.

The transmitter shall have an isolated 4-20 mA dc output linearly proportional to the measured range, with an accuracy of ± 0.5 percent of scale.

2-2.13. Total Organic Carbon Analyzers. The analyzer shall be a continuous monitoring system consisting of a flow through sensor and analyzer/transmitter designed to continuously measure the total organic carbon (TOC) of liquids and produce an output signal linearly proportional to the TOC. The measurement principle shall comply with Standard Methods 5310 C and US EPA 415.1, or US EPA 415.3.

The TOC analyzer shall have a range of 0 to 25 mg/L, accuracy ±2.0 percent of full scale, repeatability of ±2.0 percent of reading. Response time shall be between 4-8 minutes. Sample pressure maximum is 87 psig with a flow rate between 50-200 mL/min. The maximum sample temperature is 158ºF with a normal operating temperature of 50-104ºF.

TOC concentrations in the RO feed and RO permeate are the following:

RO Feed TOC: 7 – 15 mg/L

RO Permeate TOC <0.07 – 0.5 mg/L

For systems utilizing US EPA method 415.3, an inorganic carbon remover (ICR) shall be provided to reduce inorganic carbon levels.

The analyzer housing shall be a NEMA 4 enclosure equipped with stainless steel hardware for surface mounting. Connections shall be 1/4-inch flexible PVC tubing. The transmitter shall be provided with a multiline LCD display capable of indicating the sample TOC. Controls shall be provided on the front of the panel with menu-driven display for user-entered parameters and calibration. A minimum of one 4-20 mAdc output and two digital outputs shall be provided. The transmitter shall have a minimum of one alarm output. The analyzer shall be powered by 120 VAC, 60 Hz, single phase.

The analyzer shall be provided with a one year supply of all consumable products required to operate.

The analyzer shall be Hach BioTector B7000i or equal.

2-3. PROCESS GAS ANALYTICAL INSTRUMENTATION.

2-3.01. Gas Detector Systems. Gas detector systems shall be furnished complete with sensors, power supplies, alarm modules, enclosures, and appurtenant devices suitable for detecting gases as indicated on the Drawings or as listed in this section. Detector systems shall be located as indicated on the Drawings.

Gases to be detected and associated detector sensor ranges and nominal alarm setpoints shall be as follows:

Gas	Nominal Range	Nominal "Warning" and "Alarm" Values
Combustible Gas (methane)	0-100 percent LEL	10 percent/ 50 percent LEL
Hydrogen Sulfide (H_2S)	0-10 ppm or 0-50 ppm	0.5 ppm/1 ppm
Oxygen Deficiency (O_2)	0-10 percent or 0-25 percent	19.5/ percent 17 percent

Accuracy of each gas detector system shall be 2 percent of full scale, and zero drift shall not exceed 5 percent per year. Gas detector systems shall be suitable for an operating temperature range of 0 to 122°F [50°C].

Gas detector systems shall be MSA Ultima X Series, Scott Safety Freedom 5000 Series, Sierra Monitor Corporation, or equal.

2-3.01.01. Sensors. Sensors shall be of the remote mounted diffusion cell type contained in corrosion resistant weatherproof housings. Sensors shall be rated either intrinsically safe or explosion proof, and shall be suitable for the environment in which they will be located. Sensors shall not require any addition of chemical reagents and shall require no routine maintenance other than calibration checks. Combustible gas sensors shall not be adversely affected by exposure to hydrogen sulfide gases. Minimum sensor life shall be 1 year. A sufficient length of cable shall be provided for connecting the sensor to the alarm module enclosure. The transmitter shall be provided with a serial output for instrument diagnostics and process monitoring.

2-3.01.02. Receiver-Alarm Modules. Each gas detector system shall be provided with a receiver-alarm module for each sensor. The receiver-alarm modules shall be housed in weatherproof NEMA 4X enclosures suitable for an operating temperature of -4°F [-20°C] to 122°F [50°C], with a relative humidity of 5 to 95 percent. Each alarm module shall have a separate, three-digit LED or

LCD readout with units of the corresponding sensor engraved on the module face or included on the LCD readout. Each module shall have two independently adjustable alarm points, one labeled "warning" and one labeled "alarm". Each alarm point, plus a module fail alarm point shall actuate separate relays with single-pole, double-throw contacts, rated 3 amps [A] at 120 V ac, and shall illuminate three alarm lights on the module face. Modules shall be of the ac-powered type and shall be designed with failsafe circuitry, so the alarm contacts fail in the alarm condition upon power or sensor failure. Each alarm module shall actuate a local alarm horn or buzzer at the unit, which can be silenced with a button on the unit. Each alarm module shall have an isolated 4-20 mA dc output signal representing the calibrated range of the detector system and capable of driving an external 250 ohm load.

Additional relays shall be provided in the module enclosure as needed to provide additional contacts indicated on the electrical schematic Drawings.

2-3.01.03. Gas Detector Calibration Kit. A calibration kit shall be provided for use in field calibration of each gas detector. The calibration kit shall contain all necessary fittings, calibration gases, and hoses required for not less than 12 field calibration checks of each gas detector, after final acceptance of the system.

2-3.01.04. Spare Sensors. One spare sensor shall be provided for each sensor in the gas detector system. Spare sensors shall be provided in addition to any replacement sensors required during the warranty period, even if the warranty period exceeds the normal expected life of the sensor. Delivery schedule for the spare sensors shall be as recommended by the manufacturer and as coordinated with Owner.

2-3.02. Low Concentration Ozone Analyzers. Not used.

2-3.03. High Concentration Ozone Analyzers. Not used.

2-3.04. Oxygen Purity Analyzers. Not used.

2-3.05. Dewpoint Analyzers. Not used.

2-3.06. Hydrocarbon Analyzers. Not used.

PART 3 - EXECUTION

3-1. FIELD SERVICES. Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

Section 40 78 00

PANEL MOUNTED INSTRUMENTS

PART 1 - GENERAL.

1-1. SCOPE. The Panel Mounted Instruments section covers the furnishing of all panel mounted instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings or the Instrument Device Schedule.

1-2. DESIGN CRITERIA. The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated on the Drawings or in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. For "smart" devices, calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings and/or Instrument Device Schedule.

1-3. SUBMITTALS. Submittals shall be as specified in the Instrumentation and Control System section.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs describe minimum device stipulations. The Drawings or Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01 Programming Device. For systems that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). The programming device shall include appropriate operation manuals and shall be included in the training stipulations. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.02 Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a laptop computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under the Windows 10 operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device need not be furnished.

2-2. PANEL FRONT MOUNTED DEVICES.

2-2.01. Annunciators. Not used.

2-2.02. Totalizers. Not used.

2-2.03. Digital Panel Indicators. Digital indicators shall be designed for semi-flush mounting in a panel. The indicator shall be a 3-1/2 digit LED, LCD, or gas discharge type display, with digits at least 0.5 inch high. The indicator shall be easily read at a distance of 10 feet [3 m] in varying control room lighting environments. Operating temperature range shall be 32°F [0°C] to 140°F [60°C]. Accuracy shall be ±0.1 percent. The indicator shall be scaled in engineering units, with the units engraved on the display face or on the associated nameplate. The indicator shall have a selectable decimal point and shall provide over-range indication. Digital indicators shall be manufactured by Schneider Electric/Eurotherm/Action Instruments, Omega Engineering, Inc./Newport Electronics, Precision Digital Corporation, or Red Lion Controls.

2-2.04. Electronic Bar Graph Indicators. Indicators shall be of the single vertical bar graph type, with all solid-state electronic circuitry and no moving parts. The bar graph shall consist of a dot matrix, gas-discharge, or LED bar type display in combination with a digital display. Average display life shall be at least 10 years. Display length shall be 4 inches. The indicator shall have an electrical zero adjustment. Accuracy shall be ±1 percent of span. Scales shall be as indicated on the Drawings or the Instrument Device Schedule. The use of a dual display

indicator for displaying two related signals will be considered. However, Design-Builder reserves the right to require individual indicators where determined to be appropriate. Indicators shall have isolated, non-grounded inputs. If input is grounded, a signal isolator shall be provided between the meter and the rest of the signal. Bar graph indicators shall be OTEK Corporation or Weschler Instruments.

2-2.05. Edgewise Panel Indicators. Edgewise indicators, designed for panel mounting, shall have nominal 2 x 6 inch [50 x 150 mm] face dimensions. Indicators shall have nominal 4.5 inch [114 mm] scale length, and the indicator accuracy shall be ±2 percent of full scale. Major scale divisions shall be equally spaced and shall be in whole integers. Scale ranges shall be as indicated on the Drawings or the Instrument Device Schedule. Scale units (ft, mgd, etc.) shall be engraved on the scale face or on the indicator nameplate. The indicators shall be Weschler Instruments "Type 252 or equal."

2-2.06. Manual Loading Stations. Not used.

2-2.07. Ratio Stations. Not used.

2-2.08. 1/4 DIN Single-Loop Control Stations. Not used.

2-2.9. 1/4 DIN Manual/Auto Backup Stations. Not used.

2-2.10. Large Case Recorders. Not used.

2-2.11. Strip Chart Recorders. Not used.

2-2.12. Panel-Mounted Pressure Gauges. Gauge sizes and scale ranges for pressure, vacuum, or compound gauges shall be as indicated on the Drawings or the Instrument Device Schedule. Gauges shall be of the differential pressure type where indicated. Gauge scales shall have at least 5 major and 50 minor divisions. Major divisions shall be equally spaced and shall be in whole integers. Scale units (inches, psi, and feet) shall be engraved on the scale face. Each gauge shall be provided with a ball-type shutoff valve.

All gauges with spans of 10 psi or less shall have AISI Type 316 stainless steel bellows and connections. All process gauges with spans greater than 10 psi shall have an AISI Type 316 stainless steel Bourdon tube and connections.

The manufacturer's standard ranges will be considered if approximately equal to the specified range. However, Design-Builder reserves the right to require special scales and calibration if the manufacturer's standard is not acceptable. Gauges shall have clear acrylic or shatterproof glass windows, adjustable pointers, stainless steel geared movements, and shock-resistant cases. Pointer travel shall span not less than 200 degrees or more than 270 degrees. Gauge

accuracy shall be nominal 1 percent of span, corresponding to ANSI B40.1, Accuracy Grade A. Gauges shall be manufactured by Ashcroft, Ametek/U.S. Gauge, or Weksler.

2-2.13. Digital Panel Clocks. Not used.

2-2.14. Switches, Lights, and Push Buttons.

2-2.14.01. Selector Switches. Selector switches shall be 30.5-mm, heavy-duty, oil-tight type with gloved-hand or wing lever operators. Position legends shall be engraved on the switch faceplate. Switches for electric circuits shall have silver butting or sliding contacts, rated 10 amperes continuous at 120 V ac. Contact configuration shall be as indicated on the Drawings or for the application. Switches used in electronic signal circuits shall have contacts suitable for that duty. Switches shall be Micro Switch “Type PT”, Eaton/Cutler-Hammer "10250T", General Electric "CR104P", or Allen Bradley “800T”.

2-2.14.02. Indicating Lights. Indicating lights shall be 30.5-mm, heavy-duty, oil-tight type, with full voltage LED lamps. Legends shall be engraved on the lens or on a legend faceplate. Lights shall be push-to-test type. Indicating lights shall be Micro Switch “Type PT”, Eaton/Cutler Hammer "10250T", General Electric "CR104P", or Allen Bradley “800T”.

2-2.14.03. Push Buttons. Push buttons shall be 30.5-mm, heavy-duty, oil-tight type. Legends shall be engraved on the push-button faceplate. Contacts shall be rated 10 amperes continuous at 120 V ac. Push buttons shall be Eaton/Cutler-Hammer "10250T", General Electric "CR104P", or Allen Bradley “800T”.

2-2.15. Alarm Horns. Horns shall be high-decibel, panel-mount, vibrating type designed for heavy-duty use. Horn volume shall be field-adjustable from 78 to 103 dB at 10 feet. Horns shall operate at 120 volts ac. Horns shall be weatherproof NEMA Type 4X. Horns which are panel front mounted and shall be supplied with gasket. These horns shall be Edwards Signals “870P Series.” Horns may also be supplied with a field mounted enclosure. These horns shall be Edwards Signals “876 series.”

2-3. PANEL INTERIOR MOUNTED DEVICES.

2-3.01. Integrators. Not used.

2-3.02. Power Supplies. Regulated dc power supplies for instrument loops shall be designed and arranged so that loss of one supply does not affect more than one instrument loop or system. Power supplies shall be suitable for an input voltage variation of ±10 percent, and the supply output shall be fused or shortcircuit protected. Output voltage regulation shall be by the instrumentation

equipment supplied. Multiloop or multisystem power supplies will be acceptable if backup power supply units are provided which will automatically supply the load upon failure of the primary supply. The backup supply systems shall be designed so either the primary or the backup supply can be removed, repaired, and returned to service without disrupting the instrument system operation. Multiloop power supply connections shall be individually fused so a fault in one instrument loop will be isolated from the other loops being fed from the same supply. Fuses shall be clearly labeled and shall be located for easy access. Multiloop supply systems shall be oversized for an additional 10 percent future load. Failure of a multiloop supply shall be indicated on the respective instrument panel or enclosure.

Power supplies shall be Allen Bradley, Phoenix Contact, PULS, or equal.

2-3.03. Relays. Relays indicated to be provided in panels, enclosures, or systems furnished under this section shall be of the plug-in socket base type with dustproof plastic enclosures unless noted otherwise. Relays shall be UL recognized and shall have not less than double-pole, double-throw contacts. Control circuit relays shall have silver cadmium oxide contacts rated 10 amperes at 120 V ac. Electronic switching-duty relays shall have gold-plated or gold alloy contacts suitable for use with low-level signals. Relays used for computer input, alarm input, or indicating light service shall have contacts rated at least 3 amperes. Time delay relays shall have dials or switch settings engraved in seconds and shall have timing repeatability of ±2 percent of setting. Latching and special purpose relays shall be for the specific application. Unless otherwise indicated, all relays shall have an integral pilot light that illuminates to indicate an energized condition. Relays shall be IDEC "Series RR"; Potter & Brumfield "Series KRP, CB"; or Struthers-Dunn "Series 219, 246".

2-3.04. Intrinsically Safe Relays. Relays shall be solid-state electronic type in which the energy level of the sensing or actuation circuit is low enough to allow safe use in hazardous areas. Relays shall be located in non-hazardous areas. Relays shall be manufactured by GEMS, Eaton/MTL, R.Stahl, Inc., or Turck.

2-3.05. Electronic Signal Booster/Isolators. Electronic signal boosters and isolators shall have all solid-state circuitry and complete electrical isolation between the power supply and the input and output signals. Accuracy shall be ±0.15 percent of span. Isolators shall be manufactured by Acromag, Moore Industries-International, Inc., or Phoenix Contact.

2-3.06. Electronic Signal Selectors. Not used.

2-3.07. Electronic Signal Summers. Not used.

2-3.08. Fixed Deadband Signal Monitors. Not used.

2-3.09. Adjustable Deadband Signal Monitors. Not used.

2-3.10. Strip Heaters. Electric strip heaters shall be provided as indicated on the Drawings, as specified, and for the application. Strip heaters shall be sized to prevent condensation within the enclosure and to maintain the equipment above its minimum operating temperature. Strip heaters shall be located to avoid overheating electronic hardware or producing large temperature fluctuations. Strip heaters shall be controlled by adjustable thermostats with adjustment ranges of 30° to 90°F [-1° to +32°C]. A circuit disconnect switch shall be provided within the enclosure.

2-3.11. Intrinsically Safe Barriers. Barriers shall be solid-state electronic type in which the energy level of the sensing or actuation circuit is low enough to allow safe use in hazardous areas. Barriers shall be located in non-hazardous areas. Barriers shall be manufactured by MTL, R. Stahl, Inc., or Turck.

PART 3 – EXECUTION

3-1 FIELD SERVICES. Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section. Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

Section 40 79 11

MISCELLANEOUS INSTRUMENTS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of all miscellaneous instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings or the Instrument Device Schedule.

When multiple miscellaneous instruments of a particular type are indicated, and each requires different selectable features, the required features are described on the Drawings or in Instrument Device Schedule.

1-2. DESIGN CRITERIA. Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by System Supplier.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings or as indicated in the Instrument Device Schedule. The instruments shall be installed at the locations indicated on the Drawings or the Instrument Device Schedule.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated in the Instrument Device Schedule. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Instrument Device Schedule.

1-3 SUBMITTALS. Submittals shall be made as specified in Instrumentation and Control System section.

1-4 SHIPMENT, PROTECTION, AND STORAGE. Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as described in the Instrumentation and Control System section.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs provide minimum device stipulations. The Instrument Device Schedule shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. Interconnecting Cable. For systems where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of three meters or as indicated in the Instrument Device Schedule.

2-1.02. Programming Device. For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.03. Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under Microsoft's Windows 10 operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

2-2. MISCELLANEOUS INSTRUMENTS.

2-2.01. Field-Mounted Process Indicators. Not used.

2-2.02. Milliamp Calibrator. Not used.

2-2.03. Pressure Calibrator. Not used.

2-2.04. Multi-function Instrument Calibrator. The calibrator shall be completely portable and shall be capable of measuring and generating milliamperes, millivolts and volts. The calibrator shall have one 4-1/2 digit display capable of indicating either calibrator input or output. The display indication (output or input) shall be switch selectable. The input display shall be bipolar, complete with a minus (-) sign.

Inputs shall range from -50 to +50 volts; -100 to +100 mV; and -50 to +50 mA dc. Outputs ranges shall cover 0 to 110 mV, 0 to 11 volts and 0 to 22 mA dc. Input and output accuracy shall be ± 0.1 percent of full scale and shall be traceable to the National Institute of Standards and Technology. The calibrator shall be capable of simulating a two-wire transmitter operating from an external supply voltage of 12 to 65 V dc, or driving an external load of 0 to 400 ohms at 20 mA dc from the calibrator's internal 24 V dc supply. The calibrator shall have input-output isolation and shall be protected against misconnection and overvoltage.

The calibrator shall be powered from a snap-in battery pack capable of operating the calibrator for 8 hours at 20 mA continuous output. The calibrator shall be supplied with two battery packs, a separate battery charger, a carrying case, an instruction manual, and test leads. The calibrator shall be Transmation "1091PLUS".

The calibrator shall be capable of measuring pressure in inches of water or psig. Accuracy of pressure measurement shall be 0.07 percent of full scale and shall be traceable to the National Institute of Standards and Technology. The pressure modules shall have over pressure relief that protects calibration and shall be compatible with nonconductive, noncorrosive, instrument-grade clean air or clean inert gas. Pressure ranges and modules shall be provided as follows:

Pressure Ranges

Dual Scale: 0-10 PSIG; 0-280" H_2O

Dual Scale: 0-33 PSIG; 0 to 830 inches H_2O

Single Scale: 0 to 100 psig

The calibrator shall be provided with fittings, connecting tubing and a portable air supply pump. The air supply pump shall be Transmation "P".

2-2.05. Manometer. Not used.

2-2.06. Proximity (Door) Switches. Proximity switches shall be magnetic proximity type, consisting of two sensors. One sensor shall be fixed to the door and the other to the door frame. The sensor mounted to the door shall have no electrical connections. Switches shall be provided with DPDT contacts rated 5 amperes at 120 V ac. All necessary mounting hardware shall be provided to allow both the sensors to be installed at the locations indicated on the Drawings.

2-2.07. Vibration Switches. Not used.

2-2.08. Instrument Shutoff Valves. Instrument shutoff valves shall be provided for instruments as indicated on the Drawings and as detailed in the specifications. The indicated shutoff valves shall be provided by System Supplier for all instruments furnished under the Panel Mounted Instruments section, Flow Instruments section, Pressure and Level Instruments section and Analytical Instruments section. Shutoff valves shall be compatible with the measured process and shall be selected in accordance with the manufacturer's recommendations for the specified process. Unused ports of multi-port gauge valves shall be plugged. An instrument shutoff valve schedule shall be submitted indicating the quantity, material, size, and associated instrument. Permanent tagging of the instrument valves is not required. However, temporary hand-written tags or other means of identification shall be provided to ensure that the appropriate valve is installed for a given instrument.

Instrument shutoff valves shall be D/A Manufacturing, Anderson-Greenwood, or equal.

PART 3 - EXECUTION

3-1. FIELD SERVICES. Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. The System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

End of Section

Section 41 12 13.36

SCREW CONVEYORS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of screw conveyors as indicated herein:

Conveyor designation.	Conveyor
Number of conveyors.	2
Conveyor tag numbers.	SCR-COS-1001 & SCR-COS-2001
Conveyor location.	Headworks Area

1-2. GENERAL. Equipment furnished under this section shall be fabricated and assembled in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations furnished by the equipment manufacturer unless exceptions are noted by Design-Builder.

All structural and miscellaneous metal required shall conform to the requirements of the Structural Metals and Metal Fabrications sections.

The supplier shall review the contract Drawings and installation requirements and shall make any modifications required for proper installation subject to acceptance by the Design-Builder.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Power Supply. Refer to the Packaged Headworks System section for requirements.

1-2.04. Electrical. See electrical sections as identified in 01100 Section for electrical requirements.

1-2.05. Coordination. The Packaged Headworks System Supplier (PHSS) shall coordinate the equipment specified herein with equipment specified elsewhere that will discharge into the conveyors or discharge out of the conveyors. This

includes coordination of chute and flange connection dimensions. The PHSS shall be responsible for coordinating changes to the conveyors without additional cost to the Design-Builder. Any changes identifies shall be subject to acceptance by the Design-Builder.

1-2.06. Identification. Refer to the Packaged Headworks System section for requirements.

1-2.07. Welding Certification. Refer to the Packaged Headworks System section for requirements.

1-2.08. Qualifications. Not Used

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete assembly and installation drawings, together with detailed specifications and data covering material used, parts, devices, and other accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section. PHSS shall provide information as required in the Packaged Headworks System section and 1100 Section.

1-3.02. Operation and Maintenance Data and Manuals. Refer to the Packaged Headworks System section for requirements.

1-5. SPARE PARTS AND ACCESSORIES. Refer to the Packaged Headworks System section for requirements.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. The screening conveyor equipment will be used to convey screenings from the screening washer/compactors to the location shown on the Drawings.

The conveying units shall be suitable for the following service conditions:

Seismic design requirements and site elevation.	See Packaged Headworks System section
Type of environmental exposure.	Outdoor (open, uncovered from sun)
Ambient air temperature range.	See Packaged Headworks System section

Type of solids.	Screenings, Wastewater

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Conveyors shall be designed for the following performance and design requirements:

Conveyor tag numbers.	SCR-COS-1001 & SCR-COS-2001	
Screw conveyor type.	Shaftless	
Design capacity (wet).	Required to discharge screenings from Coarse Screens	ft^3/hr
Minimum screw diameter.	6	in
Approximate length.	Required to discharge screenings to location indicated on Drawings	ft
Angle of incline.	Required to discharge screenings to location indicated on Drawings	deg
Motors.		
Maximum size.	3	hp
Reversing.	Yes	

2-3. ACCEPTABLE MANUFACTURERS. Shaftless screw conveyor manufactures shall selected by the PHSS.

2-4. MATERIALS.

Flights.	316L stainless steel
Trough and cover.	316L stainless steel
Conveyor supports.	316L stainless steel
Discharge chute.	316L stainless steel
Slide gates.	316L stainless steel

2-5. CONSTRUCTION. Each screw conveyor shall consist of troughs, covers, bearings, shaft seals, drive units, and support structure.

Conveyor manufacture shall provide safety equipment and safety guards as required by OSHA and as indicated in ASME B20-1, Safety Standards for Conveyor and Related Equipment. Unless otherwise indicated, safety guards shall be in accordance with the General Equipment Stipulations section.

Conveyor configuration shall be based on the Drawings. The PHSS shall coordinate the conveyor dimensions with equipment specified elsewhere.

2-5.01. Conveyor Supports. Each conveyor shall be furnished complete with supports suitable for mounting as shown on the Drawings and as required by the supplier's design. At a minimum, each screw conveyor trough shall have supports at the drive end and the tail end of the trough plus intermediate supports at a maximum of 12 foot intervals. All shop welding shall conform to the latest standards of American Welding Society (AWS). The supports shall be designed to avoid interference with other equipment or equipment supports. The supports shall be designed to prevent excessive vibration of any portion of the conveyor unit under all loading conditions.

Conveyor supports shall be designed for a minimum live load as specified herein. All structural supporting members shall be designed such that the ratio of the untraced length to least radius of gyration (slenderness ratio) shall not exceed 120 for any compression member and shall not exceed 240 for any tension member (of angles about Z-Z axis). In addition, all structural members and connections shall be designed so that the unit stresses will not exceed the AISC allowable stresses by more than 1/3 when subject to loading of twice the maximum design operating torque of the screw conveyor drive motors.

2-5.02. Flighting. Shaftless screw conveyors shall consist of spiral flighting only attached to a flanged connecting plate. Spiral flighting for the shaftless screw conveyors shall be designed to convey material without a center shaft or hanger bearings.

Each screw conveyor shall be provided with inner and outer spirals to increase axial strength and capacity. Conveyors shall have an inner flight thickness shall not be less than 3/4 inch and outer flight thickness shall not be less than one inch. Minimum cross sectional area for conveyors having a diameter smaller than 15 inches shall be 2.9 in^2 and conveyors having a diameter of 15 inches and larger shall be 4.3 in^2. The spiral flights shall be designed for the maximum torque requirements of the equipment specified. The "spring effect" of the spiral shall not exceed 30 mils per foot of length assuming the conveyor is completely full (100% fill factor) of the material specified herein. Flights shall be formed from cold spring steel having a minimum 72,000 psi tensile strength and a minimum 220 Brinell hardness.

Spiral flighting shall have full penetration welds at all splice connections. The flights shall be aligned to assure true alignment when assembled and shall be made according to the manufacturer's recommendations. The connection of the spiral to the drive system shall be through a flanged connection plate that is welded to the spiral and shall form a smooth and continuous transformation from

the flange plate to the spiral. The drive shaft shall have a mating matching flange and shall be bolted to the spiral connection plate.

2-5.03. Troughs. Troughs shall be U-shaped and shall conform to Conveyor Equipment Manufacturers Association (CEMA) 300. Troughs shall be minimum 1/4 inch thick and shall be equipped with inlet and discharge flanged connections where indicated on the drawing. The outlet openings in the trough bottom shall be sized to prevent screw conveyor plugging. The portion of each trough that is not covered by the inlet opening shall be covered. Covers shall conform to CEMA 300 and shall be bolted and gasketed to the conveyor. The covers shall be manufactured in less than 4 foot lengths to allow for access. Stiffeners shall be placed across the top of the trough and fastened to both sides of the trough to maintain trough shape and act as a seal face for the covers. A continuous neoprene gasket shall be applied to entire top face of trough top flange and stiffeners. Support saddles shall be provided on the bottom of the troughs where indicated on the Drawings or as recommended by the manufacturer. Maximum spacing shall be 12 feet.

Wear liners shall cover the bottom 180 degrees of the trough. Wear liners shall be ultra-high molecular weight (UHMW) polyethylene. The wear liners shall be manufactured in sections four feet or less to allow for replacement. Holddown bars shall be provided to minimize vertical movement of the flights.

Flushing connections shall be provided where required. The flushing connection shall be a minimum 1 inch NPT, welded to the trough.

Drain connections shall be provided where required. The drain connection shall be a minimum 4 inch flanged, welded to the trough.

2-5.04. Drive Shafts. Not used.

2-5.05. Shaft Seals. Shaft seals shall be attached to the outside of the trough end where the shaft extends through the end wall. The seals shall provide a watertight seal when the conveyors are filled with material. Shaft seals shall be the compression type packing gland type consisting of a cast iron stuffing box with at least two Teflon-impregnated packing rings with a packing ring adjustment. The shaft seal assembly shall prevent the leakage of any liquid when properly lubricated and adjusted.

2-5.06. End Bearings. Not used.

2-5.07. Intermediate Bearings. Shafted screw conveyors greater than 12 feet in length shall have at least one intermediate bearing along the conveyor length. The intermediate bearings shall be Type 316 stainless steel construction, multiring, flexible coupling. The coupling shall provide the flexible action to accommodate both torsional loads and misalignment in two directions, without

the use of plastic, neoprene, rubber, or other materials. The intermediate bearings shall consist of a stainless steel shaft with registered fit end flanges and bolt pattern to match the conveyor shaft pipe. The intermediate bearing shall be housed in a stainless steel housing with mechanical seals.

The intermediate bearing housing shall be constructed in two parts, permitting removal of the bottom half of the housing, journal sleeves, seals, bearings, or the complete intermediate bearing assembly. The complete intermediate bearing assembly shall be able to be removed without having to remove adjoining rotor, shafts, or bearings.

The intermediate roller bearing assembly shall be free-floating ball bearings, transmitting the thrust of the sludge upon the screw conveyor shaft pipes through all intermediate bearings to the thrust end fixed bearing mounted in the drive or end bearing assembly. Bearings shall have a minimum ABMA L_{-10} Life Rating of 100,000 hours. Bearings shall be fitted with tubing and grease fittings with escape release provisions.

2-5.08. Fasteners. All bolts, nuts, washers, and other fasteners shall be constructed of stainless steel.

2-5.09. Fabrication. All stainless steel shall be pickled in accordance with ASTM A380 at the mill before being shipped.

All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces. Particulate matter shall be removed from piping and welds. Welds shall be either mechanically cleaned or pickled or passivated.

2-6. DRIVE UNITS. Each conveyor shall be driven by an electric motor through a direct drive gear reducer. Drive units shall be designed for 24 hour continuous service.

2-6.01. Belt Drive. When required, belt drives shall be either V-belt or cogged timing belt. V-belt and sheave groove dimensional tolerances shall be in accordance with the "Engineering Standards - Multiple V-Belt Drives" published by the Mechanical Power Transmission Association (MPTA) . Belt drives shall have a service factor of at least 1.6 at maximum speed based on the nameplate power rating of the drive motor. The speed reduction ratio of belt drives shall not exceed 4 to 1. Each belt drive shall include a sliding base or other suitable means of tension adjustment.

2-6.02. Gear Reducers. Gear reducers shall be a totally enclosed unit with oil or grease lubricated, rolling element, antifriction bearings throughout. Gear reducers shall be AGMA Class II, single or double reduction, helical gear units with high capacity roller bearings. Bearings shall be designed for the maximum

thrust during startup of a conveyor completely full (100 percent fill factor) of the material specified herein, and shall have a minimum ABMA L_{10} Life Rating of 100,000 hours. The reducers shall be standard air-cooled units with no auxiliary cooling allowed. The gear housing shall be of 30,000 psi cast iron, with removable inspection cover(s), oil breather(s), oil level indication, fill and drain holes with plugs; gearing lubricated through an oil bath for the mounting position and inclination required. The gear reducer shall be sized with a torque service factor of 1.5 based on motor nameplate, at the driven (output) shaft speed, whichever is greater. Gear motors in which the motor is integral with the gear reducer is not acceptable.

2-6.03. Electric Motors.
Refer to the specification section listed in 01100 for the electrical motor requirements. Maximum motor speed shall be 1800 rpm.

2-6-04. Electrical. Electrical package including outdoor rated air-conditioned (if required) NEMA rated electrical enclosure, motor starters, variable frequency drives, circuit breakers, disconnect switch, etc. shall be furnished to provide a completely system.

See electrical sections as identified in 01100 Section for electrical requirements.

2-7. ACCESSORIES.

2-7.01. Chutes. Inlet and discharge chutes shall be provided where indicated on the Drawings. Chutes shall be a minimum 10 gage thickness. Chutes sides shall not be sloped more than 70 degrees. Deflector plates shall be attached to the inside of the chutes to limit falling velocities, when the material drop is greater than 4 feet. Deflector plates shall not be sloped more than 70 degrees. Chutes connected to the screw conveyor shall be flanged to match the conveyor connection.

2-7.02. Flexible Connections. Not Used

2-7.3. Automatic Lubrication. Each conveyor bearing shall be served with its own separate automatic grease lubrication system. The grease system shall automatically provide a continuous supply of lubricant to each bearing. Lubricant for intermediate bearings shall enter the bearing from the top with the lubrication line enclosed within the intermediate bearing support housing to prevent damage. Tubing shall be 1/4 inch [6.2 mm] stainless steel.

2-7.04. Slide Gates. Not used

2-7.04.01. Manual Actuator. Not used.

2-7.04.02. Pneumatic Actuator. Not used.

2-7.04.03. Electric Actuator. Not used

2-8. CONTROLS. Motor starters and other controls not specified herein shall be furnished under the Packaged Headworks System section and 1100 Section.

The conveyor motor space heater shall be energized when the motor is not operating. The conveyor shall shut down when the emergency stop switch is activated. Shut down by any safety or equipment protection devices shall require reset at the control panel.

2-8.01. Conveyor Mounted Switches. Conveyor mounted switches shall be furnished with standard watertight covered terminal strip junction box and 1/2 inch threaded conduit connection. Each switch shall be furnished and mounted as an integral part of the conveyor equipment and framework. All switches shall have 10 ampere, 115/120 volt ac, 60 Hz, rating.

2-8.01.01. Zero Speed Switch. Not used

2-8.01.02. Emergency Stop Switches. Screw conveyors shall be equipped with two emergency stop safety switches, each with two normally closed double break contacts. Contacts shall be manually reset. Switches shall be equipped with a latching mechanism and a weight and cable along the length of the conveyor for operation of the switch. Switches shall be opened by cable linkage mounted on all sides of the conveyor. Cables shall be plastic covered metal cable (blaze orange color) and shall be located along the conveyor within easy reach of operating personnel who may be maintaining or observing the operating conveyor.

2-8.02. Electronic Shear Pins. Electronic shear pins shall be provide for each screw conveyors. Units shall provide overload protection with built-in reset button, test button, and fail-safe contacts. Electric shear pins shall be Tsubaki “Shock Relay TWBSS” or equal. Electronic shear pins shall be delivered to the electrical subcontractor for installation in the conveyor motor starter.

PART 3 - EXECUTION

3-1. INSTALLATION. Each screw conveyor shall be installed in accordance with Equipment Installation section.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check and Supervision. Installation shall be in accordance with the 01100 Section.

3-3. TESTING. Refer to the Packaged Headworks System section for testing requirements.

3-3. TRAINING. Refer to the Packaged Headworks System section for training requirements.

End of Section

Section 41 22 13.13

BRIDGE CRANES

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of bridge cranes, complete with trolleys and hoists, and accessories as indicated herein.

Equipment designation.	Maintenance Buildling Bridge Crane
Number of units.	1
Equipment location.	Maintenance Building

Each bridge crane assembly shall be furnished and installed in the location and arrangement indicated on the Drawing, complete with all structural members fabricated by the crane supplier and components (end trucks, wheels, bridge drive mechanism, trolley, and hoist), electric wiring (including collectors, conductor and conductor supports), controllers, pendant control station, and all other accessories necessary for a complete and properly operating installation.

Runway beams/crane rails are covered in the Structural and Miscellaneous Metals section.

1-2. GENERAL. Equipment and accessories furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer.

1-2.01. Coordination. Design-builder shall verify that each component of the system is compatible with all other parts of the system and that all devices necessary for a properly functioning system have been provided.

Where two or more traveling bridge cranes are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer. Similar component parts of bridge cranes shall be from the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

Each manufacturer of major equipment shall have a local service center, or with written consent of Engineer, shall be able to provide service from other locations within 24 hours. The service center shall be equipped and staffed to service the system and shall maintain a local parts supply. Information on equipment manufacturers' representatives shall be included with the submittals.

Where several manufacturers' names have been listed in this section as possible suppliers, only the products of the first manufacturer listed have been checked for size, functions, and features.

Each bridge crane assembly shall be preassembled and run in the shop, then matchmarked and disassembled for shipment.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.04. Governing Standards. Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between this section and any state law or local ordinance, the latter shall govern.

All work shall comply with Underwriters' Laboratories (UL) safety requirements.

Equipment furnished under this section shall comply with the applicable requirements of the following:

Occupational Safety and Health Standards of the U.S. Department of Labor; Subpart N, Materials Handling and Storage.

ANSI/ASME B30.10, “Hooks”

ANSI/ASME B30.11, “Monorails and Underhung Cranes”

ANSI/ASME B30.16, “Overhead Hoists (Underhung)”

For top running multiple girder electric overhead cranes:

Crane Manufacturers Association of America (CMAA) Specification No. 70, "Specifications for Electric Overhead Traveling Cranes".

For top running and under-running single girder overhead cranes:

Crane Manufacturers Association of America (CMAA) Specification No. 74, "Specification for Top Running & Under Running Single Girder Electric Overhead Traveling Cranes".

For underhung electric or manual cranes:

ANSI MH27.1, "Specifications for Underhung Cranes and Monorail Systems".

ANSI/ASME HST-2, "Performance Standard for Hand Chain Manually

Operated Chain Hoists".

ANSI/ASME HST-4, "Performance Standard for Overhead Electric Wire Rope Hoists".

1-2.05. Power Supply. Unless otherwise indicated, power supply to the equipment shall be 480 volts, 60 Hz, 3 phase. Power supply for controls shall be 120 volts, 60 Hz, single phase unless otherwise indicated or required for a properly operating system. Control power voltage shall be derived from the main equipment power supply.

1-2.06. Labels. Each bridge, trolley, and hoist shall have a conspicuous, easy-to-read label showing manufacturer's name, crane serial number, and rated capacity. The rated capacity of the hoist shall also be shown on the load block.

1-2.07. Identification. Bridge cranes shall be identified in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete assembly and installation drawings, wiring and schematic diagrams, together with detailed specifications and data covering materials, parts, devices, accessories forming a part of the equipment furnished, and load test certificates shall be submitted in accordance with the Submittals Procedures section. Device tag numbers indicated on the Drawings shall be referenced on the wiring and schematic diagrams where applicable.

Drawings shall include electrical connection diagrams and schematics identifying all items requiring electrical control or power in the operation of the bridge crane assembly, and complete details and information of the power feed system.

Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-3.02. Operation and Maintenance Data and Manuals. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-4. QUALITY ASSURANCE.

1-4.01. Welding Qualifications. All welding procedures and welding operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of AWS Standard Qualification Procedures. All procedure and operator qualifications shall be in written form. Accurate records of operator

and procedure qualifications shall be maintained by Design-Builder and made available to Owner's Representative upon request.

1-4.02. Manufacturer's Certification. The equipment manufacturer shall certify that each hoist provided has been load tested in accordance with ANSI/ASME B30.16 with a load of at least 125 percent of the rated load. A certificate shall be submitted for each hoist supplied and shall include the name of the project, the serial number on the hoist, and a description of the test performed. Testing of the equipment shall be the responsibility of the manufacturer and the certification shall be submitted before the equipment will be accepted for the project.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. Bridge crane shall be provided at the shop inside the Maintenance Building.

All equipment shall be designed to operate under the following service conditions:

Seismic design requirements.	See Meteorological and Seismic Design Criteria section	
Type of environmental exposure.	Indoor	
Ambient air temperature range.	___ to ___	°F

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Each traveling bridge crane shall be designed for the specific hoist, trolley, and bridge performance and design requirements as follows:

Bridge Crane

Use classification	CMAA, Class C	

Hoists

Hoist and trolley arrangement	Hoist hook-attached to trolley	
Hoisting capacity.	5	tons
Hoist operation.	Electric	
Elevation of hook at highest position.	12'-1"	

Elevation of hook at lowest position.	6	in
Minimum vertical travel of lifting hook	11’-7”	
Motor type	Two speed	
Hook lifting speed, minimum/maximum.	3.3 to 20	
Trolleys		
Trolley and bridge arrangement.	Underhung trolley	
Trolley type.	Electric	
Motor type.	Single speed	
Travel speed.	40 to 60	ft/min
Bridges		
Bridge operation.	Electric	
Motor type.	Single	
Travel speed.	50 to 100	ft/min
Runway Beams		
Maximum depth of runway beams.	27-3/8”	
Maximum horizontal clearance from centerline of beam to end stop	22’-9”	
Maximum available clearance above top of runway beams.	6	in
Elevation of bottom of runway beam above finished floor.	14	ft
Pendant mounting location.	Bridge	
Remote Control	No	

2-3. ACCEPTABLE MANUFACTURERS. Acceptable suppliers of bridge cranes shall be Accent Sales & Service Co., American Equipment Industries Inc., North American Industries, Konecranes, or equal.

Acceptable manufacturers of crane components shall be Yale, Acco, Chester, Coffing, R&M Material Handling Inc., or equal.

Equivalent products of manufacturers regularly producing traveling bridge crane systems, shall be subject to acceptance by Design-Builder.

2-4. HOISTS AND TROLLEYS. The hoist and trolley arrangement shall be spur-geared hoist type.

2-4.01. Hoists. Hoists shall be either manual or electric as specified herein.

2-4.01.01. Manual. Not used.

2-4.01.01.01. Load Brake. Each hoist shall be equipped with self activating mechanical load brake which will prevent acceleration of the load when lowering and which will sustain the maximum load at any point. Load brakes shall operate in sealed enclosures.

2-4.01.01.02. Chains. Load chains shall be heat-treated alloy steel, welded link type, heavily zinc plated. Chain containers shall be provided to receive idle load chain. Antifriction bearings shall be used throughout, and the assembly shall have facilities for proper lubrication.

Each hoist shall be furnished with hand chains which shall be welded link type, heavily zinc plated steel, and shall extend to approximately 3 feet above the floor.

2-4.01.02. Electric. Electric hoists shall consist of an electric motor, a grooved winding drum, and gearing arranged with the trolley. Antifriction bearings shall be used throughout. The winding drum shall have machined grooves designed to receive the full run of hoisting cable without overwrapping. The ratio between the diameter of the drum and the diameter of the hoisting cable shall be at least 20 to 1. At least two laps of cable shall remain on the drum when the lifting hook is in the lowest position.

Hoist gearing shall be spur or helical type and shall be fully enclosed in an oiltight housing. All bearings shall be antifriction type, with oil lubrication or lifetime grease packing.

The hoist shall be provided with mechanical and electrical load brakes arranged so that the load may be raised or lowered by electric power and automatically sustained at any position of the hook when the power is cut off. The mechanical load brake shall prevent acceleration of the load when lowering and shall completely sustain the load when brought to rest, independent of the electric brake. The electric brake shall be released whenever current is flowing to the hoist motor and shall be automatically activated when the current is shut off or interrupted. The mechanical load brake shall operate in oil in a sealed enclosure.

The hoist shall be provided with adjustable limit switches to stop the hoisting mechanism at the upper and lower limits of hook travel.

The lifting tackle shall consist of a lower block and hook, necessary sheaves, and wire rope, made especially for hoisting service. Wire rope shall be as recommended by the rope manufacturer for use on the specified drum. The lower block shall be of the safety type, with guarded sheaves. The sheaves shall have antifriction or sleeve type bearings.

2-4.02. Hooks. All hooks shall be a slow opening, non-fracturing, forged steel, and shall be provided with a safety latch. The hooks shall be mounted on anti-friction bearings to permit easy turning.

2-4.03. Trolleys. Each trolley shall have a rated capacity equal to or greater than the capacity of the corresponding hoist.

Each trolley frame shall be rigid. The trolley and bridge arrangement shall be as specified herein. For underhung type trolleys, the trolley frame shall be provided with lugs or wrap around side plates on both sides of the bridge. Wheels shall be double flange type for top-running trolleys, and single flange type for underhung trolleys. Wheels shall be made from rolled, forged, or cast steel, machined universal crowned or tapered treads of hardened steel. Wheel bearings shall be permanently shielded, lifetime-lubricated, antifriction type, adequate for radial and end thrust loading.

2-4.03.01. Manual. Not used.

2-4.03.02. Electric. Electric trolley drives shall be a sealed worm or spur gear units, permanently lubricated with an oil bath. Drive wheels shall have integrally cut spur gear teeth or machine-cut gears pressed on hubs. Drive wheel treads shall be hardened.

2-5. BRIDGES. Each bridge shall be the single girder type, shall be rigidly supported by end trucks, and shall operate on a runway beam type of running surface. The bridge shall be constructed to accommodate the type of trolley specified. When underhung trolleys are specified, the wearing surface of the bridge's lower flanges shall be either specially fabricated flanges or standard flanges ground smooth.

Steel design and fabrication shall comply with applicable portions of the specifications of the American Institute of Steel Construction. Loadings, impact allowances, and allowable stresses shall be in accordance with the governing standards. Deflection of the bridge girder(s) shall not exceed 1/800 of the span, with the maximum hoist load at any point.

2-5.01. End Trucks. End trucks, each fabricated from structural steel members, shall be designed to distribute the loading equally to each wheel, shall be securely attached to the bridge girder by welding or with fitted bolts in reamed holes, and shall be provided with heavy gusset plates to ensure adequate rigidity and squareness. Each truck shall have heavy end plates to engage the stops located on the specified running surface. End trucks shall have a wheelbase of approximately 1/7 the bridge span. Underhung end trucks shall be provided with lugs or wrap around side plates on both sides of the track.

The end trucks and wheels shall be designed to operate on the specified running surface, and shall clear all fittings, anchors, and splices located on, or near, that surface.

2-5.02. Wheels. Bridge crane wheels shall be made of rolled, forged, or cast steel, with machined universal crowned or tapered hardened treads, designed to operate on the specified running surface. Drive wheels in each truck shall have integrally cut spur gear teeth, or machine-cut gears pressed on hubs. The other wheels in each truck shall be idlers. Axles may be either rotating or fixed type. Wheel bearings shall be permanently shielded, lifetime-lubricated, antifriction type, adequate for radial and end thrust loading.

For top running bridges, each end truck shall have double flange wheels and one drive wheel. For underhung bridges, each end truck shall have single flange wheels and one pair of drive wheels.

2-5.03. Bridge Drive Mechanism. The bridge drive shall be a CMAA A4 individual end truck type with rotating axle and shaft-mounted gearboxes. Gearing for the bridge drive mechanism shall be helical, spur, or herringbone type, made from rolled or cast steel, and shall have machine-cut teeth. All shafts shall be made from alloy steel and shall be heat treated.

2-5.03.01. Manual. Not used.

2-5.03.02. Electric. The bridge drive shall consist of a single speed electric motor for single speed bridge drives, or a specially designed dual speed electric motor for two speed bridge drives, and enclosed reduction gearing.

The drive motor shall contain a built-in adjustable mechanical brake. The bridge brake shall be solenoid operated, adjustable shoe or disc type, acting directly on the bridge drive motor shaft.

2-6. BUMPERS AND STOPS. Bumpers and stops in compliance with the governing standards shall be installed on the bridge, trolley, and the specified running surface. The bumpers and stops shall be located so that no part of the bridge or trolley encroaches on the clearances specified or indicated on the Drawings.

2-7. ELECTRICAL.

2-7.01. Motors. Motors shall be totally enclosed, high-starting torque, squirrel-cage type, designed especially for crane and hoist service and suitable for operation with the power supply specified. Motor size and speed shall be adequate to start the fully rated load capacity.

2-7.02. Controllers. Control of all electric hoist, trolley, and bridge motions shall all be from a single pendant push-button station and a remote control unit. Controllers shall be of the reversing, magnetic contactor type, with thermal overload protection, and shall be installed at the motor and operated from the pendant station and remote control as specified herein. Bridge and trolley controllers shall be provided with variable frequency drives for cushioned starting and stopping.

2-7.02.01. Pendant Controls. The pendant shall contain a separate push button for each of the following motions: off, on, hoist up and down (when electric hoists are specified), trolley forward and reverse (when electric trolleys are specified), and bridge forward and reverse (when electric bridges are specified). The pendant shall be mounted as specified herein.

The pendant station shall be 4 feet above finished floor. The manufacturer shall determine the length of the pendant station cable.

Push buttons shall be of the interlocking type to prevent possibility of damage to equipment should two or more buttons be pressed simultaneously. Push buttons shall be provided with a spring return to neutral and shall automatically return to the off position when pressure on the button is released.

A control power transformer with one secondary lead fused and the other grounded shall be provided to reduce voltage at the push-button station to a maximum of 120 volts. The pendant control cable shall be heavy duty type with extra flexible stranding and neoprene jacket. Support for the pendant station shall be provided by a stainless steel wire rope or chain equipped with a suitable strain relief clamp for the conductor cable.

2-7.03. Power Feed System. When any part of the crane system is electrically operated, a complete electric power feed system shall be provided. The system shall consist of insulated conductors and insulated collector assemblies with copper-graphite collector shoes, and shall be U-S Safety Trolley's "Span-Guard", Conductix-Wampfler Insul-8 “8-Bar” or Duct-O-Wire "Duct-O-Bar" or equal 4 bar conductor system. The conductors shall be the completely enclosed type. The current and voltage rating of the conductors and collectors shall be not less than 90 amperes continuous duty, 135 amperes intermittent duty.

Stationary conductors shall be installed adjacent to the runway, with supports and brackets as needed. Cross conductors shall be supported by angles across the top of the bridge. Collectors for hoist operation shall be installed on the hoist trolley and wired to the hoist. Conductors and collectors shall be installed in conformity with the recommendations and instructions of the system manufacturer.

The feeder circuit for the crane assembly will be furnished and installed under the Electrical section and at the location indicated on the Drawings. A suitable surface-mounted junction box, with all hanger brackets and other accessories required for a complete installation, shall be furnished and installed under this section at the location indicated, and the feeder circuit wired in.

2-7.04. Wiring. All insulated wire shall be heat resisting and shall be insulated for 600 volts.

PART 3 - EXECUTION

3-1. ERECTION. Each crane, hoist, and trolley shall be erected in accordance with the manufacturer's recommendations by workers who are regularly engaged in crane erecting and who are acceptable to the crane manufacturer. The orientation of installation of the hoist and trolley on each crane bridge shall be as directed by Design-Builder.

3-2. WIRING. All wiring on the bridge crane shall be installed in intermediate metal conduit in accordance with the National Electrical Code.

3-3. FIELD QUALITY CONTROL.

3-3.01. Installation Check. .An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the contract price.

3-4. FIELD TESTING. After complete assembly and installation, each crane shall be subject to an acceptance test. A manufacturer's representative shall be present during all testing. The inspection and testing shall verify that each crane has been assembled properly and that all required adjustments have been made.

3-4.01. Acceptance Testing. Each crane shall be subject to operational and rated load testing.

Each crane shall raise, lower, hold in any position, and transport a test load equal to 125 percent of the rated capacity of the crane, with no detrimental effects on the crane. All motions shall be executed satisfactorily. Design-Builder shall provide the test weights.

The following functions shall be tested:

Hoisting and lowering.

Trolley travel.

Bridge travel.

Limit switches, locking and safety devices.

The trip setting of hoist limit switches shall be determined by tests with an empty hook traveling in increasing speeds up to the maximum speed. The actuating mechanism of the limit switch shall be located to trip the switch, under all conditions, in sufficient time to prevent contact of the hook or hook block with any part of the trolley.

Hoisting and lowering tests will be conducted with 0, 50, 100, and 125 percent of the nominal or rated load.

The rated load test shall consist of the following operations:

The test load shall be lifted a sufficient distance to ensure that the load is supported by the crane and held by the hoist brakes.

The test load shall be transported by means of the trolley for the full length of the bridge.

The test load shall be transported by means of the bridge for the full length of the runway in one direction with the trolley as close to the extreme right-hand end of the crane as practical and in the other direction with the trolley as close to the extreme left-hand end of the crane as practical.

The test load shall be lowered, stopped, and held with the brakes.

Wiring shall be given an insulation resistance test using a 500 volt megger.

Following completion of the tests, each crane shall be inspected by Design-builder and the manufacturer's representative, for misalignment, breakage, and undue wear.

3-4.02. Test Reports. Field inspection and testing of each crane shall be documented by the crane manufacturer's representative, noting the deficiencies and corrections and certifying that each crane is acceptable for operation. Certification of the inspection shall be submitted to Design-Builder.

End of Section

Section 43 05 21

SEAL WATER STATIONS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of seal water stations for the application types as stated in the pump specification sections. Seal water stations shall be furnished complete with all fittings, unions, valves, gauges, switches, piping, and other accessories specified herein or otherwise required for proper operation.

1-2. GENERAL. Equipment provided under this section shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Design-Builder.

Components of the seal water stations shall be the latest standard products of manufacturers regularly engaged in the production of equipment of this type.

1-2.01. Coordination. When two or more units of the same class of equipment are required they shall be the product of a single manufacturer; however all of the component parts of the system need not be the products of one manufacturer.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. Identification. All seal water stations shall be provided with a number plate with text as follows:

"SEAL WATER STATION – PUMP – [*pump designation*]"

where pump designation refers to the pump tag number as listed in the specifications or shown on the drawings. The location of number plates and the method of fastening shall be acceptable to Design-Builder. Numerals shall be at least 1 inch high and shall be black baked enamel on anodized aluminum plate.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete specifications, data and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures

section. The data and specifications for each item shall include, but shall not be limited to, the following:

Name of manufacturer.
Type and model.
Construction materials, thicknesses, and finishes.
Setpoint adjustment range.
Pressure and temperature ratings.

PART 2 - PRODUCTS

2-1. PERFORMANCE AND DESIGN REQUIREMENTS. Seal water stations shall be designed for the following requirements unless otherwise indicated:

Max design pressure	200 psig
Inlet working pressure	To be determined by Design-Builder
Outlet working pressure	To be determined by pump supplier
Temperature range	40 to 150 °F
Flow capacity	
Double mechanical seal	0.1 to 1 gpm
Single mechanical seal	3 to 5 gpm
Packing box	3 to 5 gpm
Vertical turbine pump	0.75 gpm per inch of shaft diameter

2-2. MATERIALS.

Pipe	1/2 inch Hard drawn copper tubing, ASTM B88, Type L for line piping with solder joint fittings. 1/4 inch ASTM B43. red brass, seamless, regular weight for instrument piping.
Strainers	Y-pattern type with bronze body, threaded ends, and monel or stainless steel screens (40 mesh for single mechanical seals and packing, 100 mesh for double mechanical seals). The blowoff from each strainer shall be equipped with a shutoff valve. Hoffman ITT “Series 400” or Metraflex “Model BS”.

Pressure Gauges	Liquid filled indicating dial type with 1/4 inch NPT connections, 2-1/2 inch dial, A316 stainless steel Bourdon tube, stainless steel rotary geared movement, stainless steel case, adjustable pointer, and polycarbonate or shatterproof glass window. The pointer shall span not less than 200 degrees nor more than 300 degrees. Indicating units shall be psig. Ashcroft, Duralife “Type 1009”, or Weiss Instruments, Inc.
Pressure Switches	Diaphram actuated type with a weatherproof housing, Teflon coated diaphragm, viton seals, and a stainless steel connection port. Ashcroft, Barksdale, NeoDyn, Mercoid Controls, or S.O.R.
Flow Switches	Vane-style variable area rotameters with scale pointers and adjustable switch contacts. Universal Flow Monitors “Series SN” or “Series LL”, as required by the application.
Sight Flow Indicators	Ball or paddlewheel type with threaded end connections.
Orifice Plates	Flow control orifice plates of diameter and type as recommended by the pump manufacturer.
Flexible Connections	Tygon “B-44-4X I.B.” tubing with Tygopure Reusable Fittings.
Ball Valves	Inline, two-piece, end entry, regular port with threaded end connections. Bronze body and trim with reinforced Teflon seats, seals, and washers. As manufactured by Cobraco Industries “Apollo 70-100 Series” or Powell “Fig 4210T”.
Globe Valves	Inline, metal disc, threaded bonnet, rising stem, with threaded end connections. Bronze body and trim. As manufactured by Milwauke “502”, Stockham “B-16”, or Walworth “Fig 3058”. Globe valves for Type A Stations on vertical diffusion vane shall be throttled to 25 percent open to permit some bypass flow around the solenoid valve to maintain lubrication flow around bearings.
Check Valves	Class 125 Horizontal swing, threaded bonnet type, ASTM B62 bronze, threaded end

	connections, -20 to 212°F temperature limits, Stockham “B-321”, Walworth “Fig 3406”.
Solenoid Valves	Two-position, normally closed, pilot operated with threaded end connections. Solenoid valves shall be 120 volt, 60 Hz, with class F insulation and rated for continuous duty. Bronze body with Buna-N or Teflon trim. As manufactured by ASCO “8210 Series”.
Pressure Regulating Valves	Direct acting, globe type valve with threaded connections and union assembly. Bronze body and cover, stainless steel trim, reinforced neoprene diaphragm, Buna-N disc, and stainless steel trim. As manufactured by Cla-Val “Model 990”, Cash-Acme, or Watts.

2-3. SEAL WATER STATIONS. Schematics of the different types of seal water stations are shown in Figure 1 – 43 05 21-F1. The following descriptions are for each types of seal water stations specified herein:

External Water Source Type

Type A	Solenoid valve, flow switch
Type B	Solenoid valve, pressure switch
Type C	Solenoid valve downstream of pump seal
Type D	Solenoid valve, simplified station

Re-circulating type

Type E	Re-circulating from pump discharge to pump seal
Type F	Re-circulating from pump seal to pump suction

2-4. ACCESSORIES.

2-4.01. Pressure Gauges. Except as modified or supplemented herein, all gauges shall conform to the requirements of ANSI B40.1. Accuracy shall be ANSI Grade 1A or better.

The range shall be selected so that the normal operating reading is near the midpoint of the scale.

Each gauge shall be provided with a threaded end ball-type shutoff valve.

2-4.02. Pressure Reducing Valves. Each pressure reducing valve shall be designed to provide tight shutoff under conditions of no flow and shall not “hunt”

under ordinary flow conditions. Pressure reducing valves shall be selected and sized as recommended by the valve manufacturer. Valve pressure setpoint shall be adjustable to at least 20 percent above and below the reduced pressure setpoint.

2-4.03. Pressure Switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line pressure. Switch wetted parts shall be compatible with the process fluid.

Switches shall have a fixed deadband and shall be auto-reset type. Switches shall be SPDT, rated at least 10 ampere at 120 volts ac.

Each switch shall be provided with a threaded end, ball-type shutoff valve.

2-4.04. Flow Switches. Switches shall be SPDT with contacts rated at least 10 ampere at 120 volts ac. Switches shall be suitable for a flow of 20 to 100 percent of the required flows specified herein.

PART 3 – EXECUTION

3-1. INSPECTION. All piping and equipment shall be inspected for damage and cleanliness before being installed. All strainer elements shall be removed, cleaned, and reinstalled. Any material damaged or contaminated in handling on the job shall not be used unless it is repaired and re-cleaned to the original requirements by Design-Builder. Such material shall be segregated from the clean material and shall be inspected and approved by Owner or his representative before its use.

3-2. INSTALLATION. All equipment shall be installed with sufficient clearance for proper operation of any external mechanisms, and with sufficient clearance to dismantle any portion of the station for in-place maintenance. Unions shall be required at all solenoid valves and pressure reducing valves. Installation shall be in accordance with the manufacturers' recommendations.

End of Section

Section 43 05 41

CHEMICAL STORAGE TANK INSTALLATION

PART 1 - GENERAL

1-1. SCOPE. This section covers installation of tanks for aboveground bulk storage of chemical solutions.

Tanks, piping, pipe supports, valves, and accessories which are not an integral part of the tanks are covered in other sections.

1-2. GENERAL.

1-2.01. Coordination. The tanks are to be installed in areas of limited access. The timing of installation for the tanks shall be coordinated with building construction and with construction under other contracts as needed.

1-3. DELIVERY, STORAGE, AND HANDLING. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

3-1. INSPECTION. All equipment and accessories shall be inspected for damage and cleanliness before being installed. Any item damaged or contaminated in handling on the job shall not be used unless it has been repaired and re-cleaned to the original requirements by Contractor. Such items shall be segregated from clean or undamaged items and shall be inspected and approved by Owner or his representative before its use.

3-2. PREPARATION. The concrete base for each tank shall be constructed in accordance with the Cast-in-Place Concrete section and shall be level and smooth to the tolerances recommended by the tank manufacturer.

3-3. INSTALLATION. When the tank containment area has a corrosion protection system specified, the protection system shall be applied and cured to the tank base before each tank is installed. Each tank shall be installed in accordance with the tank manufacturer's recommendations, the applicable governing standard, and to the satisfaction of Engineer. At any location where a

containment corrosion protection system lining is penetrated including anchorage of a tank, a caulking material suitable for the specified service conditions and recommended by the protection system manufacturer shall used to seal around the penetration. Grouting under the tank, if recommended by the tank manufacturer, shall be accomplished with nonshrinking grout as specified in the Grouting section.

3-4. FIELD QUALITY CONTROL.

3-4.01. Lining Testing. When a corrosion resistant lining is specified, the liner shall be tested after installation for damage occurring during installation. The lining shall be tested for holidays and pinholes using a low-voltage unit holiday detector approved by the coating manufacturer and acceptable to Engineer. Locations where holidays and pinholes are detected shall be marked for repair and retested after repair work has been completed. Contractor shall certify the lining is free of holidays and pinholes.

3-4.02. Leakage Testing. After installation and testing of any lining, each tank shall be filled with water to the level required and allowed to stand for a period of not less than 48 hours. During testing, flanged connections may be plugged by installing temporary blind flanges on the outside of the tank, but shall not be blocked or plugged on the inside. All leaks or indication of leaks shall be repaired by the tank manufacturer and the tank re-tested to the satisfaction of Engineer.

3-5. CLEANING. When installation and testing have been completed and all connections have been made, all tank surfaces, both interior and exterior, shall be thoroughly cleaned as recommended by the tank manufacturer and to the satisfaction of Engineer. Abrasive cleaning agents shall not be used.

End of Section

Section 43 11 15

DRY SCREW POSITIVE DISPLACEMENT BLOWERS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of electric motor driven, rotary dry screw, positive displacement blower packages to be installed as indicated on the Drawings and as required.

Each blower package shall be a factory fabricated skid and shall include blower, motor, inlet filter, inlet silencer, discharge silencer, belts, sheaves, belt guard, flexible connections, safety valve, discharge check valve, instrumentation, controls, and vibration isolators. The screw blowers shall be single-stage, electric motor-driven and must deliver 100% oil-free, pulsation-free air. The screw blowers must feature internal compression. Twisted rotors are not acceptable. Blowers shall be driven by an Variable Frequency Drive (VFD). VFD shall be provided by others. All components with the exception of the control panel, intake filters and AFD shall be mounted within an acoustic enclosure and the blower shall match the air demand by continuously changing the speed of the drive motor to ensure the air net pressure is maintained. Each blower package shall be complete with all spare parts, accessories and appurtenances indicated on the drawings, specified herein, or otherwise needed for proper operation.

Blower System	Process Blowers
Blower Location	Outdoors adjacent to BNR Tanks
Number of blowers	3
Blower tag numbers	AER-BL-0101
	AER-BL-0201
	AER-BL-0301

Piping, pipe supports, valves, and accessories that are not an integral part of the equipment or specified herein are covered in other sections.

1-2. GENERAL.

1-2.01. Coordination. Equipment furnished under this section shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions, and recommendations furnished by the equipment manufacturer unless exceptions are noted by the Design-Builder.

All blowers specified herein shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

The blower unit shall be a current standard product of the blower manufacturer and shall be a fully factory assembled package by one of the manufacturers specified here in or by one of the blower packagers specified herein. All accessory items, including the sound enclosure, shall be furnished by the blower manufacturer or the blower packager specified herein.

For general construction contracts and aeration applications, Design-Builder shall be responsible for coordinating the blowers with the equipment specified in the diffused aeration equipment section. Design-Builder shall be responsible for any changes required in the blower design resulting from changes in the diffused aeration equipment design, including pressure losses through the submerged piping system and diffusers.

Unless exceptions are noted by Design-Builder, the equipment arrangement and piping may be modified in accordance with the recommendations of the equipment manufacturer to suit the equipment furnished. All needed modifications shall be reviewed by the Design-Builder and shall be performed by the Design-Builder at no additional cost to Owner.

Butterfly modulating valves, flow meters and dissolved oxygen analyzers as specified in Industrial Butterfly Valves Section 400564, Flow Instruments Section 407100, and Process Analytical Instruments Section 407500 shall be furnished by the Blower Manufacturer. Complete controls system integration and programming shall be performed by the Blower Manufacturer.

1-2.01.01. Air Blower Controls System Supplier (ABCSS). Controls integration and programming shall be performed by the specified Blower Manufacturer or Blower Packager or by an I&C subcontractor provided by the specified Blower Manufacturer of Blower Packager. The ABCSS shall meet the following criteria:

Selection Procedure for Control System Supplier	
(1)	Does the ABCSS have at least 5 years in-house I&C experience with the dissolved oxygen/most open valve method of blower control, along with the capabilities to construct and program the Blower Master Control Panel (BMCP)? If "Yes," go to Item 2. If "No", go to Item 3.
(2)	ABCSS may use their own I&C department. Proof of experience will be required. Submit references, complete with contact information. Projects cited must be in full-scale operation. Mandatory meetings will be required between ABCSS, Design-Builder, and I&C Subcontractor in order to coordinate installation of flowmeters, control valves, dissolved oxygen meters, and any other appurtenances required for a fully functioning air delivery system.

Selection Procedure for Control System Supplier	
(3)	Does the ABCSS have a working relationship with an I&C Subcontractor? The ABCSS shall provide references from the I & C Subcontractor, complete with contact information, including a minimum of three completed jobs (in full-scale operation) in operation for at least 5 years. The completed jobs shall have used dissolved oxygen/most open valve blower control, and the I&C Subcontractor must have provided the BMCP along with all of the programming. If "Yes", go to Item 4. If "No", go to Item 1.
(4)	ABCSS may retain the services of their own I&C subcontractor. Proof of experience will be required. Mandatory meetings will be required between ABCSS, ABCSS's I&C Subcontractor, Design-Builder, and I&C Subcontractor. Purpose of the meetings shall include but not be limited to coordination of the BMCP and plant SCADA system.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. Governing Standards. Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations which pertain to such work. In case of a conflict between these specifications and any state law or local ordinance, the latter shall govern.

All work shall comply with Underwriters' Laboratories (UL) safety requirements.

1-2.04. Power Supply. Unless otherwise indicated, power supply to the equipment shall be 480 volts, 60 Hz, 3 phase.

1-2.05. Tagging. Each item of equipment and each part shipped separately shall be tagged and identified with indelible markings for the intended service. Tag number shall be clearly marked on all shipping labels and on the outside of all containers in accordance with the Equipment and Valve Identification section.

1-2.06. Nameplates. Each blower and accessory component having a tag number as indicated on the Drawings or specified herein, shall be provided with a permanent number plate in accordance with the Equipment and Valve Identification section. The location of number plates and the method of fastening shall be acceptable to Design-Builder.

1-2.07. Lubrication. Equipment shall be adequately lubricated by systems which require attention no more frequently than weekly during continuous operation. Lubrication systems shall not require attention during startup or shutdown and shall not waste lubricants.

Lubricants shall be provided in sufficient quantities to fill all lubricant reservoirs and to replace all consumption during testing, startup, and operation prior to acceptance of equipment. Lubricant type shall be as recommended by the equipment manufacturer.

1-2.08. Abbreviations. Reference to standards and organizations in the Specifications shall be by the following designations:

AFBMA	Antifriction Bearing Manufacturers Association
AGMA	American Gear Manufacturers Association
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
Fed Spec	Federal Specification
IEEE	Institute of Electrical and Electronics Engineers
MIL	Military Specification
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NPT	National Pipe Thread
OSHA	Occupational Safety and Health Administration
UL	Underwriters' Laboratories

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete assembly and installation drawings, wiring and schematic diagrams, together with detailed specifications and data covering materials used, parts, devices and other accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section. Device tag numbers indicated on the contract drawings shall

be referenced on the wiring and schematic diagrams where applicable. The data and specifications for each unit shall include, but not be limited to the following:

Package

Letter from the blower manufacturer confirming blower package is fully shop assembled and will meet the performance requirements specified herein.

Dimensional drawings showing overall package dimensions, connection locations and sizes.

Package weight.

Blowers

Name of manufacturer.

Type and model.

Full rotative speed at rated condition.

Blower design maximum rotative speed.

Critical speed of the rotor.

Type of bearings, AFBMA L_{10} life rating, and lubrication.

Connection sizes.

Maximum air temperature at discharge flange.

Maximum allowable forces and moments on blower inlet and discharge flanges.

Net weight of blower.

Net weight of heaviest single component requiring removal for maintenance.

Overall dimensions.

Complete performance curves or tables showing discharge pressure versus capacity and speed, blower and overall efficiency, and bhp at minimum and maximum ambient air temperatures and at standard conditions.

Reduced speed performance curve or tables for each 100 rpm increment at specified conditions including maximum, average, and minimum temperatures and corresponding relative humidity where variable frequency drives are required.

Speed versus capacity equation or data table where variable frequency drives are required.

Shop painting data.

Anchor bolt location details.

Rubber-cork vibration isolator pads and their sizing information.

Maximum free field noise level at 3 feet.

Letter from the blower manufacturer confirming that the free field noise at three feet from the blower enclosure will not exceed the specified sound level while operating at the specified capacity.

Letter from the blower manufacturer confirming that the blower inlet and discharge noised across the entire Octave Band, including the inlet and discharge silencers, will not exceed the specified maximum allowable noise levels when operating at the specified capacity.

Motors

As specified in the General Purpose Induction Motors Section 16220.

Letter from the blower manufacturer that the VFD and motor have been coordinated.

Variable Frequency Drives

As specified in the Variable Frequency Drives Section 16150.

Controls

Blower control panel layout including interior and exterior views.

Accessory device data including catalog cut sheets on all control components.

Wiring diagram.

Accessories

Name of manufacturer.

Equipment data indicating overall dimensions, connection sizes, weights and materials of construction, pressure losses, efficiencies, and noise attenuation as applicable.

Drawing showing internal silencer baffling and construction.

Sound attenuation at each octave band for each silencer.

Drawing showing internal construction of each silencer.

Inlet Filter Silencers

Manufacturer and model.

Sound attenuation at each octave band.

Filter particle arrestance and efficiency.

Filter material.

Filter housing dimensions.

Certified Shop Test Reports

Test data and results.

Sample calculations.

1-3.02. Operation and Maintenance Manuals. Adequate operation and maintenance information shall be supplied as required in the Submittals Procedures section. Operation and maintenance manuals shall be submitted in accordance with the Submittals section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-4. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

1-5. SPARE PARTS. The Supplier shall furnish all special tools and spare parts recommended by the manufacturers of equipment specified herein.

- Any special tools required for installation or maintenance of any of the furnished equipment shall be furnished.
- A complete itemized price list of all recommended special tools, spare parts, and consumables shall be submitted.
- A set of recommended spare parts and consumables for system startup and testing shall be furnished.
- A set of recommended spare parts and consumables for one year of operation from Date of Substantial Completion or Acceptance of Final Testing, whichever is later, shall be furnished.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS.

The blowers shall be suitable for the following service conditions:

Seismic and wind loading criteria	See the Meteorological and Seismic Design Criteria Section	
Barometric pressure	14.7	psia
Design maximum inlet air temperature	110	°F
Design minimum inlet air temperature	23	°F
Design relative humidity at maximum design temperature	50	%
Design relative humidity at minimum design temperature	46	%

Parts shall be interchangeable between units of similar size and capacity to extent practical.

All equipment furnished shall be designed to meet all specified conditions and to operate satisfactorily at this elevation.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Blower units shall be designed for the operating conditions as follows:

Blowers

Service	Aeration		
Blower tag numbers	AER-BL-0101 AER-BL-0201 AER-BL-0301		
Installation	Outdoors		
Operation	Parallel and Stand alone		
Discharge pipe connection	Horizontal		
Inlet pressure at blower suction flange		14.3	psia
Maximum inlet pressure loss including dirty inlet filter, inlet piping, inlet valves		0.4	psi
Rated discharge pressure at the package outlet flange		10.3	psig

Minimum capacity at rated package discharge pressure, maximum inlet air temperature and relative humidity and rated operating speed	1,050	scfm
Turndown at rated discharge pressure, minimum inlet air temperature and relative humidity	525	scfm
Ratio of maximum rated blower operating speed at normal motor speed to maximum allowable blower speed	95	%
Ratio of rated discharge pressure at blower outlet flange to maximum allowable blower discharge pressure	80	%
Maximum rated speed of motor	3600	rpm
Maximum power required at rated discharge pressure, specified ambient temperatures and relative humidity range, and rated operating speed	95	bhp
Drive motor rating	100	hp
VFD Required	Yes	
Intake Filter		
Maximum initial pressure drop.	2	in wc
Maximum face velocity at housing entrance	50	ft/min
Filter configuration	Piped (Endustra)	
Particle arrestance (removal percentage/size)	98% for 10 micron and larger particles	
Minimum inlet connection	10	in
Inlet and discharge silencer		

Minimum octave band sound attenuation		
Octave band 63	27	dB
Octave band 125	31	dB
Octave band 250	31	dB
Octave band 500	29	dB
Octave band 1000	26	dB
Octave band 2000	24	dB
Octave band 4000	23	dB
Octave band 8000	21	dB
Maximum silencer operating temperature	350	°F
Maximum estimated free field noise level with piped inlet and discharge connections at rated operating speed, measured 3 feet from any surface of sound enclosure	80	dBA
Maximum overall vibration velocity of blower at any point on the blower skid at rated operating speed	0.45	in/sec
Discharge Flexible Connections*		
Discharge configuration	Side	
Number of arches	3	
Lateral movement capability	2.5	in
Axial movement capability	5	in
Lateral spring rates range	350	lb/in
Axial spring rates range	380	lb/in
Blower discharge connection size*	10	in
Maximum face-to-face length	16	in
Temperature rating	300	°F
Package Dimensions		
Maximum Enclosure Length Including Discharge Flange	80	in

Connection		
Maximum Enclosure Width	50	in
Maximum Enclosure Height	70	in
Blower Discharge Connection Location	Short Side	
Blower Inlet Connection Location	Short Side	

(*) Flexible connection size shall match package discharge size. If size different than indicated here in, spring rates shall meet the flexible connection specifications indicated in Section 2-6.04.

Standard cubic feet per minute, scfm, is defined as air at 14.7 psia, 68°F and 36 percent relative humidity. Blowers shall be capable of providing the specified mass flow in scfm throughout the entire operating range including at the specified summer conditions.

2-3. ACCEPTABLE MANUFACTURERS. Blowers shall be as manufactured and packaged by Robuschi or Atlas Copco, or provided by the blower packager Universal Blower PAC or Excelsior Blower Systems without exception.

2-4. MATERIALS.

Casing and Impellers	Cast iron or ductile iron.
Shafts	High carbon steel or ductile iron; turned, ground and polished.
Timing Gears	Alloy steel.
Base	Fabricated steel.

2-5. CONSTRUCTION.

2-5.01. Casings. Casings shall be designed to withstand at least twice the specified discharge pressure and shall be reinforced with integrally cast ribs. Each casing shall be provided with tapped and plugged openings for casing and bearing drains and fittings for properly adding bearing and gear lubricant.

2-5.02. Impellers. The blower compression element shall comprise of helicoidal screw rotors, with lobes and flutes turning into each other. Rotors must feature internal compression. Twisted rotors are not acceptable. Some of the compression shall take place within the blower element between the rotors and the rotor and casing. Impellers shall be statically and dynamically balanced. Each impeller/shaft shall be supported by anti-friction bearings.

2-5.03. Shafts. Shafts shall be cast integrally with the impeller or shall pass completely through the impeller. Stub shafts will not be acceptable. Impellers shall be securely attached to through shafts.

2-5.04. Timing Gears. The intermeshing timing gears shall ensure the rotors do not touch each other and maintain the requisite clearance between the rotors & ensure wear and tear is eliminated and no lubrication is required in the compression space. Timing gears shall be enclosed in oiltight housings and shall be splash or lubricated. Timing gears shall provide non-slip rotor timing.

2-5.05. Belts and Sheaves. All belts and blower and motor sheaves required for the blower shall be furnished. Belts and sheaves shall be of the heavy-duty "V" type with a horsepower rating of at least 1.4 times the motor nameplate horsepower. Belts shall be matched sets.

2-5.06. Seals. Seals shall be designed to prevent lubricant from leaking into the air stream as well as to prevent oil from leaking out of the machine. The seal shall consist of two rotary slip rings mounted in a retainer with an atmospheric air gap in the center.

2-5.07. Base Frame. A full length, common base shall be provided for each blower package. The base frames shall be constructed of cast iron or heavy steel plate and structural members and shall be designed for no measurable deflection with the equipment mounted thereon and the base frame supported from the floor. Each base shall be designed so that all equipment bolted to it can be removed without access to the underside, and for ease of cleaning. Structural stiffeners shall be located under the equipment at the equipment anchor points. A drip lip will not be required. The base shall be suitable for direct attachment to the foundation. Complete support of the inlet and discharge silencers, blower control panel and the acoustic enclosure shall be from the base frame. The blower supplier shall provide and install silencer supports for each blower package. The inlet filter shall be attached to the inlet silencer.

2-5.08. Silencers. Each blower shall be furnished with a silencer in the suction and discharge piping. Silencers shall be multi-chambered reactive type or combination multi-chambered reactive/absorptive type as required by the blower operating speed. Silencers shall be equipped with ported tubes and air passageways to reduce blower pulsations and system air noise from the blower. There shall be no “line of sight” passages within the silencer design. Each silencer shall be of all-welded steel construction with painted exterior surfaces and flanged connections with diameter and drilling conforming to ASME B16.1, Class 125.

2-5.09. Acoustical Enclosure. The acoustic enclosure shall be a self-supporting structure housing the blower, motor drive, and intake and discharge silencers and mounted on the package skid base. If material is friable, the enclosure shall be constructed of panels consisting of noise dampening material sandwiched

between two metal sheets as required. If the material is non-friable such as foam rubber, the interior metal sheet is not required as long as sound attenuation is not compromised. The enclosure shall be provided with removable panels or hinged sections to allow routine blower and V-belt maintenance. A complete enclosure, enclosing the total blower package, including the silencers shall be provided. Partial enclosures are not acceptable.

The enclosure shall be designed to withstand the specified wind velocity without damage. All bracing and reinforcing members shall be integral to the enclosure. Blower oil drain piping shall be piped to outside of enclosure and terminated with a threaded pipe cap. Air piping shall be piped to outside of the enclosure and terminate with a pipe flange. The flanges shall be ASME B16.1, Class 125 diameter and drilling and shall extend not less than 4 inches outside of the enclosure for flange bolt removal.

An internal ventilating system shall be provided for the enclosure. The ventilation system shall utilize a 120 volt ac rated electric motor driven ventilating fan to draw ambient air into the enclosure for cooling the enclosed equipment prior to exhausting the air outside of the enclosure. Air inlet and exhaust openings shall have noise abatement features that meet the maximum noise level specified when the ventilating system and blower are operating simultaneously. The ventilating fan shall be powered and controlled through the blower control panel.

2-5.10. Anchor Bolts. Anchor bolts shall be per the General Equipment Stipulation and the Anchorage in Concrete and Masonry section.

2-6. ACCESSORIES.

2-6.01. Intake Filter Silencer. Each blower shall be provided an intake filter silencer shipped loose for installation by the Design-Builder in the suction piping as indicated on the Drawings. The blower package shall be provided with a flanged connection to allow connection of the inlet air piping. Each filter silencer shall be of all-welded steel construction with a powder coated epoxy exterior, replaceable synthetic, dry filter element, and flanged outlet connection with diameter and drilling conforming to ANSI B16.1, Class 125. Filter silencers shall be suitable for continuous weather exposure in exterior locations.

Filter silencer shall be installed such that the outside air inlet of the filter unit shall be a minimum of 4 feet above the adjacent grade or roof. The filter silencer shall connect to the suction piping without reducers. Additionally each inlet pipe shall be provided with differential pressure switches to shut down the blower on high differential pressure across the inlet filter (dirty filter).

Filter silencer shall be Endustra without exception.

2-6.02. Blowoff Silencers. Not used.

2-6.03. Vibration Isolator Base Pads. Rubber-cork vibration isolator pads shall be supplied by the blower packager for each blower.

2-6.04. Flexible Connections. An elastomeric, flanged, arched type flexible connection shall be provided in the suction and discharge piping adjacent to each blower as specified herein.

Each flexible connection shall be sized to allow piping movement without exceeding the blower manufacturer's force allowance at the blower flange. The number of arches shall be as specified herein or as needed to meet the specified spring rates and movement capabilities. The inlet connection shall be suitable for 7 psi vacuum service and the discharge connection shall be suitable for a pressure of 15 psig and a temperature rating of 300°F. Suction flexible connectors shall be single arch, Mercer “Type 450”, or equal. Discharge flexible connectors shall be Mercer “Type 450” with “Type 500” retaining rings and Kevlar reinforcement, or equal, with the number of arches, spring rate, and movement as indicated herein.

2-6.05. Valves.

2-6.05.01. Safety Valves. Each blower shall be provided with a safety valve as recommended by the blower manufacturer. The safety valves shall be capable of protecting the blowers from damage due to operation with a closed discharge valve. The valves shall be suitable for temperature up to 300°F. Set points shall be at least 1 psi above the rated blower discharge pressure unless otherwise indicated.

2-6.05.02. Check Valves. An air check valve shall be installed in the discharge piping from each blower downstream of the discharge silencer as part of the factory piped package. See the Check Valve section.

2-6.06. Pressure Gauges. A pressure gauge shall be furnished and installed in the discharge piping of each blower and a vacuum gauge in the suction piping of each blower.

Pressure gauges shall conform to ANSI B40.1 and shall be of the indicating dial type with C-type phosphor bronze bourdon tube, stainless steel rotary geared movement, phenolic open front turret case, adjustable pointer, stainless steel or phenolic ring, and acrylic plastic or shatterproof glass window. All gauges shall be ANSI Accuracy Grade A. Gauges installed indoors shall be liquid filled.

The dial shall be 4-1/2 inch size with white background and black markings and shall have dual English and metric indication. The English units of measurement shall be pounds per square inch and the metric units shall be kilopascals. The

range for each discharge pressure gauge shall be from 0 to 15 psig. The range for each vacuum gauge shall be from 15 inches Hg vacuum to 0. Pointer travel shall be not less than 200 degrees nor more than 270 degrees.

All gauges shall be provided with 1/2 inch NPT connections. Each gauge shall be provided with a threaded end ball type shutoff valve as specified in the Miscellaneous Ball Valves section installed at the blower discharge piping connection.

2-6.07. Pressure Switch. A pressure switch shall be furnished and installed in the discharge piping of each blower. Each switch in the blower discharge piping shall have an adjustable range of 0 to 15 psig and shall be set lower than the relief valve setting. A pressure switch shall be furnished for installation across the intake filter pair. The switch across the intake filters shall have an adjustable range from 0 to 10 inches water column vacuum.

The pressure switch shall be field adjustable and shall have a trip point repeatability of better than 1 percent of actual pressure. The switch shall have one normally open and one normally closed contact rated 10 amps at 120 volt ac. The switch shall be wired to the blower control panel and shall shut down the blower on high discharge pressure or high pressure drop across the filter. Switches shall have a weatherproof housing and shall be as manufactured by Static-O-Ring Company, Mercoid Control, Barksdale, or equal.

2-6.08. Draft Gauge. A draft gauge shall be provided having a range from 0 to 10 inches water column shall be installed across each air filter or air filter silencer.

The gauge shall have minimum 3-1/2 inch dial, pressure taps, fittings for 1/4 inch metal tubing, vent valves, mounting brackets, and an adjustable signal flag.

The draft gauge shall be "Dwyer 2000 Series Magnehelic Differential Pressure Gages" manufactured by Dwyer Instruments, Inc. or equal.

2-6.09. Thermometers. A thermometer shall be provided for monitoring of temperature in the discharge piping. The thermometer shall be mounted on the blower control panel. The capillary routing shall not require disassembly for normal maintenance of the blower, motor or V-belts.

Thermometers shall be of the remote reading gas actuated dial type. Thermometers shall have a minimum dial size of 5 inches, an adjustable pointer, shall be accurate within 1 percent of full scale. Thermometers shall have both Fahrenheit and Celsius indication. Thermometers shall be furnished complete with a uniformly graduated dial indicator, armored capillary tube, bulb or temperature sensor, and thermowell. Unless otherwise indicated in the drawings or Instrument Device Schedule, thermowells shall be weld mount style.

Thermowells shall be AISI Type 316 stainless steel. Thermometer ranges shall be such that the normal operating reading will be near the midpoint of the range. The units of measurement shall be indicated on the dial face. Spare capillary length shall be neatly coiled and tied.

2-6.10. Differential Temperature Switches. Differential temperature switches shall be remote bulb type with single pole double throw ampere switches suitable for 120 volt ac. Temperature switches shall have NEMA 4 housings, stainless steel thermal well assemblies, and armored capillaries. Capillary length shall be sufficient for convenient mounting. Each differential temperature switch shall be wired to the blower control panel and shall shut down the corresponding blower on high differential air temperature across the blower.

2-6.11. Vibration Detection Systems. Not used.

2-7. BALANCE. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibrations shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the maximum unfiltered vibration velocity, as measured at any point on the machine, shall be as required.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or its components shall be less than 0.8.

2-8. DRIVE UNITS. Each blower shall be driven by an electric motor through a belt drive as required. Drive units shall be designed for 24 hour continuous service.

2-8.01. Safety Guards. All belt drives, couplings, and other moving or rotating parts shall be covered on all sides by a safety guard. Safety guards shall be fabricated from 16 USS gage or thicker galvanized or aluminum-clad sheet steel or from 1/2 inch mesh galvanized expanded metal. Each guard shall be designed for easy installation and removal. All necessary supports and accessories shall be provided for each guard. Supports and accessories, including bolts, shall be galvanized.

2-8.02. Variable Frequency Drives. A variable frequency drive (VFD) shall be provided for the blower package by others. Variable frequency drives shall be as specified in the Variable Frequency Drives Section. The blower supplier shall coordinate with the motor and VFD manufacturers and be responsible for providing a motor and VFD which produces sufficient torque above the blower load curve to assure proper acceleration under all operating conditions. The blower supplier shall also coordinate with the motor and VFD manufacturers and be responsible for providing a motor with component mass and spring constant such that torsional resonant frequencies do not occur in the system under all

accelerating and normal operating conditions. The blower supplier shall also coordinate with the motor manufacturer and be responsible for providing a motor of adequate thermal design for the system inertia and load to permit one start per hour at rated temperature rise and two successive starts at 40 degrees C ambient without exceeding the motor insulation and component temperature limits.

2-8.03. Electric Motors. Electric motors shall be in accordance with the requirements of the General Purpose Induction Motors section.

2-9. CONTROLS.

2-9.01. Blower Motor Starters. Not used.

2-9.02. Blower Local Control Panel. Each blower shall be furnished with a local blower control panel. The power supply to the blower control panel shall be 120 volt, 60 hertz, single phase. The blower control panel shall be furnished with a main circuit breaker disconnect with a lockable operating handle on the exterior of the panel. The AIC rating of the main circuit breaker and motor circuit protectors shall be 22,000 amperes at 240 volt. The blower control panel shall be furnished with all control power transformers, gauges, relays, pilot devices, indicators, etc., required to monitor, protect and shutdown its respective blower.

The control panel shall be furnished with a Local-Off/Reset-Remote selector switch for each blower. The switch shall be lockable in the center Off/Reset position. In the Local position the blower shall run and blower speed shall be set manually at the blower control panel. In the Off/Reset position the blower shall stop and reset any equipment protection/alarm conditions. In the Remote position the control panel shall accept a normally open relay contact for blower start and stop control and a 4-20mA blower speed control signal from PLC. The selector switch shall be furnished with a contact for remote indication of Remote position.

The control panel shall be mounted separate from the blower package to prevent vibration from affecting panel mounted components, as shown on the drawings. All components installed in or on the panel shall be rated for the control power supply as required. If voltages other than the specified control power supply is required, the panel supplier shall furnish the required control power transformers.

The control panel shall be furnished with a white control power on indicating light, a green blower stopped indicating light and a red blower running indicating light.

The control panel shall be furnished with amber indicating alarm lights for high differential air temperature across the blower, high discharge pressure, high differential pressure across intake filter, and motor/AFD overload/fail.

Indicating lights shall be provided for each blower.

In lieu of the lights indicated, all items may be provided on a touch screen rather than indicated by lights if preferred by the vendor. Touch screen and HMI shall be rated for 163F.

For all conditions above requiring amber indicating lights an alarm relay shall be furnished with two normally open contacts rated 10 amperes at 120 volt ac. The normally open contacts shall close for any alarm condition and shall be used for remote annunciation of a blower alarm and shall shut down the blower.

The blower control panel shall be furnished with a normally open dry run contact rated 10 amperes at 120 volts ac for remote indication of blower running.

The panel shall be furnished with a warning and alarm light test pushbutton that illuminates all panel mounted lights when pushed. The panel shall be provided with an elapsed time hour meter for displaying the running time of each blower.

The blower control panel shall provide the following outputs to the Plant Control System:

- Blower Alarm
- Blower Running
- Blower In-Remote
- Blower Speed Indication

The blower control panel shall receive the following outputs from the Plant Control System:

- Blower Speed Control
- Blower Run Command

The blower control panel shall provide the following outputs to the Variable Frequency Drive:

- Blower Speed Command
- Blower Run Command

PLC of plant control system and the associated programming of the automatic blower control shall be provided by I&C System Supplier of Specification 13500. For VFD driven blowers, the blower manufacturer shall coordinate with I&C System Supplier and provide air flow versus speed relationship for the blowers being provided.

2-9.03. Panel Fabrication Requirements. The control panel furnished shall conform to the requirements of NEMA ICS-6. Panels shall be rated NEMA Type 4X and shall be constructed from stainless steel.

All panel wiring shall be of the type normally furnished by the manufacturer with the following exceptions. All power and control wiring for 120 volt circuits shall be stranded copper #12 AWG minimum. All power and control wiring shall have a 600 volt insulation rating and a nominal maximum operating temperature of 90 degrees C. All analog circuits shall be #16 AWG twisted shielded pair rated for at least 300 volts. Conductor insulation for power, control, and analog circuits shall have a moisture-resistant and flame-retardant covering.

All wiring shall be grouped or cabled and firmly supported inside the panel. Wiring shall be bundled in groups and bound with nylon cable ties or routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel, with removable covers, and with space equal to at least 40 percent of the depth of the duct remaining available for future use after completion of installation and field wiring. Sufficient space shall be provided between cable groups or ducts and terminal blocks for easy installation or removal of cables.

The power entrance to each panel shall be provided with a surge protection device. Surge protectors shall be nominal 120 volts ac with a nominal clamping voltage of 200 volts. Surge protectors shall be of nonfaulting and noninterrupting design, with a response time not to exceed 5 nanoseconds. Surge protectors shall be manufactured by Innovative Technology, Power Integrity Corporation, or Transtector.

Terminal blocks shall be suitable for 12 AWG wire and shall be rated 30 amperes at not less than 300 volts. Terminal blocks shall be fabricated complete with marking strips, covers, and pressure connectors. Terminals shall be labeled to agree with the identification on the System Supplier's submittal drawings. A terminal shall be provided for each conductor of external circuits, plus one ground for each shielded cable. At least 25 percent spare terminals shall be provided. Not less than 8 inches of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Nameplates shall be provided on the face of each panel and on each individual control or pilot device. Panel nameplates shall be made of laminated phenolic material with engraved letters approximately 3/16 inch high extending through the black face into the white layer, and shall be secured firmly to the panel.

All control and pilot devices furnished shall be NEMA 4 rated, heavy duty oiltight.

2-9.04. Factory Panel Test. Before shipment, the panels shall be electrically tested by the manufacturer.

2-9.05. Sequence of Operation. The blower sequence of operation shall be as indicated below:

Startup Sequence:

1. Energize blower motor.
2. Release control to PLC to adjust AFD to achieve air flow rate.

Shutdown Sequence:

1. De-energize blower motor.

2-10. SHOP PAINTING. Equipment and items furnished as specified herein shall be furnished with shop coatings suitable for permanent installation and operation in accordance with the requirements in the General Equipment Stipulations section.

2-11. SHOP TESTS. Variable speed blowers shall be tested over the entire specified capacity range with contract motors and variable frequency drives.

2-11.01. Operational Test. Each blower shall be shop tested by the manufacturer for vibration and pressure developed and shall be checked for leaks, faulty components and controls.

2-11.02. Slip Test. A one psi slip test shall be performed on each blower. The test shall consist of an ASME PTC-9 slip test, with calculations correcting the results to field conditions, to ensure compliance with specifications. The test shall be in accordance to the paragraph, 4.52 of ASME PTC-9 slip test.

2-11.03. Vibration Test. A vibration test shall be performed on each blower. When the vibration test indicates an overall vibration velocity greater than 0.45 inches per second, the manufacturer shall be responsible for performing and reviewing a frequency analysis. The manufacturer shall make corrections as necessary, and confirm that the vibration velocity will not be detrimental to the equipment. An overall vibration velocity greater than 1.0 inch per second shall be sufficient cause for rejection of the equipment.

Defective equipment and controls disclosed by the tests shall be replaced and each unit placed in satisfactory operating condition before shipping.

A PDF of the test report complete with performance curves, data, and all calculations shall be submitted to the Design-Builder in accordance with the submittals section.

PART 3 – EXECUTION

3-1. INSTALLATION. Each blower unit will be installed in accordance with Equipment Installation section and as specified herein.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily.

The manufacturer's representative shall verify:

a. Each blower discharge isolation valve is fully open.
b. Each check valve is properly installed.
c. Piping is installed such that excessive force is not being exerted on the blower flanges.
d. No resonance vibration conditions are occurring within the blower package or air piping.

All costs for these services shall be included in the contract price.

3-3. FIELD RUN TESTING. All pre-checks and preliminary tests will need to be completed and approved by the Design-Builder and manufacturer prior to performance testing.

Each blower shall be mechanically checked for proper operation. Each alarm and safety shutdown shall be checked by artificially simulating an alarm condition. Defective equipment and controls disclosed by the tests shall be replaced or corrected, and the packages placed in satisfactory operating condition. The following items shall be measured, recorded, and submitted in a field test report:

a. Discharge pressure, each blower.
b. Differential temperature across each blower unit.

c. Differential pressure across each intake filter unit.

d. Pressure and temperature at downstream end of piping system at any measurement taps provided.

e. Outdoor ambient temperature.

f. Indoor ambient temperature.

g. Barometric pressure.

3-4. TEST REPORTS. The equipment manufacturer shall prepare a test report, including all installation check and performance tests and other recorded data and observations. A PDF copy of the report shall be submitted to Design-Builder after completion of the specified tests.

3-5. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer's expense.

3-6. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-6.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-6.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

3-7. WARRANTY. All blowers shall be provided with a warranty as specified in the General Provisions section. Blower manufacturers who do not have 5 years' operating experience with the specified blower type, as indicated by a reference list complete with contact information and installation dates, shall provide an extended warranty of 5 years at no additional cost to the Owner.

End of Section

Section 43 11 17

ROTARY LOBE POSITIVE DISPLACEMENT BLOWERS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of an electric motor, variable frequency driven, rotary, positive displacement blower packages to be installed as indicated on the Drawings and as required. The Design-Builder shall be responsible for providing the blower packages for the Sludge Holding Tanks.

Each blower package shall be a factory or shop fabricated skid and shall include blower, motor, inlet filter, inlet silencer, discharge silencer, belts, sheaves, belt guard, flexible connections, safety valve, discharge check valve, instrumentation, controls, and vibration isolators. The blower package shall be complete with all spare parts, accessories and appurtenances indicated on the Drawings, specified herein, or otherwise needed for proper operation.

Blower designation.	Sludge Holding Tank Blowers
Number of blowers.	2
Blower tag numbers.	AIR-BL-0001, AIR-BL-0002
Blower location.	Residuals Area 70

Piping, pipe supports, some valves, and accessories for the equipment may be covered in other sections.

1-2. GENERAL.

1-2.01. Coordination. Equipment furnished under this section shall be fabricated and assembled in full conformity with Drawings, Specifications, Engineering data, instructions, and recommendations furnished by the equipment manufacturer unless exceptions are noted by Design-Builder.

Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

The blower unit shall be a current standard product of the blower manufacturer and shall be a fully shop assembled package by one of the blower packagers specified in the data sheet. All accessory items shall be furnished by the blower packager.

The blower supplier shall be responsible for coordinating all components of the motor driven blowers including the variable frequency drives.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations Section, the requirements specified herein shall take precedence.

1-2.03. Governing Standards. Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations which pertain to such work. In case of a conflict between these specifications and any state law or local ordinance, the latter shall govern.

All work shall comply with Underwriters' Laboratories (UL) safety requirements.

1-2.04. Power Supply. Unless otherwise indicated, power supply to the equipment shall be 480 volts, 60 Hz, 3 phase.

1-2.05. Tagging. Each item of equipment and each part shipped separately shall be tagged and identified with indelible markings for the intended service. Tag number shall be clearly marked on all shipping labels and on the outside of all containers.

1-2.06. Nameplates. The blower and accessory component having a tag number as indicated on the Drawings or specified herein, shall be provided with a permanent number plate. The location of number plates and the method of fastening shall be acceptable to Design-Builder. Permanent number plates shall be as specified in the Equipment and Valve Identification Section.

1-2.07. Lubrication. Equipment shall be adequately lubricated by systems which require attention no more frequently than weekly during continuous operation. Lubrication systems shall not require attention during startup or shutdown and shall not waste lubricants.

Lubricants shall be provided in sufficient quantities to fill all lubricant reservoirs and to replace all consumption during testing, startup, and operation prior to acceptance of equipment. Lubricant type shall be as recommended by the equipment supplier.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete assembly and installation drawings, wiring and schematic diagrams, together with detailed specifications and data covering materials used, parts, devices and other accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures Section. Device tag numbers indicated on the Contract Drawings shall be referenced on the wiring and schematic diagrams where applicable. The

data and specifications for the unit shall include, but not be limited to the following:

Package

Letter from the blower manufacturer confirming blower package is fully shop assembled and will meet the performance requirements specified herein.

Dimensional drawings showing overall package dimensions, connection locations and sizes.

Package weight.

Blowers

Name of manufacturer.

Type and model.

Full rotative speed at rated condition.

Blower design maximum rotative speed.

Critical speed of the rotor.

Type of bearings, ABMA L_{10} life rating, and lubrication.

Connection sizes.

Maximum air temperature at discharge flange.

Maximum allowable forces and moments on blower inlet and discharge flanges.

Net weight of blower.

Net weight of heaviest single component requiring removal for maintenance.

Overall dimensions.

Complete performance curves or tables showing discharge pressure versus capacity and speed, blower and overall efficiency, and bhp at minimum and maximum ambient air temperatures and at standard conditions.

Reduced speed performance curve or tables for each 100 rpm increment at specified conditions including maximum, average, and minimum temperatures and corresponding relative humidities where variable frequency drives are required.

Shop painting data.

Anchor bolt location details.

Maximum estimated free field noise level at 3 feet.

Rubber cork pads isolators.

Motors

As specified in the Common Motor Requirement for Process Equipment.

Variable Frequency Drives

As specified in the Variable Frequency Drives Section.

Controls

Accessory device data including catalog cut sheets on all control components.

Accessories

Name of manufacturer.

Equipment data indicating overall dimensions, connection sizes, weights and materials of construction, pressure losses, efficiencies, and noise attenuation as applicable.

Drawing showing internal silencer baffling and construction.

Sound attenuation at each octave band for each silencer.

Drawing showing internal construction of each silencer.

Certified Shop Test Reports

Performance data.

Test data and results.

1-3.02. Operation and Maintenance Manuals. Adequate operation and maintenance information shall be supplied as required in the Submittals Procedures Section. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures Section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-4. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the General Terms and Conditions.

1-5. SPARE PARTS. The Supplier shall furnish all special tools and spare parts recommended by the manufacturers of equipment specified herein.

- Any special tools required for installation or maintenance of any of the furnished equipment shall be furnished.
- A complete itemized price list of all recommended special tools, spare parts, and consumables shall be submitted.

- A set of recommended spare parts and consumables for system startup and testing shall be furnished.
- A set of recommended spare parts and consumables for one year of operation from Date of Substantial Completion or Acceptance of Final Testing, whichever is later, shall be furnished.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. Two dedicated blower packages consisting of two blowers shall provide mixing air to Sludge Holding Tanks 1 and 2.

The blower shall be suitable for the service conditions listed in the Meteorological and Seismic Design Criteria section and for the following service conditions:

Barometric pressure	14.7	psia
Design maximum inlet air temperature.	100	°F
Design minimum inlet air temperature.	23	°F
Design relative humidity at maximum design temperature.	50	%
Design relative humidity at average design temperature.	46	%

Parts shall be interchangeable between units of similar size and capacity to extent practical.

All equipment furnished shall be designed to meet all specified conditions and to operate satisfactorily at this elevation.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Blower units shall be designed for the operating conditions as follows:

	Sludge Holding Tank System	
Blower tag numbers.	AIR-BL-0001, AIR-BL-0002	
Operation.	Operation.	
Discharge pipe connection.	Horizontal, low	
Maximum inlet pressure loss	0.4	psi
Inlet pressure at package suction flange.	14.3	psia

	Sludge Holding Tank System	
Rated discharge pressure at package outlet flange.	10.8	psig
Rated blower differential pressure.	11.2	psi
Minimum discharge pressure at package outlet flange (at low sludge tank level)	1.5	psig
Minimum capacity at rated package discharge pressure, maximum inlet air temperature and relative humidity and rated operating speed	320	scfm
Turndown capacity rated package discharge pressure, maximum inlet air temperature and relative humidity and rated operating speed	150	scfm
Maximum rated blower speed.	TBD	rpm
Ratio of maximum rated blower operating speed at normal motor speed to maximum allowable blower speed.	90	%
Ratio of rated discharge pressure at blower outlet flange to maximum allowable blower discharge pressure.	90	%
Maximum rated speed of motor.	3600	rpm
Maximum shaft power required at rated discharge pressure, minimum inlet temperature and relative humidity, and rated operating speed.	23.5	bhp
Maximum drive motor rating	25	hp
Intake Filter		
Equipment tag numbers.	N/A	
Maximum initial pressure drop.	2	in wc

	Sludge Holding Tank System		
Maximum face velocity at housing entrance.	100		ft/min
Filter configuration	Bottom-outlet Cartridge		
Filter element type.	Synthetic		
Particle arrestance (removal percentage/size).	98% for 10 micron and larger particles		
Minimum inlet and discharge silencer sound attenuation for blowers.			
Octave band 63.		17	dB
Octave band 125.		23	dB
Octave band 250.		27	dB
Octave band 500.		31	dB
Octave band 1000.		30	dB
Octave band 2000.		27	dB
Octave band 4000.		23	dB
Maximum discharge silencer operating temperature.		300	°F
Maximum estimated free field noise level with piped inlet and discharge connections at rated operating speed, measured 3 feet from any surface of acoustic enclosure.		85	dBA
Maximum overall vibration velocity of unpackaged blower at rated operating speed.		0.45	in/sec
Discharge Flexible Connection			
Discharge configuration		Horizontal	
Number of arches.		3	
Temperature rating.		300	°F

Standard cubic feet per minute, scfm, is defined as air at 14.7 psia, 68°F and 36 percent relative humidity. Blowers shall be capable of providing the specified mass flow in scfm throughout the entire operating range including at the specified summer conditions.

2-3. ACCEPTABLE MANUFACTURERS. Blowers shall be as manufactured by Aerzen, Atlas Copco, Gardner Denver, or Kaeser and the blowers shall be packaged by Aerzen, Atlas Copco, Kaeser, or Universal Blower PAC.

2-4. MATERIALS.

Casing and Impellers	Cast iron or ductile iron.
Shafts	High carbon steel or ductile iron; turned, ground and polished.
Timing Gears	Alloy steel.
Bearings	Antifriction, oil lubricated, ABMA rated L_{10} for 80,000 hours continuous operation.
Base	Fabricated steel.
Acoustical Enclosure	Galvanized steel, 14 gage thick, primed, with sound-absorbing material a minimum of 2” thick.

2-5. CONSTRUCTION.

2-5.01. Casings. Casings shall be designed to withstand at least twice the specified discharge pressure and shall be reinforced with integrally cast ribs. Each casing shall be provided with tapped and plugged openings for casing and bearing drains and fittings for properly adding bearing and gear lubricant.

2-5.02. Impellers. Impellers shall be reinforced by internal ribs and shall have all outside surfaces machined. The impeller shall be statically and dynamically balanced. Impellers shall be arranged for vertical air flow through the units unless otherwise indicated.

2-5.03. Shafts. Shafts shall be cast integrally with the impeller or shall pass completely through the impeller. Stub shafts will not be acceptable. Impellers shall be securely attached to through shafts.

2-5.04. Timing Gears. Timing gears shall be enclosed in oil tight housings.

2-5.05. Belts and Sheaves. All belts and blower and motor sheaves required for the blower shall be furnished. Belts and sheaves shall be of the heavy-duty "V" type with a horsepower rating of at least 1.2 times the motor nameplate horsepower.

2-5.06. Base Frame. A full length, common base shall be provided for the blower package. The base frames shall be constructed of cast iron or heavy steel plate and structural members and shall be designed for no measurable deflection with the equipment mounted thereon and the base frame supported from the floor. The base shall be designed so that all equipment bolted to it can be removed without access to the underside, and for ease of cleaning. Structural stiffeners shall be located under the equipment at the equipment anchor points. A drip lip will not be required. The base shall be suitable for direct attachment to the foundation. Complete support of the inlet and discharge silencers shall be from the base frame. The blower supplier shall provide and install silencer supports for the blower package. The inlet filter shall be attached to the inlet silencer.

2-5.07. Silencers. The blower shall be furnished with a silencer in the suction and discharge piping. Silencers shall be multi-chambered reactive type or combination multi-chambered reactive/absorptive type as required by the blower operating speed. Silencers shall be equipped with ported tubes and air passageways to reduce blower pulsations and system air noise from the blower. There shall be no “line of sight” passages within the silencer design. Each silencer shall be of all-welded steel construction with painted exterior surfaces and flanged connections with diameter and drilling conforming to ASME B16.1, Class 125.

If the specified 3-lobe blower vendor does not offer the type of silencers specified in their package, the following paragraph shall apply.

If resonance in the piping occurs, an independent consultant shall be contracted to analyze the noise. If the resonance is the result of pulsations emanating from the blower package, then the blower packager will be liable for the charges relating to the acoustical analysis and correction of the problem. Correction of the problem will likely involve installation of additional silencers. Additional silencers shall be installed as close to the blower package as possible to prevent resonant piping lengths. The blower shall be initially sized with sufficient additional pressure capability to compensate for the losses through additional silencers in case they are required. Additional silencers shall be as specified herein with low frequency sound attenuation capability.

2-5.08. Acoustical Enclosure. The acoustic enclosure shall be a self-supporting structure housing at least the blower, motor and drive mounted on the package skid base. There shall not be pipe extensions on the skid made to accommodate the sound enclosure. The enclosure shall be constructed of panels

consisting of noise dampening material sandwiched between two metal sheets if the dampening material is friable. If the material not friable, the interior sheet may be omitted. The enclosure shall be provided with removable panels or hinged sections to allow routine blower and V-belt maintenance. The maximum weight required to be lifted for removal/opening the access openings shall not exceed 50 lbs.

All bracing and reinforcing members shall be integral to the enclosure. Air piping shall be piped to outside of the enclosure and terminate with a pipe flange. The flanges shall be ASME B16.1, Class 125 diameter and drilling and shall extend not less than 4 inches outside of the enclosure for flange bolt removal.

An internal ventilating system shall be provided for the enclosure. The ventilation system shall utilize a 120 volt ac rated electric motor driven ventilating fan to draw ambient air into the enclosure for cooling the enclosed equipment prior to exhausting the air outside of the enclosure. Air inlet and exhaust openings shall have noise abatement features that meet the maximum noise level specified when the ventilating system and blower are operating simultaneously. The ventilating fan shall be powered and controlled through the blower control panel. A timer shall be provided to allow the fan to continue to operate for an adjustable time period after the blower shuts down. When installed outdoors, the ventilation inlet and exhaust openings shall be designed to prevent rain/snow penetration during operation at the maximum wind speeds specified.

2-5.09. Anchor Bolts. Anchor bolts shall be per the General Equipment Stipulations and the Anchorage in Concrete and Masonry section.

2-6. ACCESSORIES.

2-6.01. Intake Filter. Each blower shall be provided with an intake filter installed in the suction piping. Each filter shall be of all-welded steel construction with powder coated exterior, replaceable synthetic filter element, and flanged outlet connection with diameter and drilling conforming to ANSI BI6.1, Class 125. Filter shall be cartridge type.

The filter shall connect to the suction piping without reducers. Filter shall be Endustra without exception.

2-6.02. Blowoff Silencers. Not used.

2-6.03. Vibration Isolator Base Pads. Vibration mount isolators shall be supplied with the blower package.

2-6.04. Flexible Connections. An elastomeric, flanged, arched type flexible connection shall be provided in the discharge piping adjacent to the blower as specified herein.

The flexible connection shall be sized to allow piping movement without exceeding the blower manufacturer's force allowance at the blower flange. Minimum piping movements allowed for each discharge flexible connection shall be as specified herein. The number of arches shall be as specified herein or as needed to meet the specified spring rates and movement capabilities. The inlet connection shall be suitable for 7 psi vacuum service and the discharge connection shall be suitable for a pressure of 15 psig and a temperature rating of 300ºF. Suction flexible connectors shall be single arch, Mercer “Type 450,” or equal. Discharge flexible connectors shall be Mercer “Type 450” with “Type 500” retaining rings and Kevlar reinforcement, or equal, with the number of arches, spring rate, and movement as indicated herein.

2-6.05. Valves.

2-6.05.01. Safety Valves. The blower shall be provided with a safety valve as recommended by the blower manufacturer. The safety valves shall be capable of protecting the blowers from damage due to operation with a closed discharge valve. Safety valves shall be suitable for temperature up to 300°F. Set points shall be at least 1 psi above the rated blower discharge pressure unless otherwise indicated.

Weighted type safety valves shall be anodized aluminum, as manufactured by Pathfinder Systems, Inc. without exception. Weights shall be chrome zinc plated and provided in half pound increments for settings below 15 psig.

2-6.05.02. Check Valves. An air check valve shall be installed in the discharge piping from the blower downstream of the discharge silencer as part of the factory piped package. See the Check Valve section.

2-6.06. Pressure Gauges. A pressure gauge shall be furnished and installed in the discharge piping of the blower and a vacuum gauge in the suction piping of the blower.

Pressure gauges shall conform to ANSI B40.1 and shall be of the indicating dial type with C-type phosphor bronze bourdon tube, stainless steel rotary geared movement, phenolic open front turret case, adjustable pointer, stainless steel or phenolic ring, and acrylic plastic or shatterproof glass window. All gauges shall be ANSI Accuracy Grade A. Gauges installed indoors shall be liquid filled.

The dial shall be a minimum 2-1/2 inch size with white background and black markings and shall have dual English and metric indication. The English units of measurement shall be pounds per square inch and the metric units shall be kilopascals. The range for each discharge pressure gauge shall be from 0 to 15 psig. The range for each vacuum gauge shall be from 15 inches Hg

vacuum to 0. Pointer travel shall be not less than 200 degrees nor more than 270 degrees.

All gauges shall be provided with 1/2 inch NPT connections. Each gauge shall be provided with a threaded end ball type shutoff valve as specified in the Miscellaneous Ball Valves section installed at the blower discharge piping connection.

2-6.07. Pressure Switch. A pressure switch shall be furnished and installed in the discharge piping of the blower and furnished for installation across each intake filter. Each switch in the blower discharge piping shall have an adjustable range of 0 to 15 psig and shall be set lower than the relief valve setting. Each switch across the intake filters shall have an adjustable range from 0 to 10 inches water column vacuum.

Each pressure switch shall be field adjustable and shall have a trip point repeatability of better than 1 percent of actual pressure. Each switch shall have one normally open and one normally closed contact rated 10 amps at 120 volt ac. Each switch shall be wired to the blower control panel and shall shut down the blower on high discharge pressure or high pressure drop across the filter. Switches shall have a weatherproof housing and shall be as manufactured by Static-O-Ring Company, Mercoid Control, Barksdale, or equal.

2-6.08. Draft Gauge. A draft gauge shall be provided having a range from 0 to 10 inches water column shall be installed across each air filter or air filter silencer.

The gauge shall have minimum 3-1/2 inch dial, pressure taps, fittings for 1/4 inch metal tubing, vent valves, mounting brackets, and an adjustable signal flag.

The draft gauge shall be "Dwyer 2000 Series Magnehelic Differential Pressure Gages" manufactured by Dwyer Instruments, Inc., or equal.

2-6.09. Thermometers. A thermometer shall be provided for monitoring of temperature in the discharge piping. The thermometer shall be mounted on the blower control panel. The capillary routing shall not require disassembly for normal maintenance of the blower, motor or V-belts.

Thermometers shall be of the remote reading gas actuated dial type. Thermometers shall have a minimum dial size of 5 inches, an adjustable pointer, shall be accurate within 1 percent of full scale. Thermometers shall have both Fahrenheit and Celsius indication. Thermometers shall be furnished complete with a uniformly graduated dial indicator, armored capillary tube, bulb or temperature sensor, and thermowell. Thermometer ranges shall be such that the normal operating reading will be near the midpoint of the range. The units of

measurement shall be indicated on the dial face. Spare capillary length shall be neatly coiled and tied.

2-6.10. Temperature Switches. Temperature switches shall be remote bulb type with one normally open and one normally closed contact rated 10 amps at 120 volt ac. Temperature switches shall have NEMA 4X housings, Type 316 stainless steel thermal well assemblies, and armored capillaries. Capillary length shall be sufficient for convenient mounting. Each temperature switch shall be wired to the blower control panel and shall shut down the corresponding blower on high discharge air temperature.

2-6.11. Vibration Detection Systems. Not used.

2-7. BALANCE. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibrations shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the maximum unfiltered vibration velocity, as measured at any point on the machine, shall be as required.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or its components shall be less than 0.8.

2-8. DRIVE UNITS. The blower shall be driven by an electric motor through either a direct drive or belt drive as required. Drive units shall be designed for 24 hour continuous service.

2-8.01. V-Belt Drives. The V-belt drive shall include a sliding base or other suitable tension adjustment.

2-8.02. Safety Guards. All belt drives, couplings, and other moving or rotating parts shall be covered on all sides by a safety guard. Safety guards shall be fabricated from 16 USS gage or thicker galvanized or aluminum-clad sheet steel or from 1/2 inch mesh galvanized expanded metal. Each guard shall be designed for easy installation and removal. All necessary supports and accessories shall be provided for each guard. Supports and accessories, including bolts, shall be galvanized.

2-8.03. Variable Frequency Drive. A variable frequency drive (VFD) shall be provided for the blower package by others. Variable frequency drives shall be as specified in the Variable Frequency Drives Section. The blower supplier shall coordinate with the motor and VFD manufacturers and be responsible for providing a motor and VFD which produces sufficient torque above the blower load curve to assure proper acceleration under all operating conditions. The blower supplier shall also coordinate with the motor and VFD manufacturers and be responsible for providing a motor with component mass and spring constant

such that torsional resonant frequencies do not occur in the system under all accelerating and normal operating conditions. The blower supplier shall also coordinate with the motor manufacturer and be responsible for providing a motor of adequate thermal design for the system inertia and load to permit one start per hour at rated temperature rise and two successive starts at 40 degrees C ambient without exceeding the motor insulation and component temperature limits.

2-9. CONTROLS.

2-9.01. Blower Motor Starters. Not used.

2-9.02. Blower Control Panel.
Each blower shall be furnished with a local blower control panel. The power supply to the blower control panel shall be 120 volt, 60 hertz, single phase. The blower control panel shall be furnished with a main circuit breaker disconnect with a lockable operating handle on the exterior of the panel. The blower control panel shall be furnished with all control power transformers, gauges, relays, pilot devices, indicators, etc., required to monitor, protect and shut down its respective blower.

The control panel shall be furnished with a Local-Off/Reset-Remote selector switch for each blower. The switch shall be lockable in the center Off/Reset position. In the Local position the blower shall run and blower speed shall be set manually at the blower control panel. In the Off/Reset position the blower shall stop and reset any equipment protection/alarm conditions. In the Remote position the control panel shall accept a normally open relay contact for blower start and stop control and a 4-20mA blower speed control signal from PLC. The selector switch shall be furnished with a contact for remote indication of Remote position.

The control panel shall be mounted separate from the blower package to prevent vibration from affecting panel mounted components, as shown on the drawings. All components installed in or on the panel shall be rated for the control power supply as required. If voltages other than the specified control power supply is required, the panel supplier shall furnish the required control power transformers.

The control panel shall be furnished with a white control power on indicating light, a green blower stopped indicating light and a red blower running indicating light.

The control panel shall be furnished with amber indicating alarm lights for high differential air temperature across the blower, high discharge pressure, high differential pressure across intake filter, and motor/AFD overload/fail.

Indicating lights shall be provided for each blower.

In lieu of the lights indicated, all items may be provided on a touch screen rather than indicated by lights if preferred by the vendor. Touch screen shall be rated for 163F.

For all conditions above requiring amber indicating lights an alarm relay shall be furnished with two normally open contacts rated 10 amperes at 120 volt ac. The normally open contacts shall close for any alarm condition and shall be used for remote annunciation of a blower alarm and shall shut down the blower.

The blower control panel shall be furnished with a normally open dry run contact rated 10 amperes at 120 volts ac for remote indication of blower running.

The panel shall be furnished with a warning and alarm light test pushbutton that illuminates all panel mounted lights when pushed. The panel shall be provided with an elapsed time hour meter for displaying the running time of each blower. The panel shall be provided with an emergency stop button.

2-9.03. Panel Fabrication Requirements. The control panel furnished shall conform to the requirements of NEMA ICS-6. Panels shall be rated NEMA Type 4X and shall be constructed from stainless steel.

All panel wiring shall be of the type normally furnished by the manufacturer with the following exceptions. All power and control wiring for 120 volt circuits shall be stranded copper #12 AWG minimum. All power and control wiring shall have a 600 volt insulation rating and a nominal maximum operating temperature of 90 degrees C. All analog circuits shall be #16 AWG twisted shielded pair rated for at least 300 volts. Conductor insulation for power, control, and analog circuits shall have a moisture-resistant and flame-retardant covering.

All wiring shall be grouped or cabled and firmly supported inside the panel. Wiring shall be bundled in groups and bound with nylon cable ties or routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel, with removable covers, and with space equal to at least 40 percent of the depth of the duct remaining available for future use after completion of installation and field wiring. Sufficient space shall be provided between cable groups or ducts and terminal blocks for easy installation or removal of cables.

The power entrance to each panel shall be provided with a surge protection device. Surge protectors shall be nominal 120 volts ac with a nominal clamping voltage of 200 volts. Surge protectors shall be of nonfaulting and noninterrupting design, with a response time not to exceed 5 nanoseconds. Surge protectors shall be manufactured by Innovative Technology, Power Integrity Corporation, or Transtector.

Terminal blocks shall be suitable for 12 AWG wire and shall be rated 30 amperes at not less than 300 volts. Terminal blocks shall be fabricated complete with marking strips, covers, and pressure connectors. Terminals shall be labeled to agree with the identification on the System Supplier's submittal drawings. A terminal shall be provided for each conductor of external circuits, plus one ground for each shielded cable. At least 25 percent spare terminals shall be provided. Not less than 8 inches of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Nameplates shall be provided on the face of each panel and on each individual control or pilot device. Panel nameplates shall be made of laminated phenolic material with engraved letters approximately 3/16 inch high extending through the black face into the white layer, and shall be secured firmly to the panel.

All control and pilot devices furnished shall be NEMA 4 rated, heavy duty oiltight.

2-9.04. Factory Panel Test. Before shipment, the panels shall be electrically tested by the manufacturer.

2-10. SHOP PAINTING. Equipment and items furnished as specified herein shall be furnished with shop coatings suitable for permanent installation and operation in accordance with the requirements in the General Equipment Stipulations section.

2-11. SHOP TESTS.

2-11.01. Operational Test. The blower shall be shop tested by the manufacturer for vibration and pressure developed and shall be checked for leaks, faulty components and controls.

2-11.02. Slip Test. A one psi slip test shall be performed on the blower. The test shall consist of an ASME PTC-9 slip test, with calculations correcting the results to field conditions, to ensure compliance with specifications. The test shall be in accordance to the paragraph, 4.52 of ASME PTC-9 slip test. Testing in accordance with ISO 1217 is an acceptable alternative.

2-11.03. Performance Test. Not required.

2-11.04. Vibration Test. A vibration test shall be performed on the blower. When the vibration test indicates an overall vibration velocity greater than 0.45 inches per second, the manufacturer shall be responsible for performing and reviewing a frequency analysis. The manufacturer shall make corrections as necessary, and confirm that the vibration velocity will not be detrimental to the equipment. An overall vibration velocity greater than 1.0 inch per second shall be sufficient cause for rejection of the equipment.

Defective equipment and controls disclosed by the tests shall be replaced and each unit placed in satisfactory operating condition before shipping.

A PDF of the test report complete with performance curves, data, and all calculations shall be submitted to the Design-Builder in accordance with the Submittals Procedures Section.

PART 3 - EXECUTION

3-1. INSTALLATION. Each unit shall be installed in accordance with Equipment Installation section and as specified herein.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily and in accordance with the specified performance requirements.

The manufacturer’s representative shall verify:

a. Each blower discharge isolation valve is fully open.
b. Each check valve is properly installed.
c. Piping is installed such that excessive force is not being exerted on the blower flanges.
d. No resonance vibration conditions are occurring within the blower package or air piping.

All costs for these services shall be included in the contract price.

3-2.02. Installation Supervision. Installation supervision by the manufacturer is not required.

3-3. FIELD RUN TESTING. All pre-checks and preliminary tests will need to be completed and approved by the Design-Builder and manufacturer prior to performance testing.

Each blower shall be mechanically checked for proper operation. Each alarm and safety shutdown shall be checked by artificially simulating an alarm condition. Defective equipment and controls disclosed by the tests shall be replaced or corrected, and the packages placed in satisfactory operating condition. The following items shall be measured, recorded, and submitted in a field test report:

a. Discharge pressure, the blower.
b. Discharge temperature, the blower.
c. Differential pressure across each intake filter unit.
d. Pressure and temperature at downstream end of piping system at any measurement taps provided.
e. Flow measurements at any flow meters provided.
e. Outdoor ambient temperature.
f. Indoor ambient temperature.
g. Barometric pressure.

3-4. TEST REPORTS. The equipment manufacturer shall prepare a test report, including all installation check and performance tests and other recorded data and observations. A PDF copy of the report shall be submitted to Design-Builder after completion of the specified tests.

3-5. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer’s expense.

3-6. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-6.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-6.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

End of Section

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Section 43 23 13.14

HORIZONTAL END SUCTION CENTRIFUGAL PUMPS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of single-stage, horizontal, end suction centrifugal pumping units as required.

Pump designation.	IPR Pump	PRW Pump
Number of pumps.	3 (2 duty/1 standby)	3 (2 duty/1 standby)
Pump tag numbers.	TW-P-0101, TW-P-0201, TW-P-0301	PRW-P-0101, PRW-P-0201, PRW-P-0301
Pump location.	IPR Product Water Pump Station Area 63	Plant Recycled Water Pump Station Area 34

Each pumping unit shall be complete with a pump, electric motor, , anchor bolts, and other appurtenances specified or otherwise required for proper operation, all mounted on a common baseplate. Pumps of the close-coupled type, with the impeller attached directly to the motor shaft without pump bearings or flexible couplings, will not be acceptable.

1-2. GENERAL. Equipment furnished under this section shall be fabricated and assembled in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer. Hydraulic considerations and definition of terms shall be as set forth in the Hydraulic Institute Standards.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Tagging. Each item of equipment and each part shipped separately shall be tagged and identified with indelible markings for the intended service. Tag number shall be clearly marked on all shipping labels and on the outside of all containers.

1-2.04. Power Supply. Unless otherwise indicated, power supply to the equipment shall be 480 volts, 60 Hz, 3 phase.

1-2.05. Identification. Pumps shall be identified in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete fabrication and assembly drawings, together with detailed specifications and data covering materials, drive unit, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section. The data and specifications for each unit shall include, but shall not be limited to, the following:

Pumps

Name of manufacturer.
Type and model.
Tag number.
Pump location.
Rotative speed.
Size of suction nozzle.
Size of discharge nozzle.
Net weight of pump only.
Net weight with baseplate and coupling.
Complete performance curves showing capacity versus head, NPSH required, pump efficiency, wire-to-water efficiency, and pump input power.
Data of coupling.
Data on shop painting.
Base and anchor bolt details.

Motors

As specified in the Common Motor Requirements for Process Equipment section.

Seismic Design Requirements

Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-3.02. Operation and Maintenance Data and Manuals. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instruction or parts lists packed with or attached to the equipment when delivered.

1-4. QUALITY ASSURANCE.

1-4.01. Balance. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the unfiltered vibration velocity, as measured at any point on the machine including the motor, shall not exceed the maximum vibration limits of the governing standard unless otherwise required.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or its components shall be less than 0.8 or more than 1.3.

1-5. SPARE PARTS. The following spare parts and accessories shall be furnished in substantial wooden boxes with identifying labels and delivered to the vicinity of the project site, as follows:

Spare Parts	Quantity
Mechanical seals	1 per pump set
Casing wearing rings	1 per pump set
Impeller wearing rings	1 per pump set
Sets of bearings	1 per pump set
Sets of bearing seals	1 per pump set

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. The IPR pumps convey recycled water to injection wells located in the Morro Valley via the IPR Product Water Transmission Main (by others).

The PRW pumps convey recycled water from the RO Feed Tanks to a bladder storage tank that supplies recycled water for washdown, irrigation, and other plant uses.

The pumping units shall be suitable for operation in accordance with the Meteorological and Seismic Design Criteria section and for the following service conditions:

Seismic design requirements.	See Meteorological and Seismic Design Criteria section
Type of environmental exposure.	Outdoor (open)

Pumps start and stop against a closed valve.	Yes

Parts shall be interchangeable between units of similar size and capacity to extent practical.

All equipment furnished shall be designed to meet all specified conditions and to operate satisfactorily at this elevation.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Pumping units shall be designed for the operating conditions as follows:

Pump tag numbers.	TW-P-0101, TW-P-0201, TW-P-0301	PRW-P-0101, PRW-P-0201, PRW-P-0301	
Rated head.	63.87	183	ft
Capacity at rated head.	333	75	gpm
Operating head range for full speed continuous operation.	51 to 82	122 to 185	ft
Minimum shutoff head.	70	180	ft
Maximum nominal pump speed.	1750	1750	rpm
Minimum head at reduced speed.	52	TBD	ft
Capacity at minimum head at reduced speed.	167		gpm
Approximate minimum pump speed, percent of maximum.	60		%
Maximum power required at pump input shaft at any point minimum operating head to shutoff head.	7.5	5	bhp
Efficiency.	74	75	%
Type of efficiency indicated.	Wire to water	Wire to water	
Efficiency calculated at.	Rated head	Rated head	
Pump designed for reverse	No	No	

Pump tag numbers.	TW-P-0101, TW-P-0201, TW-P-0301	PRW-P-0101, PRW-P-0201, PRW-P-0301	
rotation.			
Minimum NPSHA at rated head.	32	121	ft
Minimum NPSHA at minimum operating head.	32	121	ft
Maximum suction pressure.	7	60	psi
Maximum “A” rated weighted noise at 3 ft [1 m].	80	80	dBa
Maximum unfiltered vibration velocity.	HIS	HIS	
Pump rotation as viewed from driven end.	Clockwise	See Drawings	
Minimum pump suction nozzle size.	4	3	in
Minimum pump discharge nozzle size.	3	3	in
Minimum test sphere diameter.	1	2	in

All specified conditions shall be at rated speed unless otherwise indicated.

Overall (wire-to-water) efficiency for variable speed pumps shall include losses in the pump, motor, variable frequency drive, and any transformers supplied as part of the variable frequency drive equipment.

The minimum hydrostatic test pressure shall be 1.5 times shutoff head plus maximum suction pressure.

Pump performance shall be stable and free from cavitation and noise throughout the specified operating head range at design suction submergences. The design performance shall be based on a wearing ring diametral clearance of not less than 1 mil per inch of wearing ring diameter, or 12 mils total, whichever is greater.

2-3. MATERIALS. Each pump shall be constructed of the following materials as required.

Frame	Cast iron, ASTM A48.
Casing and Casing Covers	Cast iron, ASTM A48.
Casing Wearing Ring	Bronze, ASTM B505-952.
Impeller	Bronze, ASTM B62.
Impeller Wearing Ring	Bronze, ASTM B505-952.
Shaft	Carbon steel, AISI 1045.
Stuffing Box Hardware	Corrosion-resistant metal.
Packing	Braided, graphited or teflon impregnated Kevlar.
Lantern Ring	Bronze or glass-filled teflon for 2-1/2 inch [64 mm] OD and smaller shafts; bronze only for shafts larger than 2-1/2 inches [64 mm].
Shaft Sleeve (w/packing)	Bronze, ASTM B505-954.
Mechanical Seal (single)	Durametallic "Type RO" or John Crane "Type 1" or "Type 21".
Shaft Sleeve (w/mechanical seal)	Stainless steel, AISI 316.
Flexible Coupling	Not required.
Bearings	Antifriction.
Baseplate	Cast iron or fabricated steel.

2-4. PUMP CONSTRUCTION.

2-4.01. Casing Assembly. The casing assembly and drive connection shall permit the removal of the rotating element without disconnecting the piping. Casing parts shall have registered fit to maintain alignment. The nozzle flanges shall be flat faced, with ANSI/ASME B16.1, Class 125 diameter and drilling.

Pipe-tapped openings shall be provided for draining, priming, and venting the casing, except where Ni-hard or high-chrome cast iron casings are specified.

Cast iron casings shall be provided with plugged gauge cock connections on the suction and discharge nozzles.

2-4.02. Impeller. The impeller shall be a one-piece casting. The impeller shall be completely machined on all exterior surfaces, except when high chrome alloy material is specified. The interior water passages shall have uniform sections and smooth surfaces and shall be free from cracks and porosity. The impeller shall be securely locked to the shaft so that it will not be loosened by reverse rotation, but shall be easily removable.

Type of impeller.	Enclosed.
Impeller balancing.	Dynamic.
Impeller to shaft attachment.	Keyed.
Maximum number of impeller ports.	Single.

2-4.03. Shaft and Shaft Sleeves. The shaft shall be completely machined. Deflection at the stuffing box shall not exceed 0.002 inch [50 µm] at any head in the operating range. A suitable splash deflector shall be mounted on the shaft adjacent to the frame bearing housing.

The shaft shall be provided with a replaceable sleeve extending from the impeller through the stuffing box. The sleeve shall be positively secured to the shaft and shall be sealed to prevent leakage between the shaft and the sleeve. After assembly on the shaft, total runout shall not exceed 0.002 inch [50 µm].

2-4.04. Wearing Rings. Renewable wearing rings shall be provided in the casing and on the impeller. The rings shall be positively locked in place.

2-4.05. Stuffing Box. The stuffing box for each pumping unit shall contain a single mechanical seal. Each mechanical seal shall be provided with a flushing water line from the pump discharge to the stuffing box.

2-4.06. Seal Water Station. Not used.

2-4.07. Frame Assembly. The frame assembly shall rigidly support the rotating element with two bearings. The outboard bearing shall carry both axial and radial pump loads. If wearing clearance is axial, the assembly design shall permit axial adjustment of the rotor without dismantling the pump. Bearing enclosures shall keep out contaminants and retain the lubricant and shall have adequate provisions for adding and draining lubricant.

The frame shall provide ample clearance for stuffing box maintenance.

2-4.08. Bearings. Bearings shall be either oil or grease lubricated, antifriction type. Bearings shall have an ABMA L_{10} Life Rating of 40,000 hours at specified operating conditions. The pump shaft speed shall not exceed the limits specified by the bearing manufacturer.

2-4.09. Equipment Bases. Baseplates for pumps of at least 60 hp [45 kW] shall provide for tapered dowels to maintain alignment of pump and motor. Other requirements for equipment bases are specified in the General Equipment Stipulations.

2-5. ACCESSORIES. Each pump shall be provided with lifting eyebolts or lugs; tapped and plugged openings for casing assembly and bearing housing vents and drains; and appropriate fittings for adding bearing lubricant and seal water. Grease lubricated pumping units shall be provided with a means of venting the casing. Oil lubricated units shall be provided with constant level oilers or with sight glasses arranged to indicate operating and static oil levels.

2-6. DRIVE UNITS. Each pump shall be driven by an electric motor through a flexible coupling. Drive units shall be designed for 24 hour continuous service. Gearmotors shall not be used.

2-6.01. Belt Drives. Not used.

2-6.02. Couplings. Couplings shall have a horsepower [kW] rating 1.25 times the motor nameplate horsepower [kW] when the misalignment is within the manufacturer's tolerance limit. Coupling design shall permit removal of the pump rotating element without disconnecting the piping, moving the drive unit, or axial movement of the coupling halves on the shaft. The coupling shall be resilient type.

2-6.03. Electric Motors. The electric motors shall be designed as specified in the Common Motor Requirements for Process Equipment section.

2-6.04. Variable Frequency Drives. Not used

2-7. SHOP TESTS. Each pump shall be tested at the factory for capacity, power requirements, and efficiency at specified rated head, evaluated head, shutoff head, operating head extremes, and at as many other points as necessary for accurate performance curve plotting. All tests and test reports shall be made in conformity with the requirements and recommendations of the Hydraulic Institute Standards. Acceptance testing shall be per Table 14.6.3.4 Grade 1U, with no minus tolerance or margin allowed.

Design-Builder will witness shop tests, inspect and check the testing equipment used, and observe the calibration of pressure gauges and transducers. Design-Builder shall furnish a plan and elevation sketch of the test setup showing the

piping and instrumentation at least 10 days in advance of the time of each shop test. For witnessed shop tests, all readings are to be read manually from the certified and/or calibrated instruments. The use of computer data acquisition systems will not be acceptable.

If the pump fails to operate properly or fails to meet the specified conditions or requirements during witnessed shop testing, the pump manufacturer shall modify the pumping unit and perform additional tests. Labor, travel, and expenses associated with the witnessing or observation of additional tests, whether due to incomplete tests or re-testing, shall be paid by the pumping unit supplier.

PART 3 - EXECUTION

3-1. INSTALLATION. Each pumping unit shall be installed in accordance with the Hydraulic Institute Standards, the Equipment Installation section, and as specified herein.

The equipment base shall be grouted after initial fitting and alignment, but before final bolting of connecting piping. Special care shall be taken to maintain alignment of pumping unit components. No stresses shall be transmitted to the pump flanges. After final alignment and bolting, connections to pumping equipment shall be tested for applied piping stresses by loosening the flange bolts. If any movement or opening of the joints is observed, piping shall be adjusted to proper fit.

Couplings shall be realigned after grouting. Final coupling misalignment shall be within one-half of the coupling manufacturer's allowable tolerance.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with the Startup Requirements section, and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the contract price.

3-2.02. Installation Supervision. Installation supervision by the manufacturer is not required.

End of Section

Section 43 23 58

ROTARY LOBE POSITIVE DISPLACEMENT PUMPS

PART 1 - GENERAL

1-1. SCOPE. This section covers constant speed rotary tri-lobe, positive displacement type pumping units to pump various liquid streams throughout the WRF.

Pump designation.	WAS Pump	Scum Pump	Dewatering Sludge Feed Pump
Number of pumps.	1	1	2
Pump tag numbers.	WAS-P-0001	SCM-P-0001	DWT-P-0101, DWT-P-0201
Pump location.	BNR	BNR	Residuals Area

Each pumping unit shall be complete with pump, electric motor, gear reducer, coupling, coupling guard, pressure switches, anchor bolts, and all other appurtenances specified or otherwise required for proper operation. Each pumping unit shall be mounted on a common base. Pumps of the close coupled type, having the impeller attached directly to the motor shaft, with no pump bearings or flexible coupling, will not be acceptable. Pumps and motors shall be suitable for reverse rotation.

1-2. GENERAL. Equipment furnished under this section shall be fabricated, assembled in full conformity with drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer, unless exceptions are noted by the Design-Builder. Hydraulic considerations and definition of terms shall be as set forth in the Hydraulic Institute Standards.

1-2.01. Tagging. Each item of equipment and each part shipped separately shall be tagged and identified with indelible markings for the intended service. Tag number shall be clearly marked on all shipping labels and on the outside of all containers.

1-2.02. Power Supply. Unless otherwise indicated, power supply to the equipment shall be 480 volts, 60 Hz, 3 phase.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete fabrication, assembly drawings together with detailed specifications and data covering materials, drive unit, parts,

devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section and the Schedule of Submittals Section. The data and specifications for each unit shall include but shall not be limited to, the following:

Pumps

Name of manufacturer.
Type and model.
Tag number.
Pump designation.
RPM at maximum capacity.
Complete performance curve showing capacity versus head and bhp.
Maximum bhp requirements at maximum operating pressure.
Net weight of pump only.
Net weight of pump and baseplate.
Size of suction nozzle.
Size of discharge nozzle.
Data on overtorque device.
Type of coupling.
Data on mechanical seals.
Data on shop painting.

Motors

As specified in the Common Motor Requirements for Process Equipment section.

Pressure Switches and Gauges

Name of manufacturer.
Type and model.
Data sheets.

1-4. QUALITY ASSURANCE.

1-4.01. Balance. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the unfiltered vibration displacement (peak-to-peak), as measured at any point on the machine, shall not exceed 5 mils.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or its components shall be less than 0.8 or more than 1.3.

1-6. SPARE PARTS.

- A complete itemized price list of all recommended special tools, spare parts, and consumables shall be submitted.
- A set of recommended spare parts and consumables for system startup and testing shall be furnished.
- A set of recommended spare parts and consumables for one year of operation from Date of Substantial Completion or Acceptance of Final Testing, whichever is later, shall be furnished.

Where a tungsten carbide or ceramic liner is used inside the pump casing instead of wear plates, adequate spare liners shall be provided to cover the system warranty period as discussed in the general Terms and Conditions.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. Rotary lobe pumps will be used for varying service conditions throughout the WRF.

The pumping units shall be suitable for the following service conditions:

Pump designation.	WAS Pump	Scum Pump	Dewatering Sludge Feed Pump	
Type of environmental exposure.	Outdoor	Outdoor	Under canopy, Outdoor	
Type of Service	WAS	Scum	Sludge	
Liquid temperature range.	62 to 72	62 to 72	50 to 72	°F
Maximum solids concentration, by weight.	1	1	1	%
Typical solids concentration, by weight.	<1	<1	<1	%
Type of Solids	Sludge	Scum	Sludge	
Pumps start and stop against a closed valve.	No	No	No	

Parts shall be interchangeable between units of similar size and capacity to extent practical.

All equipment furnished shall be designed to meet all specified conditions and to operate satisfactorily at this elevation. Seismic design shall be in accordance with the Meteorological and Seismic Design Criteria section.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Pumping units shall be designed for the operation conditions as follows:

Pump designation.	WAS Pump	Scum Pump	Dewatering Sludge Feed Pump	
Pump tag numbers.	WAS-P-0001	SCM-P-0001	DWT-P-0101, DWT-P-0201	
Rated total differential pressure.	9	9	18	psig
Capacity at rated differential pressure.	40	40	305	gpm
Maximum differential pressure	35	35	43	psig
Maximum pump operating speed.	300	300	300	rpm
Maximum (nominal) motor operating speed.	TBD	TBD	TBD	rpm
Pump suction nozzle size.	TBD	TBD	TBD	in
Pump discharge nozzle size.	TBD	TBD	TBD	in
Minimum pump displacement.	TBD	TBD	TBD	gallons per 100 revolutions
Maximum power required.	TBD	TBD	TBD	bhp
Max Motor nameplate rating	5	5	15	hp
Minimum NPSHA at rated head.	29.8	29.8	6.1	ft
Minimum test sphere diameter.	TBD	TBD	TBD	in

Pump designation.	WAS Pump	Scum Pump	Dewatering Sludge Feed Pump	
Minimum hydrostatic test pressure, psi	TBD	TBD	TBD	psig
High pressure discharge pressure switch setting	TBD	TBD	TBD	psig

All specified conditions are at rated speed unless otherwise noted. Pumping units shall be designed so that maximum reverse rotation will not cause damage to any component. The pumps shall not require any special procedures to re-prime if the tank liquid level on the suction side of the pump falls below the pump suction flange. Pump supplier shall coordinate this provision with the motor supplier.

2.3. ACCEPTABLE PRODUCTS. The rotary lobe pumps furnished under this section shall be as manufactured by Börger, Netzsch or equal.

2-4. MATERIALS.

Rotor Casing		
	With replaceable liner	Cast iron, ASTM A48.
	Without replaceable liner	Ductile iron, ASTM A536, Brinell 220; with internal tungsten carbide coating.
Casing Cover		Ductile iron, ASTM A536, Brinell 700+ or cast iron, ASTM A48.
Rotor		Ductile iron core, ASTM A536, with stainless steel ASTM 304 outer layer; Rotors shall have quickly-exchangeable lobe tips, with abrasion resistant Buna-N coating to suit the application.
Shaft		Carbon steel, AISI 1045.
Shaft Sleeve		11-14 percent chrome stainless steel; Brinell 400+
Gear Case Bearings		Cast iron, ASTM A48 Grade 30. Antifriction, oil lubricated.
Seal Chamber Hardware		Corrosion-resistant metal.

Mechanical Seal (single)	Single water flushed or oil-bathed.
Flexible Coupling	Resilient type; Falk "Steelflex" or Woods "Sure-Flex".
Base	Cast iron or fabricated steel.

2-5. PUMP CONSTRUCTION

2-5.01. Rotor Casing and Cover. Casings shall either be hardened steel with a ceramic liner or cast iron with replaceable liners.

For casings with ceramic liner, the internal walls of hardened steel sludge pump rotor casings shall be provided with a thermal coating of tungsten carbide for abrasion resistance. High velocity oxygen fuel process shall be used to provide a coating of 0.007-0.009 inch thick. Coating shall have a hardness range of 71-73 Rockwell "C", with a porosity consistency less than 0.5 percent when applied. Bond strength shall be in excess of 20,000 psi using standard ASTM epoxy tensile test procedures. Compression test rates shall be in excess of 1,000,000 psi. Replaceable radial liners shall be a minimum of 0.118 inches thick and hardened to a minimum of 350 Brinell.

For casings with replaceable liner, the back of each rotor casing shall be fitted with a pair of replaceable wear plates securely located by threaded studs extending into the casing with a minimum hardness of 550 Brinell. Each sludge pump casing shall be provided with a removable front cover sealed with a Buna-N O-ring. The cover shall be a hardened, reversible, and shall have a replaceable wear plate.

The front cover shall permit unobstructed access to the rotors without disconnecting piping or disturbing glands or bearings and hardened to a minimum of 550 Brinell. Sludge pumps shall have side suction and discharge nozzles. The nozzle flanges shall be flat faced with ANSI/ASME B16.1, Class 125 diameter and drilling.

2-5.02. Rotor. The rotating element of each pump shall be of the tri-lobe or quad-lobe type. The radial location of the rotor shall be controlled by splines or keys to ensure correct rotor meshing. If splines are used, the rotor shall be securely fastened to the shaft by a locking assembly consisting of internally and externally expanding rings. Replacement of the rotor shall not require retiming the pump. The complete locking assembly shall be encapsulated within the rotor core by the front sealing flush disc and at the rear by an O-ring seal. The O-ring material shall be resistant to the fluid that is to be pumped.

The elastomeric coated rotor tips shall be guaranteed against bonding failure, otherwise known as delamination. The pump manufacturer shall verify rotor material and hardness are suitable for the application. Rotors shall be designed with individually replaceable tips.

2-5.03. Shaft and Shaft Sleeve. Shafts shall be completely machined. Each shaft shall be timed in its rotation by straight cut, zero backlash, high quality gears, keyed or locked to the shaft, and running in a separate oil chamber. Deflection at end of the shaft shall not exceed 0.006 inches.

Each shaft shall be provided with a replaceable sleeve passing through the stuffing box. The sleeve shall be positively locked against rotation and axial movement and shall be sealed to prevent leakage between the shaft and the sleeve. After assembly on the shaft, total runout shall not exceed 0.002 inch.

The shafts shall be non-sludge wetted. The rotor/shaft connection shall be lubricated with quench fluid of the intermediate chamber. The shafts shall be timed in their rotation by straight cut timing gear running in a separate oil chamber, which also contains the ball and roller bearings for each shaft. Sludge wetted rotor/shaft connections are not acceptable.

2-5.04. Stuffing Box. The stuffing box for each pumping unit shall contain a single mechanical seal. The mechanical seal shall be provided with a lubricating waterline connection.

2-5.05. Frame Assembly. The frame assembly for each pump shall rigidly support the rotating element with two bearings. Bearings at the driven end of the frame assembly shall carry both axial and radial loads. The assembly design shall permit axial adjustment of the rotor without dismantling the pump. Bearing enclosures shall be sealed with O-rings or gaskets to keep out contaminants and retain the lubricant and shall have adequate provisions for adding and draining the lubricant.

The frame shall house the timing gears and provide ample clearance for stuffing box maintenance.

2-5.06. Bearings. Bearings shall be oil lubricated antifriction type. Bearings shall have an ABMA L_{10} Life Rating of 40,000 hours at specified operating conditions. The pump shaft speed shall not exceed the bearing manufacturer's limitations.

2-5.07. Flexible Coupling. Not used.

2-5.08. Seal Water System. Each pumping unit shall be provided with a seal water station, as required, including all piping and accessories as specified in the Seal Water Stations Section as well as indicated in the Table below.

Pump designation.	WAS Pump	Scum Pump	Dewatering Sludge Feed Pump
Pump tag numbers.	WAS-P-0001	SCM-P-0001	DWT-P-0101, DWT-P-0201
Seal Station Water Type	Type B	Type B	Type B

2-5.09. Oil-Bathed Seal Chamber Leak Detection. Not used.

2-6. DRIVE UNITS. Each pump shall be driven by a belt drive between the motor and the pump. The nominal input power rating of the speed reducer shall be at least equal to the nameplate power rating of the drive motor. Drive units shall be designed for 24-hour continuous service. Gearmotors shall not be used.

2-6.01. Electric Motors. The electric motors shall be designed as specified in the Common Motor Requirements for Process Equipment section.

The motor shall be suitable for reverse rotation.

Submittal information shall be submitted to show that the motor can be started and stopped as specified.

2-6.02. Belt Drive. Belt drives shall be either V-belt or cogged timing belt. V-belt and sheave groove dimensional tolerances shall be in accordance with the "Engineering Standards - Multiple V-Belt Drives" published by the Multiple V-Belt Drive and Mechanical Power Transmission Association. Belt drives shall have a service factor of at least 1.6 at maximum speed based on the nameplate power rating of the drive motor. The speed reduction ratio of belt drives shall not exceed 6 to 1. Sufficient clearance shall be provided for access to the stuffing box. Each belt drive shall include a sliding base or other suitable means of tension adjustment. Belt drives shall be the side-by-side type.

Sheaves shall be of the stationary control variable sheave ratio, sized to operate at 90 percent of the maximum sheave ratio at the specified rated speed. The sliding base for stationary control variable sheaves shall have sufficient adjustment for 80 to 100 percent of the maximum sheave ratio. Motors for stationary control variable sheave ratio shall be sized for 100 percent speed at the maximum differential head.

2-6.03. Overload Device. Each rotary lobe positive displacement pump shall be provided with an overload device mounted inside the motor control center

(MCC). The Design-Builder shall be responsible for coordinating the overload device to ensure that a complete and properly operating system is furnished.

Controls for the pump equipment shall incorporate an automatic unjamming sequence. The pump shall automatically reverse rotation at least three times in a set time period in an attempt to dislodge any obstruction. The sequence shall reset to 0 should 30 seconds expire between any two jams. If the obstruction cannot be removed, the equipment shall automatically shut down and an alarm circuit shall be activated.

2-7. ACCESSORIES.

2-7.01. Pressure Switches. Pressure switches shall be provided on the suction and discharge of each pumping unit. Pressure switches shall be Ashcroft, Mercoid, Static-O-Ring Company (SOR), Barksdale. Pressure switches shall be part of the associated pressure gauge assembly where provided, and shall be furnished with the following features:

Housing:	Minimum NEMA 4 – to be determined per NFPA 820 by pump supplier and coordinated with overall system supplier, if applicable
Switch:	Snap-action single-pole double throw; 10 ampere, 120 VAC.
Deadband:	Fixed
Setpoint:	Field adjustable with visible indication
Reset:	Manual-reset on high pressure switches

High pressure switches shall be designed to stop the pump in the event of excessive discharge pressure. Switches for scum pumps shall have a range of 50 to 200 psig, safe to 225 psig surge, set to open when pressure rises to 150 psig.

2-7.02. Gauges. Each pump shall be provided with a compound pressure/vacuum gauge in the suction piping and a pressure gauge in the discharge piping. Gauges shall be liquid-filled gauges filled to approximately 75 percent of the internal volume with glycerin or silicone oil to damped shock loads.

Gauges shall conform to ANSI/ASME B40.1 and shall be indicating dial type, direct drive type with stainless steel helical-wound capillary tube pressure sensing element. The gauge shall have a phenolic open front turret case, an adjustable pointer, a stainless steel or phenolic ring, and an acrylic or shatterproof glass window. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall span not less than 200 degrees nor more than 270 degrees. All gauges shall be Accuracy Grade A or better.

The range of each gauge shall be in the range of 0 psi up to the highest potential pressure of the pumps with a 1.25 safety factor.

2-7.03. Isolators. Each pressure gauge and pressure switch shall be isolated from the pumped liquid by an in-line, flow-through, flange type gauge isolator where indicated on the Drawings. The isolator shall consist of a carbon steel housing, carbon steel assembly flanges, and a Buna-N flexible liner, and shall be filled with silicone oil. The isolator shall be suitable for installation between two flat-faced, ANSI/ASME B16.1, Class 125 cast iron pipe flanges and shall be tapped for a 1/2 inch NPT gauge connection. Isolators shall be Robbins & Myers "RKL Series W Pressure Sensor/Isolator", Red Valve "Series 48 Flanged Sensor", Ronningen-Petter "Iso-Ring", or equal.

2-7.04. Eyebolts. Each pump shall be provided with lifting eyebolts or lugs.

2-7.05. Fittings. Each pump shall be provided with fittings for properly adding bearing lubricant and seal water.

PART 3 - EXECUTION

3-1. INSTALLATION. Each unit shall be installed in accordance with Equipment Installation section and as specified herein.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily and in accordance with the specified performance requirements.

All costs for these services shall be included in the contract price.

3-3. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-3.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-3.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

End of Section

Section 43 25 60

SUBMERSIBLE HORIZONTAL PROPELLER PUMPS

PART 1 - GENERAL

1-1. SCOPE. This section specifies the horizontal submersible propeller pumps for installation as indicated on the Drawings.

Pump designation.	MBR Feed Pumps
Number of pumps.	2
Pump tag numbers.	BNR-P-1001, BNR-P-2001
Pump location.	Mixed Liquor Collection Channels

Each installed pumping unit shall be complete with a submersible electric motor, adjustable frequency drive, mounting assembly for installation as indicated on the Drawings, and all other appurtenances specified or otherwise required for proper operation, including special tools.

1-2. GENERAL. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the Design-Builder. Definition of terms and other hydraulic considerations shall be as set forth in the Hydraulic Institute Standards.

Each unit shall be furnished and installed complete with all anchors and supports, all mechanical equipment required for proper operation, and all additional materials or construction required by the manufacturer's design.

The propeller pumps specified herein shall be designed and fabricated by a single manufacturer which shall have sole responsibility for the equipment. The manufacturer shall have pumping equipment of this design and of comparable capacity in successful operation for at least 5 years.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Power Supply. Unless otherwise indicated, power supply to the equipment shall be 480 volts, 60 Hz, 3 phase.

1-2.04. Identification. Submersible horizontal propeller pumps shall be identified in accordance with the Equipment and Valve Identification section.

1-2.05. Spare Parts. A list of recommended spare parts shall be provided by the manufacturer in accordance with the general Terms and Conditions.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete fabrication and assembly drawings, together with detailed specifications and data covering materials used, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section. The data and specifications for each unit shall include, but are not limited to, the following:

Propeller Pumps
- Name of manufacturer.
- Type and model.
- Tag Number.
- Pump Designation.
- Pump Location.
- Rotative speed.
- Type of bearings.
- Net weight of propeller pump and motor.
- Complete performance curves showing capacity versus head, minimum submergence required, pump efficiency, wire-to-water efficiency, and pump input power.
- Data on shop painting.
- Anchor bolt details.

Motors
- Name of manufacturer.
- Type and model.
- Type of bearings and lubrication.
- Rated size of motor, hp.
- Temperature rating.
- Full load rotative speed.
- Efficiency and power factor at full load and rated pump condition.
- Full load current.
- Locked rotor current.
- Data on cable.

Variable Frequency Drives
- As specified in the Variable Frequency Drives section.

Moisture Detection System

Name of manufacturer.
Type and model.
Published descriptive data on each item of equipment and all accessories, indicating all specific characteristics and options.

Seismic Design Requirements

Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-3.02. Operation and Maintenance Data and Manuals. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instruction or parts lists packed with or attached to the equipment when delivered.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. The propeller pumping units will feed mixed liquor from the BNR tanks to the MBR tanks. The PCS will control the pumps to match the BNR influent flow and the RAS flow.

The equipment provided under this section shall be suitable for the following service conditions:

Maximum liquid temperature.	62 to 72	°F
Maximum solids concentration, by weight.	<1	%
Seismic design requirements	As specified in the Meteorological and Seismic Design Criteria section	

All equipment furnished shall be designed to meet all specified conditions and to operate satisfactorily at the elevation specified in the Meteorological and Seismic Design Criteria section.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. The propeller pump with its appurtenances and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 100 feet. The propeller pumping units shall be provided with a mounting system including a hoist, which enables the unit to be raised, lowered, and easily removed from the basin without the need for personnel to enter the basin.

The propeller water horsepower requirements, gear losses, and an ample

allowance for buildup of biological solids on the propeller of the unit shall be included in determination of the brake horsepower requirements.

Pumping units shall be designed for the following operating conditions, unless otherwise noted:

Pump tag numbers.	BNR-P-1001, BNR-P-2001	
Rated head.	4.0	ft
Capacity at rated head per pump	4030	gpm
Operating head range for full speed continuous operation.	1.6 to 4.0	ft
Maximum nominal pump speed.	1200	rpm
Minimum head at reduced speed.	3.4	ft
Capacity at minimum head at reduced speed.	695	gpm
Approximate minimum pump speed.	600	rpm
Maximum motor nameplate power	15	hp
Efficiency at rated head, wire to water.	50	%
Minimum submergence	2	ft
Basin depth (guide-rail mounted).	11	ft
Minimum liquid depth in basin (guide-rail and skid mounted)	6.4	ft
Maximum propeller diameter.	24	in

Overall (wire-to-water) efficiency for variable speed pumps shall include losses in the pump, motor, adjustable frequency drive, and any transformers supplied as part of the adjustable frequency drive equipment.

2-3. ACCEPTABLE MANUFACTURERS. The submersible propeller pumping equipment shall be as manufactured by Flygt Corporation, Landia, and KSB, without exception.

2-4. MATERIALS. Pumps and accessories shall be constructed of the following materials.

Guide Bar System

Guide Bars	Stainless steel pipe, Schedule 40S, AISI Type 316
Upper guide bar holders and intermediate guide bar supports	Stainless steel, AISI Type 316
Lifting Cable	Stainless steel, AISI Type 316.
Retaining Chain	Stainless steel, AISI Type 316.
Lifting Bracket or Bridle Chain	Stainless steel, AISI Type 316.

Propeller Pump

Stator housing and oil chamber housing	Stainless steel, AISI Type 316.
Propeller Shaft	Alloy steel, hard chrome plated; or stainless steel, AISI Type 316.
Propeller Shaft Mechanical Seal	Stainless steel with tungsten carbide or silicon carbide rings.
Motor Shaft Mechanical Seal	Stainless steel with tungsten carbide or silicon carbide rings.
Propeller	Same as stator housing.
Inlet Cone	Stainless steel, AISI Type 316.
All Assembly Fasteners	Stainless steel, AISI Type 316.
Primer and Finish Coat (Note)	
Epoxy	PPG Amercoat "Amercoat 385 Epoxy", Carboline "Carboguard 890", ICI Devoe Devran "224HS", Tnemec "Series N69 Hi-Build Epoxoline II", or Sherwin-Williams "Macropoxy 646".

Note: The manufacturer's coating recommended for the specified service that is equivalent to the specified coating will be acceptable.

Where stainless steel components are welded, the stainless steel shall be AISI Type 316L.

All stainless steel shall be pickled in accordance with ASTM A380 at the mill before being shipped. Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. After fabrication, pickled surfaces shall be subjected to a 24 hour water test for a ferroxyl test to detect the presence of

residual embedded iron. All pickled surfaces contaminated or damaged during fabrication including welded areas shall be repickled or passivated in accordance with ASTM A380 as needed to remove all traces of iron contamination and heat tint. All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces.

2-5. CONSTRUCTION.

2-5.01. Propeller Pump. Each propeller pump shall be the direct-driven, close-coupled, submersible type. All components of the unit, including motor and gear box, shall be designed for the specified requirements of pump service and shall be capable of continuous underwater operation. In addition, all components of the unit, including motor and gear box, shall be capable of continuous operation in air, completely unsubmerged, for 2 hours.

A sliding bar guide bracket shall be an integral part of the pumping unit. The entire weight of the mixer unit shall be guided by a single bracket which shall be capable of handling all thrust created by the mixer.

Cast components shall have smooth surfaces devoid of blow holes and other irregularities.

Each pumping unit shall be equipped with an integral inlet cone and use a wall mounting plate or pipe adapter as indicated on the Drawings. The design of the inlet cone shall ensure good hydraulic efficiency.

If required per manufacturer, a vortex baffle plate shall be provided on the pump to improve performance due to low water levels indicated in the performance criteria.

2-5.02. Propeller. The propeller shall consist of two or three blades, each integrated on a shaft for mounting in a hub. The blades shall be dynamically balanced and of non-clogging backward curve design.

2-5.03. Oil Chamber Housing. The oil chamber shall contain an inspection plug, drain plug, and vent plug.

2-5.04. Mechanical Seals. Each pump shall be provided with a lapped end face type mechanical seal (propeller shaft) and two lip seals (gear box for gear-driven mixers), running in oil reservoirs for cooling and lubrication. The mechanical seal between the propeller and propeller shaft oil chamber shall contain one stationary and one positively driven rotating face ring running in an oil reservoir for cooling and lubrication. The seals between the shaft and gear box, and gear box and motor chamber shall be of the lip style. All seal springs shall be isolated from the pumped liquid.

Four seals separating the various parts as specified herein will also acceptable. The outer seal in the propeller hub shall be either a viton or nitrile rubber lip seal, sealing propeller shaft and grease chamber from the mixed media running on a replaceable stainless steel bushing. The two inner seals on the propeller shaft shall be either viton or nitrile rubber lip seals insulating the propeller shaft grease chamber from the gearbox oil chamber. The fourth seal shall be a mechanical seal running in the oil for cooling and lubrication. It shall be mounted on the motor shaft to insulate the gear box oil chamber from the dry motor stator housing.

The seals shall require neither maintenance nor adjustment, but shall be easy to check, relap, and replace. Neither shaft seals lacking positively driven rotating members nor conventional double mechanical seals which use a common single or double spring and require a pressure differential to offset external pressure and effect sealing will be acceptable.

2-5.05. Sealing of Mating Surfaces. All mating surfaces shall be machined and fitted with nitrile rubber O-rings where watertight sealing is required. Fitting shall be such that sealing is accomplished by metal-to-metal contact between machined surfaces. The use of elliptical O-rings, gaskets, or seals requiring a specific fastener torque value to obtain and maintain gasket or seal compression and watertightness will not be acceptable. The use of secondary sealing compounds, gasket cement, grease, or other devices to obtain watertight joints will not be acceptable.

2-5.06. Pump Mounting Assembly. Each pumping unit shall be furnished with a vertical guide rail system and wall mounting plate. Two 2-inch, 316 stainless steel, Schedule 40S pipes shall be provided to guide the pump during installation and removal. Guide rail holders of 316 stainless steel shall be furnished and installed. Upper guide bar holders shall be furnished and installed to connect the top of the guide bar system to the structure as depicted on the Drawings. Lower guide rail holders shall be furnished and installed to connect the bottom of the guide bar system to the bottom slab or to the flange of the discharge pipe.

The mounting plate for pumping units shall function as a quick disconnect discharge connection for the pumping unit. The plate shall be suitable for mounting to a pipe as indicated on the Drawings. The pumping unit shall interlock with the mounting plate to form a metal-to-metal seal between the pump and the discharge connection. No gaskets, O-rings, or other sealing arrangements shall be required to seal the discharge connection. The pumping unit shall not require any bolts, nuts, or fasteners to mount to the discharge connection.

2-5.07. Hoist Assembly. One removable manual winch assembly shall be provided to use for both pumps. The winch assembly shall be shared by two pumps. The winch assembly shall consist of a lifting davit, winch, and 40 feet of 0.25-inch 316 stainless steel lifting cable. The lifting davit assembly shall be constructed of 316 stainless steel and shall be mounted in flush mounted mast

wells. The boom arm shall be adjustable and the length shall be suitable for the pump installation. The boom shall provide a rotation of 270 degrees. The winch assemblies shall provide a minimum working capacity 50 percent greater than the pumping unit weight. The winch assembly shall be capable of picking up the pump perpendicular to the pump direction as indicated on the drawings.

Each pumping unit shall utilize a positive means of submersible propeller pump recovery, similar to the Flygt "Grip Eye" system. A stainless steel guide cable shall be attached to the pump lifting chain and to a stainless steel eyebolt attached to the basin wall via a quick disconnect clip. The lifting cable assembly shall normally remain attached to the pump so “fishing” is not required to establish a positive connection. The grip eye shall be connected to the end of the winch lifting cable. The supplier shall furnish all necessary appurtenant items required to facilitate these connections.

The hoists shall be capable of being moved to any pump location and shall not weigh more than 225 pounds. Suitable lifting handles shall be provided. The pump guide bar assemblies shall be compatible with the hoist and provide a cable quick disconnect feature, similar to the Flygt "Grip-Eye" system so the pump lifting cable can be left permanently attached to the pumping units.

2-5.08. Bolts and Nuts. Field assembly bolts and nuts and anchor bolts and nuts shall be provided for each item of equipment. Anti-seize compound shall be applied to the threads of all stainless steel bolts before assembly.

2-6. BALANCE AND VIBRATION. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. At any operating speed, the ratio of rotation speed to the critical speed of the unit or components thereof shall be less than 0.8 or more than 1.3.

2-7. FABRICATION AND MANUFACTURE.

2-7.01. Welding. All welded joints shall be sealed watertight with continuous welds.

2-7.02. Edge Grinding. Sharp projections of cut or sheared edges of ferrous metals shall be ground to a radius as necessary to ensure satisfactory paint adherence.

2-7.03. Surface Preparation. All welds shall be thoroughly cleaned and ground smooth in preparation for painting. All ferrous metal surfaces, except motors, speed reducers, and stainless steel, shall be solvent cleaned in accordance with SSPC-SP1 before shop primer is applied.

2-7.04. Shop Painting. All iron and steel parts, except for stainless steel parts, which will be in contact with liquid or submerged after installation shall be shop cleaned in accordance with the coating manufacturer's recommendations and painted with an epoxy coating system. The coating shall have a dry film thickness of at least 10 mils and shall consist of a prime (first) coat and finish coats. At least one quart of the finish coat material shall be furnished with each mixer for field touchup painting.

See the General Equipment Stipulations for other shop painting requirements.

2-8. DRIVE UNITS.

2-8.01. Electric Motors. Each propeller pump shall be driven by a submersible, electric motor manufactured and furnished by the pump manufacturer. Motor nameplate rating shall exceed the maximum power required by the pump over the operating range. Each motor shall be rated for the power supply provided to the pump, and shall have a service factor of 1.10. The stator housing shall be an air-filled, watertight casing. A cooling jacket shall encase the motor housing for each pump where needed to maintain adequate cooling. The cooling jacket shall require no external source of cooling water. Motor insulation shall be moisture resistant, Class F, 155°C. Each motor shall be NEMA Design B for continuous duty at 40°C ambient temperature, and designed for at least 10 starts per hour.

The motor bearings shall be antifriction, permanently lubricated type. The bearings shall have a calculated ABMA L_{10} Life Rating of 40,000 hours when operating at maximum operating point. Maximum shaft run-out at the mechanical seals shall not exceed 2 mils at any point in the operating range.

The water seal design for cable entry shall not require a specific fastener torque to ensure a watertight and submersible seal. The use of epoxies, silicones, or other secondary sealing systems will not be acceptable. The cable entry junction box and motor shall be separated by a stator lead sealing gland or terminal board. The junction box shall isolate the motor interior from moisture gaining access through the top of the stator housing.

Each pump shall be provided with a separate or combined submersible power cable and submersible control cable. The power cable shall contain a ground conductor and one conductor per power phase. All submersible cables shall have a legend or code permanently embossed on the cable indicating the cable is suitable for submersible use. Cable sizing shall conform to NEC requirements. The cable lengths shall be sufficient to extend to the junction boxes specified below plus an extra 10 feet. Each cable shall be provided with stainless steel Kellems grips and stainless steel support brackets to help prevent damage to the cable insulation.

Motors shall be specifically selected for service with an adjustable frequency type speed controller and shall be derated to compensate for harmonic heating effects

and reduced self-cooling capability at low speed operation so that the motor does not exceed Class B temperature rise when operating in the installed condition at load with power received from the adjustable frequency drive. All motors driven by adjustable frequency drives shall be supplied with full phase insulation on the end turns and shall meet the requirements of NEMA MG 1, Part 31. In addition to the requirements of NEMA MG 1, Part 31, motors shall be designed to be continually pulsed at the motor terminals with a voltage of 1600 volts ac.

2-8.02. Variable Frequency Drives. Not used.

2-9. MOTOR CONTROLS.

2-9.01. Junction Box. Each pump shall be provided with a junction box for power and control cable termination. The junction box shall be mounted as indicated on the Drawings. The power and control cables to the pump shall be terminated in the junction box. A Kellems grip or other suitable strain relief device shall be provided on each submersible cable to prevent excess strain between the submersible cable and the junction box.

The junction box shall be as specified in the Electrical section.

2-9.02. Moisture Detection System. Each submersible pump housing shall be provided with a moisture detection system complete with all sensors, control power transformers if required, and relays. The moisture detection system shall be rated for a 120-volt ac supply voltage. If the system operates on a voltage other than 120 volt ac, the manufacturer shall provide the necessary control power transformer. The moisture detection system shall provide one normally open dry output contact rated 5 amps at 120 volts ac. The contact shall close when moisture is detected in the submersible pump motor housing or motor pre-chamber as recommended by the equipment manufacturer. All moisture detection system components shall be furnished by the submersible pump supplier and components not integral to the pump shall be shipped loose for installation into the motor controller enclosure.

2-9.03. Temperature Detection System. Each motor shall be protected by one motor temperature switch embedded in each phase winding. Each switch shall be designed to operate at 125°C (±5°C). Each switch shall be normally closed automatic reset type rated 5 amps at 120 V ac. The switches shall be wired in series with end leads wired to terminals within the motor housing.

PART 3 - EXECUTION

3-1. INSTALLATION. Each unit shall be installed in accordance with Equipment Installation section and as specified herein.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily and in accordance with the specified performance requirements.

All costs for these services shall be included in the contract price.

3-3. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-3.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-3.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

End of Section

Section 43 40 40

LIQUID CHEMICAL FEED SYSTEMS

PART 1 - GENERAL

1-1. SCOPE. This section covers liquid chemical feed equipment and accessories. Principal items to be furnished and installed shall include the following:

Sodium Hypochlorite Feed System.

One quick connect adapter.
One strainer.
Seven installed metering pumps with integral control panels.
Seven shelf spare metering pumps with integral control panels.
Two calibration column.
Seven chemical diffusers.

Sodium Hydroxide Feed System.

One quick connect adapter.
Three metering pumps with integral control panels.
Three shelf spare metering pumps with integral control panels.
One calibration column.
Three chemical diffusers.

Sodium Bisulfite Feed System.

One containment with integral scale.
One quick connect coupler.
One metering pump with integral control panel.
One shelf spare metering pump with integral control panel.
One calibration column.
One chemical diffuser.

Antiscalant Feed System.

One containment with integral scale.
One quick connect coupler.
One metering pump with integral control panel.
One shelf spare metering pump with integral control panel.
One calibration column.
One chemical diffuser.

Citric Acid Feed System.

One containment with integral scale.
One quick connect coupler.
Two metering pumps with integral control panels.
Two shelf spare metering pumps with integral control panels.
One calibration column.
Two chemical diffusers.

Sulfuric Acid Feed System.

One containment with integral scale.
One quick connect coupler.
Two metering pumps.
Two shelf spare metering pumps with integral control panels.
One calibration column.
One sulfuric acid dilution panel.
Two chemical diffusers.

The following items of work and equipment are covered under other sections:

Piping and valves between items of equipment.
Water supply and electric power supply to the equipment.
Drain and vent piping.

1-2. SYSTEM INTEGRATOR. The chemical feed systems shall be designed, coordinated, and supplied by a competent System Integrator. The System Integrator shall be regularly engaged in the business of designing and assembling liquid chemical feed systems for water treatment or wastewater treatment plant projects. The System Integrator shall be responsible for ensuring that a complete functioning system is supplied for each Chemical Feed System. The System Integrator shall be responsible for coordinating all equipment, piping, and valves, and appurtenances for each Chemical Feed System.

1-2.01. System Integrator Qualifications. The System Integrator shall meet all of the following requirements and within 30 days after the Notice of Award, the System Integrator shall submit proof of the following qualifications for the intended System Integrator:

The System Integrator has successfully provided similar work for at least 5 years.

The names of at least three references who are users of similar systems designed, assembled, and furnished by the System Integrator.

The System Integrator has the required financial capability.

The names of manufacturers whose products will be supplied.

The System Integrator maintains a qualified technical staff and design office.

The System Integrator has the physical plant and fabricating personnel to complete the work specified.

The System Integrator has and will maintain competent service personnel to service the equipment furnished.

1-3. GENERAL. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by the Design-Builder.

Each item shall be furnished and installed complete with all mechanical and electrical equipment required for proper operation, all components indicated on the drawings or specified, and all additional materials or construction required by the design of the system.

1-3.01. Coordination. The System Integrator shall verify that each system component is compatible and consistent with all other components of the system, that all pipe materials and sizes are appropriate, and that all devices necessary for a properly functioning system have been provided. Devices and appurtenances necessary for a properly functioning system shall be constructed of materials consistent with the piping materials unless otherwise indicated. The System Integrator shall assume responsibility for ensuring that Minimum Suction Head and NPSH available is adequate for the supplied pumps.

Similar components of different chemical feed systems shall be from the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

Review of drawings submitted prior to the final determination and coordination of related equipment to be provided will not relieve the System Integrator from responsibility for supplying systems in full compliance with the specific requirements of the related equipment.

1-3.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. Piping on skids shall be constructed consistent with the piping and valve specifications.

1-3.03. Governing Standards. All electrical equipment shall conform to applicable standards of the National Electrical Manufacturers Association and the National Electrical Code.

1-3.04. Power Supply. Unless otherwise specified, the power supply will be 120 volts, 60 Hz, single phase. Where control voltage lower than the power supply voltage is required, a suitable control power transformer shall be furnished. Both power and control equipment shall be insulated for not less than 600 volts even though operating voltages may be lower.

1-3.05. Metal Thicknesses. Metal thicknesses and gauges specified herein are the minimum required. Gauges refer to US Standard gauge.

1-3.06. Nameplates. A nameplate shall be provided and mounted on or adjacent to each piece of chemical feed equipment to identify its function. Nameplates shall be approximately 1 by 3 inches, made from black on white phenolic material. Letters shall be engraved to the white interior and shall be at least 3/16-inch high. Feeder designations on the nameplates shall correspond to those indicated on the drawings.

1-3.07. Spare Parts. A list of recommended spare parts with pricing shall be furnished during the submittal phase.

1-4. SUBMITTALS. Submittals for chemical feed systems shall have the following organization and information as a minimum.

1-4.01. Submittal Organization. The submittal shall be split up into different sections with a separate section for each chemical feed system. Each system section shall be supplied with the following information.

System Integrator Name, Contact Name, Phone Number, Address, and email address.

System Integrator Contact Name Qualifications and Experience

Bill of Materials

System piping and instrumentation diagram (P&ID) with legend

Equipment and piping layout starting from bulk storage tank pump suction nozzle to discharge of anti-siphon loop.

Tote scale and pallet selection

Strainer selection

Metering pump selections

Metering pump appurtenances including calibration column

Control Panel layout and wiring diagram.

Diffuser selection.

Control narrative.

Spare parts

1-4.02. Drawings and Data. Complete fabrication, assembly, installation and equipment and piping layout drawings, piping and instrumentation diagrams, and wiring diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Section.

1-4.03. Calibration Graphs. The System Integrator shall prepare a calibration graph from field tests for each chemical feed pump. Each graph shall include a family of curves of pump speed/stroke length versus gallons per hour at 25, 50, 75 and 100 percent speed and 10, 25, 50, 75, and 100 percent stroke length. Each graph shall be furnished on hard paper and sealed in clear plastic.

1-4.04. Control Narrative. A narrative description of the proposed metering pump controls, including all control modes, manual and automatic operations, electrical interlocks, alarms, and interfaces to the Plant Control System shall be submitted.

1-4.05. Operation and Maintenance Data and Manuals. Operation and maintenance manuals shall be supplied and shall be submitted in accordance with the submittals section. Equipment designations used shall correspond to those indicated on the drawings.

Operation and maintenance manuals shall include the following:

a. Equipment function, normal operating characteristics, and limiting conditions.
b. Assembly, installation, alignment, adjustment, and checking instructions.
c. Operating instructions for startup, routine and normal operation, regulation and control, shutdown, and emergency conditions.
d. Lubrication and maintenance instructions.
e. Guide to troubleshooting.
f. Parts lists and predicted life of parts subject to wear.
g. Outline, cross-section, and assembly drawings; engineering data; and wiring diagrams.
h. Test data and performance curves, where applicable.
i. A listing of all filter locations, type, size, and quantity associated with each piece of equipment.

The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

PART 2 - PRODUCTS

2-1. SYSTEM INTEGRATOR. The chemical feed system shall be coordinated and supplied by a qualified System Integrator who is regularly engaged in the business of designing and assembling liquid chemical feed systems for water treatment or wastewater treatment plant projects.

2-2. CONSTRUCTION. Chemical feed equipment shall be of substantial construction with all parts designed for long life under working conditions including corrosive atmospheres and intermittent or continuous operation. All wearing parts and items requiring adjustment shall be readily accessible. Each unit shall be completely enclosed and dusttight when in operation. All parts which are exposed to corrosive conditions shall be made from corrosion-resistant materials or covered with suitable protective coatings.

2-3. SODIUM HYPOCHLORITE FEED SYSTEM. One assembly of feeding equipment shall be furnished and installed to dispense Sodium Hypochlorite to the following feed points:

- Ocean Outfall
- RO Concentrate Water
- RO Feed
- UV AOP System
- RO Product Water
- MBR Backwash/CIP
- Recycled Water Pumps

2-3.01. Quick Connect Adapter. One quick connect adapter shall be provided at the truck unloading station to connect the truck's hose to the storage tank fill line as indicated on the drawings. The material of construction shall be compatible with the chemical and approved by the Design-Builder. The quick connect shall be the standard cam and groove type manufactured to specification A-A-59326D. The quick connect fitting shall be the adapter type (grooved fitting) with a locking dust cap. The adapter shall be constructed of material suitable for the chemical service with female NPT threads for connecting to the fill piping. The adapters shall be the same size as the storage tank fill line as indicated on the drawings. The quick connect adapters shall be as manufactured by OPW Engineered Systems, PT Coupling Company, Inc, or equal.

2-3.02. Strainer. One transparent PVC bodied Y-pattern strainer with 12-mesh screen and Viton O-ring seals shall be provided on the suction side of the metering pump skids.

2-3.03. Metering Pump Skids. Two metering pump skids shall be furnished and installed as indicated on the drawings to dispense 12.5 percent sodium hypochlorite with a specific gravity of 1.18 to the points of application. Each skid shall be located in the Chemical Facility.

Skid No. 1 shall have three metering pumps on the skid, pipe appurtenances, appropriate valves and piping, calibration columns, and a control panel. The piping requirements, valving, and appurtenances shall be as shown on the piping and instrument diagrams. Skid No. 1 shall have a footprint no larger than 2'-6" by 4'-6".

Skid No. 2 shall have four metering pumps on the skid, pipe appurtenances, appropriate valves and piping, calibration columns, and a control panel. The piping requirements, valving, and appurtenances shall be as shown on the piping and instrument diagrams. Skid No. 2 shall have a footprint no larger than 2'-6" by 6'-0".

All power and control wiring within each skid shall be provided by the System Integrator such that the skid requires connection of a single primary 120V power circuit.

Each skid shall be of substantial construction, shall be constructed of a material resistant to the pumped solution, and shall have an open construction such that there is unobstructed access to the controls, pump head, and pump check valves. Valves and appurtenances shall be within easy reach from the skid edge.

Piping on the skids shall be consistent with specification the Miscellaneous Plastic Piping Section. Valves shall be type VPN-2 consistent with the Pinch Valves and Diaphragm Valves Section. Valves shall be labeled with valve numbers shown on the piping and instruments diagrams.

2-3.03.01. Metering Pumps. Seven metering pumps shall be furnished and installed on the skid as indicated on the drawings to dispense 12.5 percent sodium hypochlorite with a specific gravity of 1.18 to the feed points as listed below.

Seven metering pumps shall be furnished to be shelf spare units.

Each pump shall include continuous local and remote electric and local manual mechanically controlled metering of solution under the following conditions and requirements listed in the table below.

Feed point	Ocean Outfall	RO Concentrate Water	RO Feed	UV AOP System	RO Product Water	MBR Backwash /CIP	Recycled Water Pumps
Tag No.	PMP-0101	PMP-0201	PMP-0301	PMP-0401	PMP-0501	PMP-0601	PMP-0701
Skid No.	1	1	1	2	2	2	2
Installed pump quantity	One	One	One	One	One	One	One
Shelf spare pump quantity	One	One	One	One	One	One	One
Capacity control range, percent	0 - 100	0 - 100	0 - 100	0 - 100	0 - 100	0 - 100	0 - 100
Metering range, gph	0.6 - 65	0.04 - 0.63	0.6 - 4.6	0.2 - 1.3	0.01 - 0.32	150	0.01 - 0.11
Maximum speed, rpm	225	225	225	225	225	225	225
Nominal discharge pressure, psi	30	30	30	30	30	30	30

Pumps shall be positive displacement, tube-type peristaltic, case-drive pumps complete with retractable roller pump head, rotor assembly with a minimum of two compression rollers, self-contained variable speed drive, flexible extruded tube, and integral key pad control panel.

The process fluid shall only be in contact with the inside of the pump tubing. The pump tubing shall be constructed of material chemically resistant to the pumped solution, as acceptable to the Design-Builder. The pump shall be capable of accepting at least five tube diameters to increase capacity range. The tubing shall have a minimum wall thickness of 1.5 mm. A 50-foot section of tubing shall be provided for each pump or a total of ten spare replacement tubing assemblies shall be provided.

The pump head shall consist of a fixed track, hinged transparent guard door or removable transparent cover with lock and magnetic safety interlock and two roller rotor assemblies. The door and safety interlock shall render the drive inoperable when the door is open. Conversely, a removable cover shall include an imbedded magnetic safety interlock which will limit the motor rotation speed to 6 rpm when removed.

The tubing shall be in contact with the inside diameter of a fixed track (housing) through an angle of 180º and shall be held in place on the suction and discharge by the clamp mechanisms or pump tube assembly connection fittings. Tube clamps requiring tools will not be acceptable. Tubing replacement shall not require the use of tools.

Rotor assembly shall be equipped with a minimum of two 316 SS or polymeric compression rollers and SS bearings or two polymeric compression rollers and encapsulated SS bearings. Compression rollers shall be located a maximum of 180 degrees apart for compression of the tube against the track a minimum of twice per rotor revolution. One roller shall at all times be fully engaged with the tubing providing complete compression to prevent backflow or siphoning. Tube occlusion or spring tension shall be factory set for the tubing wall thickness and shall not require additional adjustment for other tubing sizes. The rotor assembly shall be securely attached to the output shaft of the drive gear motor by the manufacturer's standard assembly for that model.

The self-contained variable speed drive for each pump shall be fully operational over the entire flow range requirements indicated above. Additionally, the pumps shall be fully capable of the discharge back pressure required above. Pumps and drives shall be suitable for continuous 24-hour operation at the conditions specified.

Each pump shall be completely self-priming with a suction lift capability of up to 30 feet of water. The pump shall be capable of running dry without damaging effects to the pump or hose. The pump shall be valveless and without diaphragms and check valves. Flow through the hose shall be in the direction of the rotor rotation and the motor shall be capable of being fully reversed.

Each installed pump shall be furnished with the following accessories. All metering pump suction and discharge appurtenances described below and branch piping to these appurtenances shall be the same sizes as the suction and discharge piping indicated on the P&ID.

One pressure gauge and pressure switch with isolating diaphragm in each pump discharge piping arrangement. The pressure gauge shall be indicating dial type with adjustable pointer and acrylic plastic or shatterproof glass window. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall be approximately 270 degrees. The unit of measurement shall be pounds per square inch and shall be indicated on the dial face. The gauge shall be selected so that gauge readings will be mid-scale under normal operating conditions. The isolating diaphragm shall protect the pressure gauge from the chemical solution. The pressure-switches shall be diaphragm actuated type switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line

pressure. Switches shall have weatherproof housings. Switch wetted parts shall be compatible with the process fluid. Where the process is not defined, all wetted parts shall be Teflon-coated or Viton and the connection port shall be stainless steel. All stem-mounted switches shall be provided with ½-inch NPT connections. All pressure switches shall be ranged in psi. Unless otherwise indicated, switches shall have a fixed deadband and shall be auto-reset type. As a minimum, switches shall be SPDT, rated 10 amp at 120 V ac. Switches shall be installed at the locations indicated on the Drawings, with installation conforming to the installation details. All switches, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation of the switch or diaphragm seal. Switches shall be manufactured by Ashcroft, Barksdale, Dwyer/Mercoid, ITT/NeoDyn, or S.O.R.

One external relief valve sized to pass the maximum displacement of the pump.

One properly sized diaphragm type pulsation dampener in each pump discharge piping arrangement. Each pulsation dampener shall be fabricated of materials resistant to the pumped solution and shall include an air charging valve and air gauge. The pulsation dampener shall be sized to limit pressure surges to between 5 and 10 percent of mean pressure.

Leak detection system that shall detect a tubing failure by sensing the presence of liquid inside of the pump head with output signal for remote alarm.

Metering pumps shall be Watson-Marlow “Model 520 Series" or Blue & White “M-4 Series” without exception.

2-3.03.01. Metering Pump Drive Units. The pump shall be supplied with a case-drive integral reversible servo permanent magnet dc drive motor with internal gearbox to accept 120 volts ac, 60 Hz, single phase. Housing shall be pressure cast aluminum with a corrosion resistant powder coat. Unpainted housings, including 316SS, shall not be acceptable. Each pump shall not consume in excess of 790 VA. Drive unit shall be classified for continuous heavy shock duty, AGMA. Each drive unit shall be furnished with a grounded power cord and plug suitable for plugging into a standard grounded 120-volt receptacle. Power cord conductor size shall be #12 AWG minimum for both power and ground. The connection between the power cord and the drive unit shall be as recommended by the manufacturer.

The drive shall be rated Class II, 24-hour duty. Pump drive shall be closed coupled and self-aligning without requiring flexible couplings.

Drive circuitry shall be microprocessor controlled with temperature and load compensation and protection. External VFDs or SCRs shall not be acceptable.

Drive enclosure shall be NEMA 4X rated.

The drive motor shall be capable of varying the speed of the pump to deliver the metering range in gph as specified. The drive shall be provided with an "HAND-OFF-AUTO" or "REMOTE/LOCAL" control of the pump. In the "HAND" or "LOCAL" position, the pump shall run and the speed of motor shall be varied by a manual speed adjustment on the pump. In "AUTO" or "REMOTE", the pump shall be started by a remote input dry contact. Pump speed shall be varied by a remote input 4-20 mA signal. The drive shall provide an output 4-20 mA speed signal for remote monitoring. "Running", "In Remote" selector switch position, "High Pressure," and "Fail" contacts shall be provided for remote monitoring. Running and fault indications shall also be provided on the pump control panel.

2-3.04. Calibration Column. Two transparent plastic calibrating columns, one per metering pump skid, shall be furnished and installed on the pump suction piping as indicated on the drawings. The column shall be clear PVC or other resistant, rigid, transparent plastic tubing having a vented top cap and screwed flow fitting. Each column shall be graduated in the respective increments over the specified range, complete with a numeral at each graduation.

Feed point	Ocean Outfall	RO Concentrate Water	RO Feed	UVAOP System	RO Product Water	MBR Backwash/CIP	Recycled Water Pumps
Column ID, in	2			0.75			
Skid No.	1			2			
Screwed Flow Fitting, in	0.5			0.5			
Graduated Increments, gal	0.005			0.001			
Capacity, gal	1.08			2.5			

The bottom of the calibration column shall be located at or below the bottom of elevation of the storage/day tank metering pump suction nozzle. The columns

shall be Valcom, Inc., "Model 85000", or equal, and shall be mounted on steel legs.

2-3.05. Pressure Relief Valves. Pressure relief valves shall be located anywhere sodium hypochlorite can become trapped in the chemical feed piping and not less than as indicated on the drawings to protect the system from damage due to excess pressure build-up resulting from the decomposition of sodium hypochlorite.

Valves shall have adjustable relief pressure setting, with initial relief pressure set at 120 psi. The valve body shall be constructed of CPVC. All wetted materials including seats, seals and diaphragms shall be constructed of CPVC, Viton, or Teflon, as acceptable to Design-Builder. Each valve shall be supplied with a tamper proof seal, which must be broken in order to change the factory pressure setting. A tag indicating the initial pressure setting shall be provided.

Valves shall be Griffco Valve, Inc. "Pressure Relief Valves," Hydroflo Corporation "HydroGarD High Pressure Safety Relief Valves," or Plast-O-Matic “Series RVDT.”

2-3.06. Diffusers. Seven diffusers shall be provided as shown on the drawings

2-4. SODIUM HYDROXIDE FEED SYSTEM. One assembly of feeding equipment shall be furnished and installed to dispense Sodium Hydroxide to the following feed points:

- RO CIP/Neutralization Tank
- Product Water Tank
- Fine Screen Effluent

2-4.01. Quick Connect Adapter. One quick connect adapter shall be provided at the truck unloading station to connect the truck’s hose to the storage tank fill line as indicated on the drawings. The material of construction shall be compatible with the chemical and approved by the Design-Builder. The quick connect shall be the standard cam and groove type manufactured to specification A-A-59326D. The quick connect fitting shall be the adapter type (grooved fitting) with a locking dust cap. The adapter shall be constructed of material suitable for the chemical service with female NPT threads for connecting to the fill piping. The adapters shall be the same size as the storage tank fill line as indicated on the drawings. The quick connect adapters shall be as manufactured by OPW Engineered Systems, PT Coupling Company, Inc, or equal.

2-4.02. Metering Pump Skid. One metering pump skid shall be furnished and installed as indicated on the drawings to dispense 25 percent sodium hydroxide with a specific gravity of 1.25 to the points of application. The skid shall be located in the Chemical Facility. The skid shall have three metering pumps on the skid, pipe appurtenances, appropriate valves and piping, calibration columns,

and a control panel. The piping requirements, valving, and appurtenances shall be as shown on the piping and instrument diagrams. All power and control wiring within the skid shall be provided by the System Integrator such that the skid requires connection of a single primary 120V power circuit.

Skids shall be of substantial construction, shall be constructed of a material resistant to the pumped solution, and shall have an open construction such that there is unobstructed access to the controls, pump head, and pump check valves. Valves and appurtenances shall be within easy reach from the skid edge. The skid shall have a footprint no larger than 2'-6" by 4'-6".

Piping on the skids shall be consistent with the Miscellaneous Plastic Piping Section. Valves shall be type VB-10 consistent with the Miscellaneous Ball Valves Section. Valves shall be labeled with valve numbers shown on the piping and instruments diagrams.

One carbon steel bodied Y-pattern strainer with 12-mesh screen and Viton O-ring seals shall be provided on the skid inlet pipe, upstream of all metering pumps.

2-4.02.01. Metering Pumps. Three metering pumps shall be furnished and installed on the skid as indicated on the drawings to dispense 25 percent sodium hydroxide with a specific gravity of 1.25 to the feed points as listed below.

Three metering pumps shall be furnished to be shelf spare units.

Each pump shall include continuous local and remote electric and local manual mechanically controlled metering of solution under the following conditions and requirements listed in the table below.

Feed point	RO CIP/Neutralization Tank	Product Water Tank	Fine Screen Effluent
Designation	PMP-0101	PMP-0201	PMP-0301
Installed pump quantity	One	One	One
Shelf spare quantity	One	One	One
Capacity control range, percent	0 - 100	0 - 100	0 - 100
Metering range, gph	130	0.07 - 0.21	0.1 - 9.0
Maximum speed, rpm	225	225	225
Nominal discharge pressure, psi	30	30	30

Pumps shall be positive displacement, tube-type peristaltic, case-drive pumps complete with retractable roller pump head, rotor assembly with a minimum of two compression rollers, self-contained variable speed drive, flexible extruded tube, and integral key pad control panel.

The process fluid shall only be in contact with the inside of the pump tubing. The pump tubing shall be constructed of material chemically resistant to the pumped solution, as acceptable to the Design-Builder. The pump shall be capable of accepting at least five tube diameters to increase capacity range. The tubing shall have a minimum wall thickness of 1.5 mm. A 50-foot section of tubing shall be provided for each pump or a total of ten spare replacement tubing assemblies shall be provided.

The pump head shall consist of a fixed track, hinged transparent guard door or removable transparent cover with lock and magnetic safety interlock and two roller rotor assemblies. The door and safety interlock shall render the drive inoperable when the door is open. Conversely, a removable cover shall include an imbedded magnetic safety interlock which will limit the motor rotation speed to 6 rpm when removed.

The tubing shall be in contact with the inside diameter of a fixed track (housing) through an angle of 180^{o} and shall be held in place on the suction and discharge by the clamp mechanisms or pump tube assembly connection fittings. Tube clamps requiring tools will not be acceptable. Tubing replacement shall not require the use of tools.

Rotor assembly shall be equipped with a minimum of two 316 SS or polymeric compression rollers and SS bearings or two polymeric compression rollers and encapsulated SS bearings. Compression rollers shall be located a maximum of 180 degrees apart for compression of the tube against the track a minimum of twice per rotor revolution. One roller shall at all times be fully engaged with the tubing providing complete compression to prevent backflow or siphoning. Tube occlusion or spring tension shall be factory set for the tubing wall thickness and shall not require additional adjustment for other tubing sizes. The rotor assembly shall be securely attached to the output shaft of the drive gear motor by the manufacturer's standard assembly for that model.

The self-contained variable speed drive for each pump shall be fully operational over the entire flow range requirements indicated above. Additionally, the pumps shall be fully capable of the discharge back pressure required above. Pumps and drives shall be suitable for continuous 24-hour operation at the conditions specified.

Each pump shall be completely self-priming with a suction lift capability of up to 30 feet of water. The pump shall be capable of running dry without damaging effects to the pump or hose. The pump shall be valveless and without diaphragms and check valves. Flow through the hose shall be in the direction of the rotor rotation and the motor shall be capable of being fully reversed.

Each pump shall be furnished with the following accessories. All metering pump suction and discharge appurtenances described below and branch piping to these appurtenances shall be the same sizes as the suction and discharge piping indicated on the P&ID.

One pressure gauge and pressure switch with isolating diaphragm in each pump discharge piping arrangement. The pressure gauge shall be indicating dial type with adjustable pointer and acrylic plastic or shatterproof glass window. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall be approximately 270 degrees. The unit of measurement shall be pounds per square inch and shall be indicated on the dial face. The gauge shall be selected so that gauge readings will be mid-scale under normal operating conditions. The isolating diaphragm shall protect the pressure gauge from the chemical solution. The pressure-switches shall be diaphragm actuated type switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line pressure. Switches shall have weatherproof housings. Switch wetted parts shall be compatible with the process fluid. Where the process is not defined, all wetted parts shall be Teflon-coated or viton and the connection port shall be stainless steel. All stem-mounted switches shall be provided with 1/2-inch NPT connections. All pressure switches shall be ranged in psi. Unless otherwise indicated, switches shall have a fixed deadband and shall be auto-reset type. As a minimum, switches shall be SPDT, rated 10 amp at 120 V ac. Switches shall be installed at the locations indicated on the Drawings, with installation conforming to the installation details. All switches, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation of the switch or diaphragm seal. Switches shall be manufactured by Ashcroft, Barksdale, Dwyer/Mercoid, ITT/NeoDyn, or S.O.R.

One external relief valve sized to pass the maximum displacement of the pump. Pressure relief valves shall be constructed of carbon steel to match the pipe.

One properly sized diaphragm type pulsation dampener in each pump discharge piping arrangement. Each pulsation dampener shall be fabricated of materials resistant to the pumped solution and shall include an air charging valve and air gauge. The pulsation dampener shall be sized to limit pressure surges to between 5 and 10 percent of mean pressure.

Leak detection system that shall detect a tubing failure by sensing the presence of liquid inside of the pump head with output signal for remote alarm.

Metering pumps shall be Watson-Marlow “Model 520 Series" or Blue & White “M-4 Series” without exception.

2-4.02.02. Metering Pump Drive Units. The pump shall be supplied with a case-drive integral reversible servo permanent magnet dc drive motor with internal gearbox to accept 120 volts ac, 60 Hz, single phase. Housing shall be pressure cast aluminum with a corrosion resistant powder coat. Unpainted housings, including 316SS, shall not be acceptable. Each pump shall not consume in excess of 790 VA. Drive unit shall be classified for continuous heavy shock duty, AGMA. Each drive unit shall be furnished with a grounded power cord and plug suitable for plugging into a standard grounded 120-volt receptacle. Power cord conductor size shall be #12 AWG minimum for both power and ground. The connection between the power cord and the drive unit shall be as recommended by the manufacturer.

The drive shall be rated Class II, 24-hour duty. Pump drive shall be closed coupled and self-aligning without requiring flexible couplings.

Drive circuitry shall be microprocessor controlled with temperature and load compensation and protection. External VFDs or SCRs shall not be acceptable.

Drive enclosure shall be NEMA 4X rated.

The drive motor shall be capable of varying the speed of the pump to deliver the metering range in gph as specified. The drive shall be provided with an “HAND-OFF-AUTO” or “REMOTE/LOCAL” control of the pump. In the “HAND” or “LOCAL” position, the pump shall run and the speed of motor shall be varied by a manual speed adjustment on the pump. In “AUTO” or “REMOTE”, the pump shall be started by a remote input dry contact. Pump speed shall be varied by a remote input 4-20 mA signal. The drive shall provide an output 4-20 mA speed signal for remote monitoring. “Running”, “In Remote” selector switch position, “High Pressure,” and “Fail” contacts shall be provided for remote monitoring. Running and fault indications shall also be provided on the pump control panel.

2-4.03. Calibration Column. One transparent plastic calibrating column shall be furnished and installed on the pump suction piping as indicated on the drawings. The column shall be clear PVC or other resistant, rigid, transparent plastic tubing having a vented top cap and screwed flow fitting. Each column shall be graduated in the respective increments over the specified range, complete with a numeral at each graduation.

Feed point	RO CIP/Neutralization Tank	Product Water Tank	Fine Screen Effluent
Column ID, in	0.5		
Screwed Flow Fitting, in	0.5		
Graduated Increments, gal	0.0005		
Capacity, gal	2.17		

The bottom of the calibration column shall be located at or below the bottom of elevation of the storage/day tank metering pump suction nozzle. The columns shall be Valcom, Inc., "Model 85000", or equal, and shall be mounted on steel legs.

2-4.04. Diffusers. Three diffusers shall be provided as shown on the drawings.

2-5. SODIUM BISULFITE FEED SYSTEM. One assembly of feeding equipment shall be furnished and installed to dispense Sodium Bisulfite to the following feed points:

- Dechlorination to Ocean Outfall

2-5.01. Tote and Containment Level Measurement. One containment pallet and scale shall be furnished and installed in the sodium bisulfite chemical tote storage area as shown on the drawings. This unit can be either a single assemblage as shown on the P&IDs or individual pieces.

2-5.01.01 Tote Containment. The containment pallet shall have a capacity of 400 gallons and shall include a platform that can support totes measuring 38 to 50 inches in width. The maximum load capacity shall be 10,000 pounds and the pallet shall be constructed of polyethylene. Provisions shall be included to drain the pallet of rainwater.

Pallets shall be Interstate Products, Inc. “1680 IBC Spill Unit”, Scaletron Industries, Ltd. “4042-63 IBC”, or equal.

2-5.01.02. Day Tank Scale. One electronic load cell scale of the digital type, suitable for weighing the alum day tank, shall be furnished and installed in the chemical feed area as indicated on the drawings. The scale shall have total weighing capacity of 3,000 pounds and shall be designed for floor surface mounting. The scale shall include a digital electronic indicator with capability of transmitting a loop powered 4-20 mA dc signal to the plant control system. The indicator shall have the capability of displaying net, gross, and tare weights. The indicator shall include a digital keyboard for indicator programming and tare

weight entry. The indicator shall be programmable to indicate 0 to 3,000 pounds in 1-pound increments.

The scale shall be Eagle Microsystems "LP4200 Platform Scale" with "EI 1000 Indicator", Force Flow Equipment "Model 40-DR30LP Scale" with "Wizard 4000 Indicator", Scaletron Industries, Ltd. “Model 1099”, or equal.

2-5.02. Quick Connect Coupler. One quick connect coupler shall be furnished and installed on the hose connections for the chemical delivery tote bin as indicated on the drawings. The material of construction shall be compatible with the chemical and approved by the Design-Builder. The quick connect shall be the standard cam and groove type manufactured to specification A-A-59326D. The quick connect fitting shall be the coupler type with cam arms and hose shank or female NPT threads for connecting to hose or piping as indicated on the drawings. The coupler shall be the same size as the hoses or piping as indicated on the drawings. The quick connect coupler shall be as manufactured by OPW Engineered Systems, PT Coupling Company, Inc, without exception.

2-5.03. Metering Pump Skid. One metering pump skid shall be furnished and installed as indicated on the drawings to dispense 38 percent sodium bisulfite with a specific gravity of 1.31 to the points of application. The skid shall be located in the Chemical Facility. The skid shall have one metering pump on the skid, pipe appurtenances, appropriate valves and piping, calibration columns, and a control panel. The piping requirements, valving, and appurtenances shall be as shown on the piping and instrument diagrams. All power and control wiring within the skid shall be provided by the System Integrator such that the skid requires connection of a single primary 120V power circuit.

The skid shall be of substantial construction, shall be constructed of a material resistant to the pumped solution, and shall have an open construction such that there is unobstructed access to the controls, pump head, and pump check valves. Valves and appurtenances shall be within easy reach from the skid edge. The skid shall have a footprint as determined by the System Integrator.

Piping on the skids shall be consistent with the Miscellaneous Plastic Piping Section. Valves shall be type VB-10 consistent with the Miscellaneous Ball Valves Section. Valves shall be labeled with valve numbers shown on the piping and instruments diagrams.

2-5.03.01. Metering Pumps. One metering pump shall be furnished and installed on the skid as indicated on the drawing to dispense 38 percent sodium bisulfite with a specific gravity of 1.31 to the feed points as listed below.

One metering pump shall be furnished to be a shelf spare unit.

Each pump shall include continuous local and remote electric and local manual mechanically controlled metering of solution under the following conditions and requirements listed in the table below.

Feed point	Ocean Outfall
Designation	PMP-0001
Installed pump quantity	One
Shelf spare pump quantity	One
Capacity control range, percent	0 - 100
Metering range, gph	0.002 - 11.6
Maximum speed, rpm	225
Nominal discharge pressure, psi	30

Pumps shall be positive displacement, tube-type peristaltic, case-drive pumps complete with retractable roller pump head, rotor assembly with a minimum of two compression rollers, self-contained variable speed drive, flexible extruded tube, and integral key pad control panel.

The process fluid shall only be in contact with the inside of the pump tubing. The pump tubing shall be constructed of material chemically resistant to the pumped solution, as acceptable to the Design-Builder. The pump shall be capable of accepting at least five tube diameters to increase capacity range. The tubing shall have a minimum wall thickness of 1.5 mm. A 50-foot section of tubing shall be provided for each pump or a total of ten spare replacement tubing assemblies shall be provided.

The pump head shall consist of a fixed track, hinged transparent guard door or removable transparent cover with lock and magnetic safety interlock and two roller rotor assemblies. The door and safety interlock shall render the drive inoperable when the door is open. Conversely, a removable cover shall include an imbedded magnetic safety interlock which will limit the motor rotation speed to 6 rpm when removed.

The tubing shall be in contact with the inside diameter of a fixed track (housing) through an angle of 180^{o} and shall be held in place on the suction and discharge by the clamp mechanisms or pump tube assembly connection fittings. Tube clamps requiring tools will not be acceptable. Tubing replacement shall not require the use of tools.

Rotor assembly shall be equipped with a minimum of two 316 SS or polymeric compression rollers and SS bearings or two polymeric compression rollers and encapsulated SS bearings. Compression rollers shall be located a maximum of

180 degrees apart for compression of the tube against the track a minimum of twice per rotor revolution. One roller shall at all times be fully engaged with the tubing providing complete compression to prevent backflow or siphoning. Tube occlusion or spring tension shall be factory set for the tubing wall thickness and shall not require additional adjustment for other tubing sizes. The rotor assembly shall be securely attached to the output shaft of the drive gear motor by the manufacturer's standard assembly for that model.

The self-contained variable speed drive for each pump shall be fully operational over the entire flow range requirements indicated above. Additionally, the pumps shall be fully capable of the discharge back pressure required above. Pumps and drives shall be suitable for continuous 24-hour operation at the conditions specified.

Each pump shall be completely self-priming with a suction lift capability of up to 30 feet of water. The pump shall be capable of running dry without damaging effects to the pump or hose. The pump shall be valveless and without diaphragms and check valves. Flow through the hose shall be in the direction of the rotor rotation and the motor shall be capable of being fully reversed.

Each pump shall be furnished with the following accessories. All metering pump suction and discharge appurtenances described below and branch piping to these appurtenances shall be the same sizes as the suction and discharge piping indicated on the P&ID.

One transparent PVC bodied Y-pattern strainer with 12-mesh screen and Viton O-ring seals.

One pressure gauge and pressure switch with isolating diaphragm in each pump discharge piping arrangement. The pressure gauge shall be indicating dial type with adjustable pointer and acrylic plastic or shatterproof glass window. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall be approximately 270 degrees. The unit of measurement shall be pounds per square inch and shall be indicated on the dial face. The gauge shall be selected so that gauge readings will be mid-scale under normal operating conditions. The isolating diaphragm shall protect the pressure gauge from the chemical solution. The pressure-switches shall be diaphragm actuated type switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line pressure. Switches shall have weatherproof housings. Switch wetted parts shall be compatible with the process fluid. Where the process is not defined, all wetted parts shall be Teflon-coated or Viton and the connection port shall be stainless steel. All stem-mounted switches shall be provided with ½-inch NPT connections. All pressure switches shall be ranged in psi. Unless otherwise indicated, switches shall have a fixed deadband and shall be auto-reset type. As a minimum, switches shall be SPDT, rated

10 amp at 120 V ac. Switches shall be installed at the locations indicated on the Drawings, with installation conforming to the installation details. All switches, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation of the switch or diaphragm seal. Switches shall be manufactured by Ashcroft, Barksdale, Dwyer/Mercoid, ITT/NeoDyn, or S.O.R.

One external relief valve sized to pass the maximum displacement of the pump.

One properly sized diaphragm type pulsation dampener in each pump discharge piping arrangement. Each pulsation dampener shall be fabricated of materials resistant to the pumped solution and shall include an air charging valve and air gauge. The pulsation dampener shall be sized to limit pressure surges to between 5 and 10 percent of mean pressure.

Leak detection system that shall detect a tubing failure by sensing the presence of liquid inside of the pump head with output signal for remote alarm.

Metering pumps shall be Watson-Marlow “Model 520 Series" or Blue & White “M-4 Series” without exception.

2-5.03.01. Metering Pump Drive Units. The pump shall be supplied with a case-drive integral reversible servo permanent magnet dc drive motor with internal gearbox to accept 120 volts ac, 60 Hz, single phase. Housing shall be pressure cast aluminum with a corrosion resistant powder coat. Unpainted housings, including 316SS, shall not be acceptable. Each pump shall not consume in excess of 790 VA. Drive unit shall be classified for continuous heavy shock duty, AGMA. Each drive unit shall be furnished with a grounded power cord and plug suitable for plugging into a standard grounded 120-volt receptacle. Power cord conductor size shall be #12 AWG minimum for both power and ground. The connection between the power cord and the drive unit shall be as recommended by the manufacturer.

The drive shall be rated Class II, 24-hour duty. Pump drive shall be closed coupled and self-aligning without requiring flexible couplings.

Drive circuitry shall be microprocessor controlled with temperature and load compensation and protection. External VFDs or SCRs shall not be acceptable.

Drive enclosure shall be NEMA 4X rated.

The drive motor shall be capable of varying the speed of the pump to deliver the metering range in gph as specified. The drive shall be provided with an "HAND-OFF-AUTO" or "REMOTE/LOCAL" control of the pump. In the "HAND" or "LOCAL" position, the pump shall run and the speed of motor shall be varied by a manual speed adjustment on the pump. In "AUTO" or "REMOTE", the pump shall be started by a remote input dry contact. Pump speed shall be varied by a remote input 4-20 mA signal. The drive shall provide an output 4-20 mA speed signal for remote monitoring. "Running", "In Remote" selector switch position, "High Pressure," and "Fail" contacts shall be provided for remote monitoring. Running and fault indications shall also be provided on the pump control panel.

2-5.04. Calibration Column. One transparent plastic calibrating column shall be furnished and installed on the pump suction piping as indicated on the drawings. The column shall be clear PVC or other resistant, rigid, transparent plastic tubing having a vented top cap and screwed flow fitting. Each column shall be graduated in the respective increments over the specified range, complete with a numeral at each graduation.

Feed point	Ocean Outfall
Column ID, in	0.5
Screwed Flow Fitting, in	0.5
Graduated Increments, gal	0
Capacity, gal	0.2

The bottom of the calibration column shall be located at or below the bottom of elevation of the storage/day tank metering pump suction nozzle. The columns shall be Valcom, Inc., "Model 85000", or equal, and shall be mounted on steel legs.

2-5.05. Diffuser. One diffuser shall be provided as shown on the drawings.

2-6. ANTISCALANT FEED SYSTEM. One assembly of feeding equipment shall be furnished and installed to dispense Sodium Bisulfite to the following feed points:

- Common RO Header

2-6.01. Tote and containment Level Measurement. One containment pallet and scale shall be furnished and installed in the antiscalant chemical tote storage area as shown on the drawings. This unit can be either a single assemblage as shown on the P&IDs or individual pieces.

2-6.01.01. Tote Containment. The containment pallet shall have a capacity of 400 gallons and shall include a platform that can support totes measuring 38 to 50 inches in width. The maximum load capacity shall be 10,000 pounds and the

pallet shall be constructed of polyethylene. Provisions shall be included to drain the pallet of rainwater.

Pallets shall be Interstate Products, Inc. “1680 IBC Spill Unit”, Scaletron Industries, Ltd. “4042-63 IBC”, or equal.

2-6.01.02. Day Tank Scale. One electronic load cell scale of the digital type, suitable for weighing the alum day tank, shall be furnished and installed in the chemical feed area as indicated on the drawings. The scale shall have total weighing capacity of 3,000 pounds and shall be designed for floor surface mounting. The scale shall include a digital electronic indicator with capability of transmitting a loop powered 4-20 mA dc signal to the plant control system. The indicator shall have the capability of displaying net, gross, and tare weights. The indicator shall include a digital keyboard for indicator programming and tare weight entry. The indicator shall be programmable to indicate 0 to 3,000 pounds in 1-pound increments.

The scale shall be Eagle Microsystems "LP4200 Platform Scale" with "EI 1000 Indicator", Force Flow Equipment "Model 40-DR30LP Scale" with "Wizard 4000 Indicator", Scaletron Industries, Ltd. “Model 1099”, or equal.

2-6.02. Quick Connect Coupler. One quick connect coupler shall be furnished and installed on the hose connections for the chemical delivery tote bin as indicated on the drawings. The material of construction shall be compatible with the chemical and approved by the Design-Builder. The quick connect shall be the standard cam and groove type manufactured to specification A-A-59326D. The quick connect fitting shall be the coupler type with cam arms and hose shank or female NPT threads for connecting to hose or piping as indicated on the drawings. The coupler shall be the same size as the hoses or piping as indicated on the drawings. The quick connect coupler shall be as manufactured by OPW Engineered Systems, PT Coupling Company, Inc, without exception.

2-6.03. Metering Pump Skids. One metering pump skid shall be furnished and installed as indicated on the drawings to dispense 100 percent antiscalant with a specific gravity of 1.12 to the points of application. The skid shall be located in the chemical building. The skid shall have seven metering pumps on the skid, pipe appurtenances, appropriate valves and piping, calibration columns, and a control panel. The piping requirements, valving, and appurtenances shall be as shown on the piping and instrument diagrams. Each skid shall have a dedicated control panel, and all power and control wiring within the skid shall be provided by the System Integrator such that the skid requires connection of a single primary 120V power circuit.

Skids shall be of substantial construction, shall be constructed of a material resistant to the pumped solution, and shall have an open construction such that there is unobstructed access to the controls, pump head, and pump check

valves. Valves and appurtenances shall be within easy reach from the skid edge. The skid shall have a footprint as determined by the System Integrator.

Piping on the skids shall be consistent with the Miscellaneous Plastic Piping Section. Valves shall be type VB-10 consistent with the Miscellaneous Ball Valves Section. Valves shall be labeled with valve numbers shown on the piping and instruments diagrams.

2-6.03. Metering Pumps. One metering pump shall be furnished and installed on the skid as indicated on the drawing to dispense 100 percent antiscalant with a specific gravity of 1.12 to the feed points as listed below.

One metering pump shall be furnished to be a shelf spare unit.

Each pump shall include continuous local and remote electric and local manual mechanically controlled metering of solution under the following conditions and requirements listed in the table below.

Feed point	Common RO Header
Designation	PMP-0001
Installed pump quantity	One
Shelf spare pump quantity	One
Capacity control range, percent	0 - 100
Metering range, gph	0.02 - 0.21
Maximum speed, rpm	225
Nominal discharge pressure, psi	30

Pumps shall be positive displacement, tube-type peristaltic, case-drive pumps complete with retractable roller pump head, rotor assembly with a minimum of two compression rollers, self-contained variable speed drive, flexible extruded tube, and integral key pad control panel.

The process fluid shall only be in contact with the inside of the pump tubing. The pump tubing shall be constructed of material chemically resistant to the pumped solution, as acceptable to the Design-Builder. The pump shall be capable of accepting at least five tube diameters to increase capacity range. The tubing shall have a minimum wall thickness of 1.5 mm. A 50-foot section of tubing shall be provided for each pump or a total of ten spare replacement tubing assemblies shall be provided.

The pump head shall consist of a fixed track, hinged transparent guard door or removable transparent cover with lock and magnetic safety interlock and two roller rotor assemblies. The door and safety interlock shall render the drive

inoperable when the door is open. Conversely, a removable cover shall include an imbedded magnetic safety interlock which will limit the motor rotation speed to 6 rpm when removed.

The tubing shall be in contact with the inside diameter of a fixed track (housing) through an angle of 180^{o} and shall be held in place on the suction and discharge by the clamp mechanisms or pump tube assembly connection fittings. Tube clamps requiring tools will not be acceptable. Tubing replacement shall not require the use of tools.

Rotor assembly shall be equipped with a minimum of two 316 SS or polymeric compression rollers and SS bearings or two polymeric compression rollers and encapsulated SS bearings. Compression rollers shall be located a maximum of 180 degrees apart for compression of the tube against the track a minimum of twice per rotor revolution. One roller shall at all times be fully engaged with the tubing providing complete compression to prevent backflow or siphoning. Tube occlusion or spring tension shall be factory set for the tubing wall thickness and shall not require additional adjustment for other tubing sizes. The rotor assembly shall be securely attached to the output shaft of the drive gear motor by the manufacturer's standard assembly for that model.

The self-contained variable speed drive for each pump shall be fully operational over the entire flow range requirements indicated above. Additionally, the pumps shall be fully capable of the discharge back pressure required above. Pumps and drives shall be suitable for continuous 24-hour operation at the conditions specified.

Each pump shall be completely self-priming with a suction lift capability of up to 30 feet of water. The pump shall be capable of running dry without damaging effects to the pump or hose. The pump shall be valveless and without diaphragms and check valves. Flow through the hose shall be in the direction of the rotor rotation and the motor shall be capable of being fully reversed.

Each pump shall be furnished with the following accessories. All metering pump suction and discharge appurtenances described below and branch piping to these appurtenances shall be the same sizes as the suction and discharge piping indicated on the P&ID.

One transparent PVC bodied Y-pattern strainer with 12-mesh screen and Viton O-ring seals.

One pressure gauge and pressure switch with isolating diaphragm in each pump discharge piping arrangement. The pressure gauge shall be indicating dial type with adjustable pointer and acrylic plastic or shatterproof glass window. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall be approximately 270 degrees. The unit of measurement shall be pounds per square inch and shall be indicated on the dial face. The gauge shall

be selected so that gauge readings will be mid-scale under normal operating conditions. The isolating diaphragm shall protect the pressure gauge from the chemical solution. The pressure-switches shall be diaphragm actuated type switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line pressure. Switches shall have weatherproof housings. Switch wetted parts shall be compatible with the process fluid. Where the process is not defined, all wetted parts shall be Teflon-coated or viton and the connection port shall be stainless steel. All stem-mounted switches shall be provided with 1/2-inch NPT connections. All pressure switches shall be ranged in psi. Unless otherwise indicated, switches shall have a fixed deadband and shall be auto-reset type. As a minimum, switches shall be SPDT, rated 10 amp at 120 V ac. Switches shall be installed at the locations indicated on the Drawings, with installation conforming to the installation details. All switches, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation of the switch or diaphragm seal. Switches shall be manufactured by Ashcroft, Barksdale, Dwyer/Mercoid, ITT/NeoDyn, or S.O.R.

One external relief valve sized to pass the maximum displacement of the pump.

One properly sized diaphragm type pulsation dampener in each pump discharge piping arrangement. Each pulsation dampener shall be fabricated of materials resistant to the pumped solution and shall include an air charging valve and air gauge. The pulsation dampener shall be sized to limit pressure surges to between 5 and 10 percent of mean pressure.

Leak detection system that shall detect a tubing failure by sensing the presence of liquid inside of the pump head with output signal for remote alarm.

Metering pumps shall be Watson-Marlow “Model 520 Series" or Blue & White “M-4 Series” without exception.

2-6.03.01. Metering Pump Drive Units. The pump shall be supplied with a case-drive integral reversible servo permanent magnet dc drive motor with internal gearbox to accept 120 volts ac, 60 Hz, single phase. Housing shall be pressure cast aluminum with a corrosion resistant powder coat. Unpainted housings, including 316SS, shall not be acceptable. Each pump shall not consume in excess of 790 VA. Drive unit shall be classified for continuous heavy shock duty, AGMA. Each drive unit shall be furnished with a grounded power cord and plug

suitable for plugging into a standard grounded 120-volt receptacle. Power cord conductor size shall be #12 AWG minimum for both power and ground. The connection between the power cord and the drive unit shall be as recommended by the manufacturer.

The drive shall be rated Class II, 24-hour duty. Pump drive shall be closed coupled and self-aligning without requiring flexible couplings.

Drive circuitry shall be microprocessor controlled with temperature and load compensation and protection. External VFDs or SCRs shall not be acceptable.

Drive enclosure shall be NEMA 4X rated.

The drive motor shall be capable of varying the speed of the pump to deliver the metering range in gph as specified. The drive shall be provided with an "HAND-OFF-AUTO" or "REMOTE/LOCAL" control of the pump. In the "HAND" or "LOCAL" position, the pump shall run and the speed of motor shall be varied by a manual speed adjustment on the pump. In "AUTO" or "REMOTE", the pump shall be started by a remote input dry contact. Pump speed shall be varied by a remote input 4-20 mA signal. The drive shall provide an output 4-20 mA speed signal for remote monitoring. "Running", "In Remote" selector switch position, "High Pressure," and "Fail" contacts shall be provided for remote monitoring. Running and fault indications shall also be provided on the pump control panel.

2-6.04. Calibration Column. One transparent plastic calibrating column shall be furnished and installed on the pump suction piping as indicated on the drawings. The column shall be clear PVC or other resistant, rigid, transparent plastic tubing having a vented top cap and screwed flow fitting. Each column shall be graduated in the respective increments over the specified range, complete with a numeral at each graduation.

Feed point	Common RO Header
Column ID, in	0.5
Screwed Flow Fitting, in	0.5
Graduated Increments, gal	0.005
Capacity, gal	0.004

The bottom of the calibration column shall be located at or below the bottom of elevation of the storage/day tank metering pump suction nozzle. The columns shall be Valcom, Inc., "Model 85000", or equal, and shall be mounted on steel legs.

2-6.05. Diffuser. One diffuser shall be provided as shown on the drawings.

2-7. CITRIC ACID FEED SYSTEM. One assembly of feeding equipment shall be furnished and installed to dispense citric acid to the following feed points:

- RO CIP System
- MBR Maintenance

2-7.01. Tote and containment Level Measurement. One containment pallet and scale shall be furnished and installed in the citric acid chemical tote storage area as shown on drawing 90-I-006. This unit can be either a single assemblage as shown on the P&IDs or individual pieces.

2-7.01.01. Tote Containment. The containment pallet shall have a capacity of 400 gallons and shall include a platform that can support totes measuring 38 to 50 inches in width. The maximum load capacity shall be 10,000 pounds and the pallet shall be constructed of polyethylene. Provisions shall be included to drain the pallet of rainwater.

Pallets shall be Interstate Products, Inc. “1680 IBC Spill Unit”, Scaletron Industries, Ltd. “4042-63 IBC”, or equal.

2-7.01.02. Day Tank Scale. One electronic load cell scale of the digital type, suitable for weighing the alum day tank, shall be furnished and installed in the chemical feed area as indicated on the drawings. The scale shall have total weighing capacity of 3,000 pounds and shall be designed for floor surface mounting. The scale shall include a digital electronic indicator with capability of transmitting a loop powered 4-20 mA dc signal to the plant control system. The indicator shall have the capability of displaying net, gross, and tare weights. The indicator shall include a digital keyboard for indicator programming and tare weight entry. The indicator shall be programmable to indicate 0 to 3,000 pounds in 1-pound increments.

The scale shall be Eagle Microsystems "LP4200 Platform Scale" with "EI 1000 Indicator", Force Flow Equipment "Model 40-DR30LP Scale" with "Wizard 4000 Indicator", Scaletron Industries, Ltd. “Model 1099”, or equal.

2-7.02. Quick Connect Coupler. One quick connect coupler shall be furnished and installed on the hose connections for the chemical delivery tote bin as indicated on the drawings. The material of construction shall be compatible with the chemical and approved by the Design-Builder. The quick connect shall be the standard cam and groove type manufactured to specification A-A-59326D. The quick connect fitting shall be the coupler type with cam arms and hose shank or female NPT threads for connecting to hose or piping as indicated on the drawings. The coupler shall be the same size as the hoses or piping as indicated on the drawings. The quick connect coupler shall be as manufactured by OPW Engineered Systems, PT Coupling Company, Inc, without exception.

2-7.03. Metering Pump Skid. One metering pump skid shall be furnished and installed as indicated on the drawings to dispense 50 percent citric acid with a specific gravity of 1.24 to the points of application. The skid shall be located in the Chemical Facility. The skid shall have two metering pumps on the skid, pipe appurtenances, appropriate valves and piping, calibration columns, and control panels. The piping requirements, valving, and appurtenances shall be as shown on the piping and instrument diagrams. All power and control wiring within the skid shall be provided by the System Integrator such that the skid requires connection of a single primary 120V power circuit.

Skids shall be of substantial construction, shall be constructed of a material resistant to the pumped solution, and shall have an open construction such that there is unobstructed access to the controls, pump head, and pump check valves. Valves and appurtenances shall be within easy reach from the skid edge. The skid shall have a footprint as determined by the System Integrator.

Piping on the skids shall be consistent with the Miscellaneous Plastic Piping Section. Valves shall be type VB-10 consistent with the Miscellaneous Ball Valves Section. Valves shall be labeled with valve numbers shown on the piping and instruments diagrams.

One transparent PVC bodied Y-pattern strainer with 12-mesh screen and Viton O-ring seals shall be provided on the skid inlet pipe, upstream of all metering pumps.

2-7.03.01. Metering Pumps. Two metering pumps shall be furnished and installed on the skid as indicated on the drawing to dispense 50 percent citric acid with a specific gravity of 1.24 to the feed points as listed below.

Two metering pumps shall be furnished to be shelf spare units.

Each pump shall include continuous local and remote electric and local manual mechanically controlled metering of solution under the following conditions and requirements listed in the table below.

Feed point	RO CIP System	MBR Maintenance
Designation	PMP-0101	PMP-0201
Installed pump quantity	One	One
Shelf spare pump quantity	One	One
Capacity control range, percent	0 - 100	0 - 100
Metering range, gph	105	0.06 -150
Maximum speed, rpm	225	225
Nominal discharge pressure, psi	30	30

Pumps shall be positive displacement, tube-type peristaltic, case-drive pumps complete with retractable roller pump head, rotor assembly with a minimum of two compression rollers, self-contained variable speed drive, flexible extruded tube, and integral key pad control panel.

The process fluid shall only be in contact with the inside of the pump tubing. The pump tubing shall be constructed of material chemically resistant to the pumped solution, as acceptable to the Design-Builder. The pump shall be capable of accepting at least five tube diameters to increase capacity range. The tubing shall have a minimum wall thickness of 1.5 mm. A 50-foot section of tubing shall be provided for each pump or a total of ten spare replacement tubing assemblies shall be provided.

The pump head shall consist of a fixed track, hinged transparent guard door or removable transparent cover with lock and magnetic safety interlock and two roller rotor assemblies. The door and safety interlock shall render the drive inoperable when the door is open. Conversely, a removable cover shall include an imbedded magnetic safety interlock which will limit the motor rotation speed to 6 rpm when removed.

The tubing shall be in contact with the inside diameter of a fixed track (housing) through an angle of 180^{o} and shall be held in place on the suction and discharge by the clamp mechanisms or pump tube assembly connection fittings. Tube clamps requiring tools will not be acceptable. Tubing replacement shall not require the use of tools.

Rotor assembly shall be equipped with a minimum of two 316 SS or polymeric compression rollers and SS bearings or two polymeric compression rollers and encapsulated SS bearings. Compression rollers shall be located a maximum of 180 degrees apart for compression of the tube against the track a minimum of twice per rotor revolution. One roller shall at all times be fully engaged with the tubing providing complete compression to prevent backflow or siphoning. Tube occlusion or spring tension shall be factory set for the tubing wall thickness and

shall not require additional adjustment for other tubing sizes. The rotor assembly shall be securely attached to the output shaft of the drive gear motor by the manufacturer's standard assembly for that model.

The self-contained variable speed drive for each pump shall be fully operational over the entire flow range requirements indicated above. Additionally, the pumps shall be fully capable of the discharge back pressure required above. Pumps and drives shall be suitable for continuous 24-hour operation at the conditions specified.

Each pump shall be completely self-priming with a suction lift capability of up to 30 feet of water. The pump shall be capable of running dry without damaging effects to the pump or hose. The pump shall be valveless and without diaphragms and check valves. Flow through the hose shall be in the direction of the rotor rotation and the motor shall be capable of being fully reversed.

Each pump shall be furnished with the following accessories. All metering pump suction and discharge appurtenances described below and branch piping to these appurtenances shall be the same sizes as the suction and discharge piping indicated on the P&ID.

One pressure gauge and pressure switch with isolating diaphragm in each pump discharge piping arrangement. The pressure gauge shall be indicating dial type with adjustable pointer and acrylic plastic or shatterproof glass window. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall be approximately 270 degrees. The unit of measurement shall be pounds per square inch and shall be indicated on the dial face. The gauge shall be selected so that gauge readings will be mid-scale under normal operating conditions. The isolating diaphragm shall protect the pressure gauge from the chemical solution. The pressure-switches shall be diaphragm actuated type switches. Switches shall be field adjustable type, with trip point repeatability better than 1 percent of actual pressure. Switches shall have over-range protection to maximum process line pressure. Switches shall have weatherproof housings. Switch wetted parts shall be compatible with the process fluid. Where the process is not defined, all wetted parts shall be Teflon-coated or Viton and the connection port shall be stainless steel. All stem-mounted switches shall be provided with ½-inch NPT connections. All pressure switches shall be ranged in psi. Unless otherwise indicated, switches shall have a fixed deadband and shall be auto-reset type. As a minimum, switches shall be SPDT, rated 10 amp at 120 V ac. Switches shall be installed at the locations indicated on the Drawings, with installation conforming to the installation details. All switches, snubbers, and diaphragm seals shall be installed in the vertical, upright position. Thread sealer, suitable for use with the associated process, shall be used in the assembly of threaded connections. All connections shall be free from leaks. Lines shall be purged of trapped air at switch locations prior to installation of the switch

or diaphragm seal. Switches shall be manufactured by Ashcroft, Barksdale, Dwyer/Mercoid, ITT/NeoDyn, or S.O.R.

One external relief valve sized to pass the maximum displacement of the pump.

One properly sized diaphragm type pulsation dampener in each pump discharge piping arrangement. Each pulsation dampener shall be fabricated of materials resistant to the pumped solution and shall include an air charging valve and air gauge. The pulsation dampener shall be sized to limit pressure surges to between 5 and 10 percent of mean pressure.

Leak detection system that shall detect a tubing failure by sensing the presence of liquid inside of the pump head with output signal for remote alarm.

Metering pumps shall be Watson-Marlow “Model 520 Series" or Blue & White “M-4 Series” without exception.

2-7.03.02. Metering Pump Drive Units. Each pump shall be supplied with a case-drive integral reversible servo permanent magnet dc drive motor with internal gearbox to accept 120 volts ac, 60 Hz, single phase. Housing shall be pressure cast aluminum with a corrosion resistant powder coat. Unpainted housings, including 316SS, shall not be acceptable. Each pump shall not consume in excess of 790 VA. Drive unit shall be classified for continuous heavy shock duty, AGMA. Each drive unit shall be furnished with a grounded power cord and plug suitable for plugging into a standard grounded 120-volt receptacle. Power cord conductor size shall be #12 AWG minimum for both power and ground. The connection between the power cord and the drive unit shall be as recommended by the manufacturer.

The drive shall be rated Class II, 24-hour duty. Pump drive shall be closed coupled and self-aligning without requiring flexible couplings.

Drive circuitry shall be microprocessor controlled with temperature and load compensation and protection. External VFDs or SCRs shall not be acceptable.

Drive enclosure shall be NEMA 4X rated.

The drive motor shall be capable of varying the speed of the pump to deliver the metering range in gph as specified. The drive shall be provided with an “HAND-OFF-AUTO” or “REMOTE/LOCAL” control of the pump. In the “HAND” or “LOCAL” position, the pump shall run and the speed of motor shall be varied by a manual speed adjustment on the pump. In “AUTO” or “REMOTE”, the pump shall be started by a remote input dry contact. Pump speed shall be varied by a remote input 4-20 mA signal. The drive shall provide an output 4-20 mA speed

signal for remote monitoring. “Running”, “In Remote” selector switch position, “High Pressure,” and “Fail” contacts shall be provided for remote monitoring. Running and fault indications shall also be provided on the pump control panel.

2-7.04. Calibration Column. One transparent plastic calibrating column shall be furnished and installed on the pump suction piping as indicated on the drawings. The column shall be clear PVC or other resistant, rigid, transparent plastic tubing having a vented top cap and screwed flow fitting. Each column shall be graduated in the respective increments over the specified range, complete with a numeral at each graduation.

Feed point	RO CIP System	MBR Maintenance
Column ID, in	6	
Screwed Flow Fitting, in	1	
Graduated Increments, gal	0.05	
Capacity, gal	2.7	

The bottom of the calibration column shall be located at or below the bottom of elevation of the storage/day tank metering pump suction nozzle. The columns shall be Valcom, Inc., "Model 85000", or equal, and shall be mounted on steel legs.

2-7.05. Diffusers. Two diffusers shall be provided as shown on the drawings.

2-8. SULFURIC ACID FEED SYSTEM. One assembly of feeding equipment shall be furnished and installed to dispense sulfuric acid to the following feed points:

- RO Feed Tank Outlet
- UV/AOP System

2-8.01. Tote and containment Level Measurement. One containment pallet and scale shall be furnished and installed in the citric acid chemical tote storage area as shown on drawing 90-I-006. This unit can be either a single assemblage as shown on the P&IDs or individual pieces.

2-8.01.01. Tote Containment. The containment pallet shall have a capacity of 400 gallons and shall include a platform that can support totes measuring 38 to 50 inches in width. The maximum load capacity shall be 10,000 pounds and the pallet shall be constructed of polyethylene. Provisions shall be included to drain the pallet of rainwater.

Pallets shall be Interstate Products, Inc. “1680 IBC Spill Unit”, Scaletron Industries, Ltd. “4042-63 IBC”, or equal.

2-8.01.02. Day Tank Scale. One electronic load cell scale of the digital type, suitable for weighing the alum day tank, shall be furnished and installed in the chemical feed area as indicated on the drawings. The scale shall have total weighing capacity of 3,000 pounds and shall be designed for floor surface mounting. The scale shall include a digital electronic indicator with capability of transmitting a loop powered 4-20 mA dc signal to the plant control system. The indicator shall have the capability of displaying net, gross, and tare weights. The indicator shall include a digital keyboard for indicator programming and tare weight entry. The indicator shall be programmable to indicate 0 to 3,000 pounds in 1-pound increments.

The scale shall be Eagle Microsystems "LP4200 Platform Scale" with "EI 1000 Indicator", Force Flow Equipment "Model 40-DR30LP Scale" with "Wizard 4000 Indicator", Scaletron Industries, Ltd. “Model 1099”, or equal.

2-8.02. Quick Connect Coupler. One quick connect coupler shall be furnished and installed on the hose connections for the chemical delivery tote bin as indicated on the drawings. The material of construction shall be compatible with the chemical and approved by the Design-Builder. The quick connect shall be the standard cam and groove type manufactured to specification A-A-59326D. The quick connect fitting shall be the coupler type with cam arms and hose shank or female NPT threads for connecting to hose or piping as indicated on the drawings. The coupler shall be the same size as the hoses or piping as indicated on the drawings. The quick connect coupler shall be as manufactured by OPW Engineered Systems, PT Coupling Company, Inc, without exception.

2-8.03. Metering Pump Skid. One metering pump skid shall be furnished and installed as indicated on the drawings to dispense 93 percent sulfuric acid with a specific gravity of 1.81 to the points of application. The skid shall be located in the Chemical Facility. The skid shall have two metering pumps on the skid, pipe appurtenances, appropriate valves and piping, calibration columns, and control panels. The piping requirements, valving, and appurtenances shall be as shown on the piping and instrument diagrams. All power and control wiring within the skid shall be provided by the System Integrator such that the skid requires connection of a single primary 120V power circuit.

Skid shall be of substantial construction, shall be constructed of a material resistant to the pumped solution, and shall have an open construction such that there is unobstructed access to the controls, pump head, and pump check valves. Valves and appurtenances shall be within easy reach from the skid edge. The skid shall have a footprint as determined by the System Integerator.

Piping on the skids shall be consistent with the Miscellaneous Steel Piping Section. Valves shall be type alloy-20 body valves consistent with the Miscellaneous Ball Valves Section. Valves shall be labeled with valve numbers shown on the piping and instruments diagrams.

One Carpenter 20 bodied Y-pattern strainer with 12-mesh screen and Viton O-ring seals shall be provided on the skid inlet pipe, upstream of all metering pumps.

2-8.03.01. Metering Pumps. Two metering pumps shall be furnished and installed on the skid as indicated on the drawing to dispense 93 percent sulfuric acid with a specific gravity of 1.81 to the feed points as listed below.

Two metering pumps shall be furnished to be shelf spares.

Each pump shall include continuous local and remote electric and local manual mechanically controlled metering of solution under the following conditions and requirements listed in the table below.

Feed point	RO Feed Tank Outlet	UV/AOP System
Designation	HSO4-P--0101	HSO4-P-0201
Installed pump quantity	One	One
Shelf spare pump quantity	One	One
Capacity control range, percent	0 - 100	1 - 100
Metering range, gph	0.15 - 0.84	0.01 - 0.10
Minimum drive motor, hp	0.50	0.50
Maximum stroke rate at rated conditions, spm	100	100
Accuracy, percent of scale over metering range	2	2
Minimum suction head required, psia	9.5	9.5
Nominal discharge pressure, psi	40	40

Each pump shall be of the positive displacement type using a hydraulic or mechanically actuated diaphragm. The diaphragm shall have an integrally molded O-ring for installation in the pump housings.

Metering pumps shall have an internal drive shaft connected to a motor with support bearings on both ends within the gear case. Each pump shall have one adjustable head.

Inlet and outlet check valves shall be of the single valve type, with valve housing which are removable without disassembly of the pipe fittings.

Material of construction of the pump head, check valves, and pump appurtenances shall be Carpenter 20 unless otherwise noted.

Materials of construction shall be selected for resistance to the pumped solution, as acceptable to the Design-Builder.

The rate of metering shall be changed by manually or automatically varying the stroking speed and the stroke length. Minimum flow rate shall be achieved at a stroking length not less than 10 percent and a stroking speed not less than 20 spm.

Each pump liquid end shall be equipped with a manual mechanical stroke length adjustment knob to provide capacity adjustment without the use of tools and while the pump is running. All moving parts shall be totally enclosed and self-lubricating.

Each pump liquid end shall be equipped with an automatic stroke length controller set to operate from a remote signal. The input signal shall be 4-20 mA dc and shall be ungrounded type with an input resistance of not more than 250 ohms.

Motor horsepower for each pump shall be based on the above requirements and on the discharge back pressure required by the pump furnished. Motor shall not be less than the indicated horsepower. Power to the motor shall be provided by an SCR controlled rate controller as specified herein. Motor shall be supplied with a tachometer to close the loop with the variable speed drive. Power and control wiring from the controller to the motor shall be provided by the pump supplier.

Each pump motor shall be equipped with an electric speed adjustment to operate from an SCR controller. The signal input shall be 4-20 mA dc and shall be ungrounded differential type with an input resistance of not more than 250 ohms. The controller shall accept either the remote signal or a manual rate control signal at the controller, and vary the dc voltage to the motor, with feedback as required to attain the desired rate. Each controller shall operate from a 120 volt, single phase, 60 Hz power supply, and shall be mounted in a metering pump control panel as described in the Metering Pump Control Panel paragraph.

Each pump's liquid end shall include a diaphragm failure detection and alarm normally-open dry contact switch. Upon activation, the switch shall an alarm signal to the control panel which shall promptly stop the pump drive motor and activate the 'Fail' indicating light.

Each pump shall be furnished with the following accessories. All metering pump suction and discharge appurtenances described below and branch piping to these appurtenances shall be the same sizes as the suction and discharge piping indicated on the P&ID.

One pressure gauge and high pressure switch with isolating diaphragm installed in the discharge piping. The pressure gauge shall be indicating dial type with adjustable pointer and acrylic plastic or shatterproof glass window. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall be approximately 270 degrees. The unit of measurement shall be pounds per square inch and shall be indicated on the dial face. The gauge shall be selected so that gauge readings will be mid-scale under normal operating conditions. The high pressure switch shall be of the diaphragm type, shall have a weatherproof housing, shall have a trip point reliability better than 1 percent of actual pressure, and shall at minimum be SPDT rated at 10 amp at 120 VAC. The isolating diaphragm shall protect the pressure gauge from the chemical solution.

One external pressure relief valve sized to pass the maximum displacement of the pump. The pressure setting shall be as recommended by the pump manufacturer. The pressure relief valve shall be constructed of Carpenter 20.

One properly sized backpressure valve as recommended by the manufacturer. The back pressure valve shall be constructed of Carpenter 20.

One properly sized diaphragm type pulsation dampener in each pump discharge piping arrangement. Each pulsation dampener shall be fabricated of materials resistant to the pumped solution and shall include an air charging valve and air gauge. The pulsation dampener shall be sized to limit pressure surges to between 5 and 10 percent of mean pressure.

All wiring shall be furnished complete and ready for connection of an external power circuit.

2-8.03.02. Diaphragm Metering Pump Controls. For variable speed diaphragm metering pumps, the pump supplier shall provide a local control panel for each pump. The control panel shall house the SCR drive and control components required for operation of the metering pump as specified herein. The control panel shall be a fiberglass or 316 SS NEMA Type 4X enclosure mounted on the pump skid complete with wiring to the pump motor and other skid mounted devices. All wiring terminals shall be furnished complete and ready for connection to the external power supply, the remote pump controls, and the pump and pump mounted devices. Each control panel shall be provided with an engraved nameplate indicating the controlled unit, and nameplates for all major components contained on the panel face and within the control panel.

Control panels for variable speed diaphragm metering pumps shall have an “On-Off-Remote” switch and local speed adjustment on the panel front. When “On” is selected, the pump shall run and speed shall be adjusted using the local controls. When “Remote” is selected, run/stop control shall be by a normally open contact input to the panel, and speed control shall be by a 4-20 mA input. Indicating lights shall be provided on the panel front for “Run”, “Stopped”, and “Drive Failure”. These indicating lights shall be red, green, and amber respectively. Where a high discharge pressure switch is indicated on the drawings or specified to be provided for the pump, the pump shall shut down on high discharge pressure, and an amber “High Discharge Pressure” indicating light on the panel front shall illuminate. Where a diaphragm leak detection system is indicated on the drawings or specified to be provided for the pump, the pump shall shut down on diaphragm leakage and an amber “Diaphragm Failure” indicating light on the panel front shall illuminate. LCD or similar type display functions are acceptable alternatives to indicating lights.

Outputs shall be provided from panels for variable speed diaphragm metering pumps as follows:

In Remote (NO dry contact)
Running (NO dry contact)
Fail (NO dry contact)
Speed (4-20 mA)
Stroke Length (4-20 mA), where electronic stroke length control is provided
Leak Detected (NO dry contact)
High Pressure (NO dry contact)

The signal controlling the Fail contact shall be generated by the SCR drive. Where high discharge pressure and/or diaphragm leakage is monitored, the Fail contact shall include these conditions. Manual reset of the failure condition shall be required at the control panel.

Where an electronic stroke length controller is specified, the controller shall be provided with a “Local-Remote” switch. When “Remote” is selected, stroke length adjustment shall be by a 4-20 mA input signal. When “Local” is selected, stroke length control by the 4-20 mA input signal shall be disabled and stroke length shall be adjusted manually. A 4-20 mA output signal proportional to stroke length shall also be provided. The controller and related devices shall have NEMA 4X enclosures.

2-8.04. Calibration Column. One transparent plastic calibrating column shall be furnished and installed on the pump suction piping as indicated on the drawings. The column shall be clear PVC or other resistant, rigid, transparent plastic tubing having a vented top cap and screwed flow fitting. Each column shall be graduated in the respective increments over the specified range, complete with a numeral at each graduation.

Feed point	RO Feed Tank Outlet	UV/AOP System
Column ID, in	0.5	
Screwed Flow Fitting, in	0.5	
Graduated Increments, gal	0.0005	
Capacity, gal	0.02	

The bottom of the calibration column shall be located at or below the bottom of elevation of the storage/day tank metering pump suction nozzle. The columns shall be Valcom, Inc., "Model 85000", or equal, and shall be mounted on steel legs.

2-8.05. Sulfuric Acid Dilution Meter Panel. One sulfuric acid dilution panel (P-HSO4-PNL-0001) of the 2-in 2-out type shall be provided in accordance with the drawings and as specified to provide diluted sulfuric acid. The nameplates and all components shall be supplied panel-mounted by the System Integrator.

The panel shall be rigidly supported in the location indicated on the Drawings. The panel shall be constructed of stainless steel and suitably reinforced. The panel shall be a frame assembly that permits easy removal of components mounted on the panel.

All facilities shall be rigidly mounted on the panel, including piping and valves necessary for control of sulfuric acid, rotameters, and other necessary appurtenances, all as indicated and required. Piping and valves shall conform to the specification sections.

The two water rotameters shall consist of calibrated glass tubes provided with floats of materials as recommended by the manufacturer of the equipment. Each of the rotameters shall be capable of indicating flow suitable for a solution concentration of 2-10% sulfuric acid by weight. Each rotameter shall be provided with a nameplate indicating the point of application.

Two manual globe valves shall be provided on the discharge of the rotameters as indicated on the drawings. The globe valves shall meet the requirements of the Globe Valves Section.

Two motorized ball valves (NPW-V-001 and NPW-V-0003) shall be provided for water flow to the injection quill. The globe valves shall meet the requirements of Miscellaneous Ball Valves Section.

Two motorized ball valves (HSO4-V-0002 and HSO4-V-0004) constructed of Carpenter 20 shall be provided for sulfuric acid flow to the injection quill. The ball valves shall meet the requirements of the Miscellaneous Ball Valves Section.

Four check valves, each constructed of Carpenter 20, shall be provided on the two inlet sides of each injection quill. Each check valve shall meet the requirements of the Check Valves Section.

Two injection quills shall be provided to mix inlet water and sulfuric acid. Each injection quill shall be Neptune injection quill “Model QC-C20-50.”

Two temperature transmitters and elements (TE/AIT-001 and TE/TIT-002 shall be furnished and installed as indicated in the Instruments Section.

Two conductivity measurement transmitters and elements (AE/TIT-001 and AE/AIT-002 shall be furnished and installed as indicated in the Instruments Section.

Water inlet piping shall be PVC-2 as specified in the Miscellaneous Plastic Pipe Section.

Sulfuric acid inlet piping shall be CRP-1 as specified in the Miscellaneous Steel Pipe Section.

Injection quill outlet pipe shall be Teflon lined carbon steel piping as specified in the Miscellaneous Steel Pipe Section.

The panel shall have a nameplate with the words "SULFURIC DILUTION PANEL" mounted on the top of the panel.

2-8.06. Diffusers. Two diffusers shall be provided as shown on the drawings.

2-09. SAFETY EQUIPMENT. Six chemical handling safety equipment kits shall be provided. Each kit shall include, but shall not be limited to, chemical splash goggles, canister type dust and mist respirator, rubber gloves, and rubber apron, all packed in a suitable carrying case.

PART 3 - EXECUTION

3-1. SHOP INSPECTION. Should the Design-Builder elect, each pump skid shall be made available for inspection at the factory prior to being shipped. The System Integrator shall inform the Design-Builder one month prior to shipping such that arrangements can be made to inspect the equipment prior to shipping. The skids shall be set up to pump water during the inspection such that during the inspection the pump and control panel operation can be verified. Design-Builder reserves the right to reject the equipment and/or skids during the shop inspection including but not limited to incorrect pipe materials, incorrect valve types, incorrect solvent cements, shoddy construction, and equipment malfunction.

3-2 SHIPPING. Prior to being shipped, the skids shall be thoroughly dried. Shipping of the skids shall conform to the Shipping section such that the skids are not damaged in transit.

3-3. INSTALLATION. Equipment and materials furnished under this section shall be installed in proper operating condition in full conformity with Drawings, specifications, and recommendations of the equipment manufacturer, unless exceptions are noted by the Design-Builder. All items necessary for a complete operating system shall be installed.

3-3.01. Equipment Bases. Unless otherwise specified or indicated on the Drawings, each item of chemical feed equipment shall be mounted on a concrete base approximately six inches above the floor. If feeders or other components must be supported at higher elevations above the floor, suitable supplementary bases shall be provided.

3-3.02. Installation Check. An experienced, competent, and authorized representative of the System Integrator shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when equipment is placed in operation and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The System Integrator's representative shall furnish a written report certifying that the equipment has been properly installed; that gas piping has been properly cleaned; is in accurate alignment; is free from undue stress imposed by connecting piping or anchor bolts; and has been operated at full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the contract price for the number of days and round trips to the site as required.

3-4. CLEANING. At the completion of installation and testing, all equipment, pipes, ductwork, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired.

3-5. TRAINING. The System Integrator shall provide a qualified representative at the jobsite for one day to train the Owner's personnel in operating and maintaining the equipment.

End of Section

Section 43 40 41

POLYMER FEED SYSTEMS

PART 1 - GENERAL

1-1. SCOPE. This section covers polymer feed equipment and accessories. Principal items to be furnished and installed shall include the following:

Polymer Feed System.

One tote mixer
One containment with integral scale.
One quick connect coupler.
One polymer feeder/blender system skid.
One shelf spare neat polymer pump
One calibration column.

The following items of work and equipment are covered under other sections:

Piping and valves between items of equipment.
Water supply and electric power supply to the equipment.
Drain and vent piping.

1-2. SYSTEM INTEGRATOR. The polymer feed systems shall be designed, coordinated, and supplied by a competent System Integrator. The System Integrator shall be regularly engaged in the business of designing and assembling polymer feed systems for water treatment or wastewater treatment plant projects. The System Integrator shall be responsible for ensuring that a complete functioning system is supplied for each Polymer Feed System. The System Integrator shall be responsible for coordinating all equipment, piping, and valves, and appurtenances for each Polymer Feed System as well as coordination with the Dewatering System Supplier where the polymer will be used.

1-2.01 System Integrator Qualifications. The System Integrator shall meet all of the following requirements and within 30 days after the Notice of Award, shall submit proof of the following qualifications for the intended System Integrator:

The System Integrator has successfully provided similar work for at least 5 years.

The names of at least three references who are users of similar systems designed, assembled, and furnished by the System Integrator.

The System Integrator has the required financial capability.

The names of manufacturers whose products will be supplied.

The System Integrator maintains a qualified technical staff and design office.

The System Integrator has the physical plant and fabricating personnel to complete the work specified.

The System Integrator has and will maintain competent service personnel to service the equipment furnished.

1-3. GENERAL. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by the Design-Builder.

Each item shall be furnished and installed complete with all mechanical and electrical equipment required for proper operation, all components indicated on the drawings or specified, and all additional materials or construction required by the design of the system.

1-3.01. Coordination. The System Integrator shall verify that each system component is compatible and consistent with all other components of the system, that all pipe materials and sizes are appropriate, and that all devices necessary for a properly functioning system have been provided. Devices and appurtenances necessary for a properly functioning system shall be constructed of materials consistent with the piping materials unless otherwise indicated. The System Integrator shall assume responsibility for ensuring that Minimum Suction Head and NPSH available is adequate for the supplied pumps.

Similar components of different polymer feed systems shall be from the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

Review of drawings submitted prior to the final determination and coordination of related equipment to be provided will not relieve the System Integrator from responsibility for supplying systems in full compliance with the specific requirements of the related equipment.

1-3.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. Piping on skids shall be constructed consistent with the piping and valve specifications.

1-3.03. Governing Standards. All electrical equipment shall conform to applicable standards of the National Electrical Manufacturers Association and the National Electrical Code.

1-3.04. Power Supply. Unless otherwise specified, the power supply will be 120 volts, 60 Hz, single phase. Where control voltage lower than the power supply voltage is required, a suitable control power transformer shall be furnished. Both power and control equipment shall be insulated for not less than 600 volts even though operating voltages may be lower.

1-3.05. Metal Thicknesses. Metal thicknesses and gauges specified herein are the minimum required. Gauges refer to US Standard gauge.

1-3.06. Nameplates. A nameplate shall be provided and mounted on or adjacent to each piece of polymer feed equipment to identify its function. Nameplates shall be approximately 1 by 3 inches, made from black on white phenolic material. Letters shall be engraved to the white interior and shall be at least 3/16-inch high. Feeder designations on the nameplates shall correspond to those indicated on the drawings.

1-3.07. Spare Parts. A list of recommended spare parts with pricing shall be furnished during the submittal phase.

1-4. SUBMITTALS. Submittals for polymer feed systems shall have the following organization and information as a minimum.

1-4.01. Submittal organization. The submittal shall be split up into different sections with a separate section for each polymer feed system. Each system section shall be supplied with the following information.

System Integrator Name, Contact Name, Phone Number, Address, and email address.

System Integrator Contact Name Qualifications and Experience

Bill of Materials

System piping and instrumentation diagram with legend

Equipment and piping layout starting from dry polymer hopper/bulk storage tank pump suction nozzle to discharge piping of metering pumps.

Liquid polymer feeder/blender selection

Dilution water appurtenances

Polymer system control panel layout and wiring diagram.

Control narrative.

Spare parts

1-4.02. Drawings and Data. Complete fabrication, assembly, installation and equipment and piping layout drawings, piping and instrumentation diagrams, and wiring diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Section. A narrative description of the proposed control method, including all automatic operations, electrical interlocks, alarms, and interfaces to the Plant Control System shall be submitted.

1-4.03. Calibration Graphs. The System Integrator shall prepare a calibration graph from field tests for each polymer feed unit which does not have a rate set device reading in pounds per hour for dry feeders or in gallons per hour for liquid feeders. The graph shall show the rate setter graduation conversion to pounds per hour or gallons per hour throughout the range of the feed unit. Each graph shall be furnished on hard paper and sealed in clear plastic.

1-4.05. Operation and Maintenance Data and Manuals. Operation and maintenance manuals shall be supplied and shall be submitted in accordance with the submittals section. Equipment designations used shall correspond to those indicated on the drawings.

Operation and maintenance manuals shall include the following:

a. Equipment function, normal operating characteristics, and limiting conditions.
b. Assembly, installation, alignment, adjustment, and checking instructions.
c. Operating instructions for startup, routine and normal operation, regulation and control, shutdown, and emergency conditions.
d. Lubrication and maintenance instructions.
e. Guide to troubleshooting.
f. Parts lists and predicted life of parts subject to wear.
g. Outline, cross-section, and assembly drawings; engineering data; and wiring diagrams.
h. Test data and performance curves, where applicable.
i. A listing of all filter locations, type, size, and quantity associated with each piece of equipment.

The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

PART 2 - PRODUCTS

2-1. SYSTEM INTEGRATOR. The polymer feed system shall be coordinated and supplied by a qualified System Integrator who is regularly engaged in the business of designing and assembling polymer feed systems for water treatment or wastewater treatment plant projects.

2-2. CONSTRUCTION. Polymer feed equipment shall be of substantial construction with all parts designed for long life under working conditions including corrosive atmospheres and intermittent or continuous operation. All wearing parts and items requiring adjustment shall be readily accessible. Each unit shall be completely enclosed and dusttight when in operation. All parts which are exposed to corrosive conditions shall be made from corrosion-resistant materials or covered with suitable protective coatings.

2-3. THICKENING POLYMER FEED SYSTEM. One assembly of feeding equipment shall be furnished and installed, with the coordination of the Dewatering System Supplier, to dispense thickening polymer solution to the following feed points:

- Belt Filter Press No. 1

2-3.01. Tote Mixer. One electric motor driven mixer shall be provided to mix the contents of the totes of polymer. The mixer shaft and paddles shall be constructed of Type 316 stainless steel and shall pass through the 2-inch opening of a tote. The mixer base shall be supported by a clamp and adjustable mounting bracket. The adjustable mounting bracket shall be adjustable from 32 inches to 50 ½ inches wide and be made of steel. The mixer shall be capable of mixing 1,500 cps viscosity polymer at less than 500 revolutions per minute.

The mixer shall be provided complete with tote adjustable mounting brackets, plastic drip pans, and grounding cords and plug assemblies.

The mixer shall be provided with a manual starter with automatically reset thermal overload protection, housed in a NEMA Type 4X enclosure.

The mixer shall be Neptune “DT Series” or equal

2-3.02. Tote and containment Level Measurement. One containment pallet and scale shall be furnished and installed in the thickening polymer chemical tote storage area as shown on the drawings. This unit can be either a single assemblage as shown on the P&IDs or individual pieces.

2-3.02.01. Tote Containment. The containment pallet shall have a capacity of 400 gallons and shall include a platform that can support totes measuring 38 to 50 inches in width. The maximum load capacity shall be 10,000 pounds and the pallet shall be constructed of polyethylene. Provisions shall be included to drain the pallet of rainwater.

Pallets shall be Interstate Products, Inc. “1680 IBC Spill Unit”, Scaletron Industries, Ltd. “4042-63 IBC”, or equal.

2-3.02.02. Day Tank Scale. One electronic load cell scale of the digital type, suitable for weighing the neat thickening polymer tote, shall be furnished and installed in the chemical feed area as indicated on the drawings. The scale shall have total weighing capacity of 3,000 pounds and shall be designed for floor surface mounting. The scale shall include a digital electronic indicator with capability of transmitting a loop powered 4-20 mA dc signal to the plant control system. The indicator shall have the capability of displaying net, gross, and tare weights. The indicator shall include a digital keyboard for indicator programming and tare weight entry. The indicator shall be programmable to indicate 0 to 3,000 pounds in 1-pound increments.

The scale shall be Eagle Microsystems "LP4200 Platform Scale" with "EI 1000 Indicator", Force Flow Equipment "Model 40-DR30LP Scale" with "Wizard 4000 Indicator", Scaletron Industries, Ltd. “Model 1099”, or equal.

2-3.03. Quick Connect Coupler. One quick connect coupler shall be furnished and installed on the hose connections for the chemical delivery tote bin as indicated on the drawings. The material of construction shall be compatible with the chemical and approved by the Design-Builder. The quick connect shall be the standard cam and groove type manufactured to specification A-A-59326D. The quick connect fitting shall be the coupler type with cam arms and hose shank or female NPT threads for connecting to hose or piping as indicated on the drawings. The coupler shall be the same size as the hoses or piping as indicated on the drawings. The quick connect coupler shall be as manufactured by OPW Engineered Systems, PT Coupling Company, Inc, without exception.

2-3.04. Dilution Water Accessories. The following accessories shall be furnished and installed on the water pipe upstream of the polymer feeder/blender.

One back pressure valve shall be provided. The back pressure valve shall meet the requirements of the Back Pressure Valve section.

One pressure gauge with indicating dial type with adjustable pointer and acrylic plastic or shatterproof glass window shall be provided. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall be approximately 270 degrees. The unit of measurement shall be pounds per square inch and shall be indicated on the dial face. The gauge shall be selected so that gauge readings will be mid-scale under normal operating conditions.

2-3.05. Liquid Polymer Feed System. The liquid polymer system shall pull neat, liquid polymer from a storage tote, blend it into a solution with water from the plant water supply, and transfer the solution to the Belt Filter Press No. 1.

The liquid polymer feed system shall be Fluid Dynamics “Dynablend L Series”, US Filter/Stranco "Polyblend M-Series", or Velodyne “VeloBlend Series,” without exception. Manufacturer’s standard equipment shall be modified as required to comply with the specification requirements.

2-3.05.01. Polymer Feeder/Blender. One polymer feeder/blender unit shall be furnished and installed. Each unit shall include a neat polymer pump, blender and controller, and shall be capable of automatically metering, diluting, activating and transferring liquid solution polymer with water. Each blending unit shall be capable of effectively activating a wide range of polymers.

Each unit shall be sized for a capacity of 0.6 gallons per hour of liquid polymer and be capable of delivering a 1% solution by weight to the feed point. Each polymer feeder/blender shall transfer the blended polymer solution to the feed point as indicated on the drawings.

All metal components in contact with the polymer or polymer solutions shall be Type 304 or 316 stainless steel. All piping material shall be Schedule 80 PVC. Valves shall be constructed of stainless steel or PVC and shall use chemically resistant seats and seals. All components that require periodic maintenance shall be readily accessible. The skid shall be constructed of stainless steel. The skid shall have forklifting points for ease of transportation.

2-3.05.02. Dilution Water Control. Primary dilution water shall be supplied to each mixing chamber of the polymer feeder/blenders at a target rate of 1.0 gallons per minute with capacity for up to 2.0 gallons per minute. Each blender/feeder unit shall have a manual rate set valve for throttling of water flow and an electrically operated valve for on/off control of dilution water.

Water control components and piping shall include pressure switches, pressure gauges, and rotameters to control water capacity as required through the feeder/blender. The pressure switches shall not allow the system to operate with inadequate water supply pressure. The feeder/blender unit shall have a rotameter to measure primary dilution water flow into the feeder/blender. Each rotameter shall consist of an acrylic tube provided with a float constructed of material as recommended by the rotameter manufacturer. Each rotameter shall be capable of indicating a maximum flow as determined by the System Integrator for the dilution rate required.

Stainless steel, liquid filled dilution water pressure gauges shall be provided integral to each feeder/blender to measure both dilution water inlet pressure and mixing chamber pressure.

2-3.05.03. Neat Polymer Transfer Pump. One neat polymer transfer pump shall be furnished and installed as indicated on the drawings to dispense neat polymer to the feeder/blender system.

One neat polymer transfer pump shall be furnished to be a shelf spare.

Each pump shall include continuous local and remote electric and local manual mechanically controlled metering of solution under the following conditions and requirements listed in the table below in coordination with the Dewatering System Supplier. If requirements for the Dewatering System vary from what is shown herein, Design-Builder shall be notified.

Feed point	Belt Filter Press No. 1
Designation	MSH-0001
Installed pump quantity	One
Shelf spare pump quantity	One
Capacity control range, percent	0 - 100
Metering range, gph	0.22 – 0.60
Maximum speed, rpm	225
Nominal discharge pressure, psi	30

Pumps shall be positive displacement, tube-type peristaltic, case-drive pumps complete with retractable roller pump head, rotor assembly with a minimum of two compression rollers, self-contained variable speed drive, flexible extruded tube, and integral key pad control panel.

The process fluid shall only be in contact with the inside of the pump tubing. The pump tubing shall be constructed of material chemically resistant to the pumped solution, as acceptable to the Design-Builder. The pump shall be capable of accepting at least five tube diameters to increase capacity range. The tubing shall have a minimum wall thickness of 1.5 mm. A 50-foot section of tubing shall be provided for each pump or a total of ten spare replacement tubing assemblies shall be provided.

The pump head shall consist of a fixed track, hinged transparent guard door or removable transparent cover with lock and magnetic safety interlock and two roller rotor assemblies. The door and safety interlock shall render the drive inoperable when the door is open. Conversely, a removable cover shall include an imbedded magnetic safety interlock which will limit the motor rotation speed to 6 rpm when removed.

The tubing shall be in contact with the inside diameter of a fixed track (housing) through an angle of 180^{o} and shall be held in place on the suction and discharge by the clamp mechanisms or pump tube assembly connection fittings. Tube clamps requiring tools will not be acceptable. Tubing replacement shall not require the use of tools.

Rotor assembly shall be equipped with a minimum of two 316 SS or polymeric compression rollers and SS bearings or two polymeric compression rollers and encapsulated SS bearings. Compression rollers shall be located a maximum of 180 degrees apart for compression of the tube against the track a minimum of twice per rotor revolution. One roller shall at all times be fully engaged with the tubing providing complete compression to prevent backflow or siphoning. Tube occlusion or spring tension shall be factory set for the tubing wall thickness and shall not require additional adjustment for other tubing sizes. The rotor assembly shall be securely attached to the output shaft of the drive gear motor by the manufacturer's standard assembly for that model.

The self-contained variable speed drive for each pump shall be fully operational over the entire flow range requirements indicated above. Additionally, the pumps shall be fully capable of the discharge back pressure required above. Pumps and drives shall be suitable for continuous 24-hour operation at the conditions specified.

Each pump shall be completely self-priming with a suction lift capability of up to 30 feet of water. The pump shall be capable of running dry without damaging effects to the pump or hose. The pump shall be valveless and without diaphragms and check valves. Flow through the hose shall be in the direction of the rotor rotation and the motor shall be capable of being fully reversed.

Each pump shall be furnished with the following accessories. All metering pump suction and discharge appurtenances described below and branch piping to these appurtenances shall be the same sizes as the suction and discharge piping indicated on the P&ID.

One pressure gauge with isolating diaphragm in each pump discharge piping arrangement. The pressure gauge shall be indicating dial type with adjustable pointer and acrylic plastic or shatterproof glass window. The dial shall be 4-1/2 inches in diameter, with white background and black markings. Pointer travel shall be approximately 270 degrees. The unit of measurement shall be pounds per square inch and shall be indicated on the dial face. The gauge shall be selected so that gauge readings will be mid-scale under normal operating conditions. The isolating diaphragm shall protect the pressure gauge from the chemical solution.

One external relief valve sized to pass the maximum displacement of the pump.

Leak detection system that shall detect a tubing failure by sensing the presence of liquid inside of the pump head with output signal for remote alarm.

Metering pumps shall be Watson-Marlow "Model 520 Series" or Blue & White "M-4 Series" without exception.

2-3.05.04. Metering Pump Drive Units. The pump shall be supplied with a case-drive integral reversible servo permanent magnet dc drive motor with internal gearbox to accept 120 volts ac, 60 Hz, single phase. Housing shall be pressure cast aluminum with a corrosion resistant powder coat. Unpainted housings, including 316SS, shall not be acceptable. Each pump shall not consume in excess of 790 VA. Drive unit shall be classified for continuous heavy shock duty, AGMA. Each drive unit shall be furnished with a grounded power cord and plug suitable for plugging into a standard grounded 120-volt receptacle. Power cord conductor size shall be #12 AWG minimum for both power and ground. The connection between the power cord and the drive unit shall be as recommended by the manufacturer.

The drive shall be rated Class II, 24-hour duty. Pump drive shall be closed coupled and self-aligning without requiring flexible couplings.

Drive circuitry shall be microprocessor controlled with temperature and load compensation and protection. External VFDs or SCRs shall not be acceptable.

Drive enclosure shall be NEMA 4X rated.

The drive motor shall be capable of varying the speed of the pump to deliver the metering range in gph as specified. The drive shall be provided with an “HAND-OFF-AUTO” or “REMOTE/LOCAL” control of the pump. In the “HAND” or “LOCAL” position, the pump shall operate and the speed of motor shall be varied by a manual speed adjustment on the pump. In “AUTO” or “REMOTE”, the pump shall be started by a remote input dry contact. Pump speed shall be varied by a remote input 4-20 mA signal. The drive shall provide an output 4-20 mA speed signal for remote monitoring. “Running”, “In Remote” selector switch position, and “Fail” contacts shall be provided for remote monitoring. Running and fault indications shall also be provided on the pump control panel.

2-3.05.05. Activation Chamber. Polymer activation shall be accomplished using one of two options: a hydrodynamic blending device or a motor driven activation device.

The hydrodynamic blending device shall be cylindrical, non-mechanical, and shall be specifically designed to dilute and activate polymer. The activation chamber’s mixing energy shall be staged such that it provides for high, non-damaging mixing energy over the full operating range of the system. At no time shall polymer be exposed to excessive shear. A mixing chamber drain valve with a ½-inch fitting shall be provided.

The motor driven activation device shall be a horizontally mounted activation chamber consisting of a rotor and stationary sleeve, each constructed of polymer-resistant synthetic materials. When rotating, the rotor shall generate a turbulent blending action within a number of horizontal cylindrical chambers internal to the rotor. Activated polymer solution shall exit from within these

chambers through a series of radial openings and pass through a controlled shear zone at the interface of the rotor into the stationary sleeve. Activated solution shall then flow through a series of slots in the sleeve and out of the activation chamber. A minimum 1.5 hp washdown duty motor, shall drive the mixer impeller. Impeller speed shall be not exceed 3,450 rpm. The motor shall be direct-coupled to the impeller shaft. Each motor shall comply with the Common Motor Requirements ofr Process Equipment Section except as specified herein. Each motor shall be horizontal, squirrel-cage induction type rated 460 volts, three phase, 60 Hz with a totally enclosed fan cooled (TEFC) or totally enclosed non-ventilated (TENV) enclosure.

2-3.06. Calibration Column. One transparent plastic calibrating column shall be furnished and installed on the pump suction piping as indicated on the drawings. The column shall be clear PVC or other resistant, rigid, transparent plastic tubing having a vented top cap and screwed flow fitting. Each column shall be graduated in the respective increments over the specified range, complete with a numeral at each graduation.

Feed point	Belt Filter Press No. 1
Column ID, in	0.5
Screwed Flow Fitting, in	0.5
Graduated Increments, gal	0.0005
Flow range, gal	0.01

The bottom of the calibration column shall be located at or below the bottom of elevation of the storage/day tank metering pump suction nozzle. The columns shall be Valcom, Inc., "Model 85000", or equal, and shall be mounted on steel legs.

2-3.07. Diffusers. One diffuser shall be provided as shown on the drawings.

2-4. SAFETY EQUIPMENT. One chemical handling safety equipment kit shall be provided. Each kit shall include, but shall not be limited to, chemical splash goggles, canister type dust and mist respirator, rubber gloves, and rubber apron, all packed in a suitable carrying case.

PART 3 - EXECUTION

3-1. INSTALLATION. Equipment and materials furnished under this section shall be installed in proper operating condition in full conformity with Drawings, specifications, and recommendations of the equipment manufacturer, unless exceptions are noted by the Design-Builder. All items necessary for a complete operating system shall be installed.

3-1.01. Equipment Bases. Unless otherwise specified or indicated on the

Drawings, each item of chemical feed equipment shall be mounted on a concrete base approximately six inches above the floor. If feeders or other components must be supported at higher elevations above the floor, suitable supplementary bases shall be provided.

3-2. CLEANING. At the completion of installation and testing, all equipment, pipes, ductwork, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired .

3-3. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer's expense.

3-4. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-4.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-4.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

End of Section

Section 43 41 45-13

FIBERGLASS REINFORCED PLASTIC TANKS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of tanks fabricated of fiberglass reinforced plastic and intended for aboveground bulk storage of chemical solutions and process fluids as indicated herein.

Piping, pipe supports, valves, and accessories which are not an integral part of the equipment or are not specified herein are covered in other sections.

1-2. GENERAL. Equipment furnished under this section shall be fabricated and assembled in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by Design-Builder.

1-2.01. Coordination. Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.04. Governing Standards. Except as modified or supplemented herein, materials and construction methods shall conform with the applicable provisions of the following standards:

> Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment, ASTM C582.
>
> Standard Specification for Filament-Wound Glass-Fiber Reinforced Thermoset Resin Chemical-Resistant Tanks, ASTM D3299.
>
> Standard Specification for Contact-Molded Glass-Fiber Reinforced Thermoset Resin Chemical-Resistant Tanks, ASTM D4097.

1-2.05. Nameplates. Each tank shall be provided with a nameplate. The nameplates shall be of white phenolic material with black engraved lettering 3 inches high, and shall be mounted on the tank straight shell. The chemical name and the tank tag number indicated on the Tank Data Sheet shall be engraved on the nameplate.

1-2.06. Certification Plates. A stainless steel certification plate shall be mounted a maximum of four feet above the tank bottom on the side of each storage tank. Bracketed flat surfaces shall be provided on the tank for installation of nameplate and certification plate.

At least the following data shall be included on the certification plate:

Name of tank fabricator.

Date of manufacture.

Manufacturer's serial number.

Resin designation for entire tank (structural and corrosion barrier).

Maximum allowable concentration and temperature of the specified chemical solution that can be stored safely.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete drawings, details, and specifications covering the storage tanks, connections, and accessories shall be submitted in accordance with the Submittals Procedures section.

The data shall include full information on all tank fabrication materials and test data confirming the chemical resistance of the proposed resins to the intended tank contents.

Drawings shall include a profile diagram of the entire tank wall resin system indicating the thickness, resin designation, reinforcement, and surfacing matt material of each layer including the structural and corrosion barrier layers.

The data shall also indicate the sizes of all major tank components; size, spacing, and design loading of supporting saddles; anchor bolt locations and details; and full information and details concerning field assembly and installation.

A total of three cutouts from each tank shall be provided and shipped with and attached to the associated tank. The cutouts shall consist of one from the roof and two from the tank wall. The cutouts shall be from any of the tank connections with a diameter of 2 inches or larger.

Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-3.02. Operation and Maintenance Data and Manuals. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-4. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section and the manufacturer's recommendations. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section and the manufacturer's recommendations.

PART 2 - PRODUCTS

2-1. PERFORMANCE AND DESIGN REQUIREMENTS. Each tank shall be designed for storage of the fluid or chemical at the design conditions specified in the attached Tank Data Sheet(s).

Useable capacity shall be measured from the invert of the tank overflow nozzle to the top of the pump suction nozzle.

Vertical tanks shall be vertical cylinders with a bottom and top constructed as specified herein. Horizontal tanks shall be a horizontal cylinder with flat or dished heads and supported on saddles. Tanks shall be provided with a suitable overflow connection. Tanks shall be vented and will normally be used to store the specified chemical at atmospheric pressure, but shall be designed to withstand the hydrostatic head resulting from the tank being surcharged to 6 inches above the top of the tank.

Design criteria for calculating wind, snow and seismic loads shall be as indicated in the Meteorological and Seismic Design Criteria section.

2-1.01. Tank Bases. Unless otherwise indicated or specified, all tanks shall be installed on concrete bases at least 6 inches high. The tanks shall be anchored to the concrete base with suitable anchor bolts.

2-2. RECOMMENDED MANUFACTURERS. Recommended manufacturers shall be as specified in the Tank Data Sheet.

2-3. MATERIALS.

Resin	Bisphenol-A polyester or vinyl ester resins suitable for use with the specified chemical as recommended by the resin manufacturer.
Reinforcement	Boron free E-CR glass for mat, woven roving and roving for filament winding.
Surfacing Mat	Nexus veil by Precision Fabrics Group.
Plastic Laminate	In conformity with the applicable governing standards.

Also reference the attached Tank Data Sheet(s) for additional materials requirements.

2-4. CONSTRUCTION. The tanks shall be of hand lay-up, spray-up, or filament-wound construction in accordance with the applicable governing standard. The entire tank, structural and corrosion barrier, shall be constructed of a single generic type of thermoset resin and shall not contain colorants, dyes, fillers, or pigments unless otherwise specified. Ultraviolet absorber shall be added to the resin used in the fabrication of tanks indicated in the Tank Data Sheet(s) for installation in outdoor locations.

The inner surface layer of sodium hypochlorite and the hydrofluosilicic acid tanks shall consist of a resin rich corrosion barrier with a minimum thickness of 120 mils. The surface of the corrosion barrier exposed directly to the corrosive chemical shall consist of a two-ply surfacing veil with a minimum thickness of 20 mils. The remainder of the corrosion barrier shall consist of two layers or more of chopped strand mat or equivalent.

The inner surface layer of hydrochloric acid tanks shall consist of a resin rich corrosion barrier with a minimum thickness of 200 mils. The surface of the corrosion barrier exposed directly to the corrosive chemical shall consist of a two-ply surfacing veil with a minimum thickness of 20 mils. The remainder of the corrosion barrier shall consist of two layers or more of chopped strand mat or equivalent.

The inner surface layer of all other tanks shall consist of a resin rich corrosion barrier with a minimum thickness of 110 mils. The surface of the corrosion barrier exposed directly to the corrosive chemical shall consist of a singly-ply surfacing veil with a minimum thickness of 10 mils. The remainder of the corrosion barrier shall consist of two layers or more of chopped strand mat or equivalent.

Sodium hypochlorite tanks shall be catalyzed with a benzoyl peroxide/dimethyl aniline (BPO/DMA) catalyst system. Each tank shall undergo a four hour dry oven post-cure at a minimum temperature of 180°F after fabrication per the resin

manufacturer's recommendation. Use of thixotropic resin additives will not be allowed. Alternative catalyst systems will be considered if written confirmation from the resin manufacturer verifying the effectiveness of the proposed system is provided.

When a vertical tank with removable top is required, the tank shall be provided with an outward projecting stiffening flange for connection of the removable top. A chemical resistant elastomeric gasket and assembly bolts shall be furnished for attachment of the top.

When a vertical tank with a flat or closed top is required, the top of the tank shall be reinforced as specified in the applicable governing standard. Additional reinforcement shall be provided as necessary to support the required accessories and personnel loads. Tank roofs shall be provided with nonskid strips or a nonslip finish over the entire roof surface.

The tank shall be provided with the appropriate number and size of lifting lugs for handling and installation and hold-down lugs for anchoring the tank to the concrete base.

2-5. ACCESSORIES.

2-5.01. Special Tools and Accessories. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices.

2-5.02. Access Manways. Access manways shall have a nominal diameter of 24 inches. The number and location of access manways on the tank shall be as indicated in the Tank Nozzle Schedule. Each manway shall be flanged, fully gasketed, and furnished with a fabricated blind flange having the same properties as the tank wall laminate. Flange diameter and drilling shall conform to (ANSI B16.5, Class 150) ASTM D3299 Table 5. Side access manways shall be centered approximately 3 feet above the bottom of the tank.

2-5.03. Hinged Covers. Not used.

2-5.04. Flanged Nozzles. Nozzles for connecting piping and accessories shall be provided on each tank at the locations and of the sizes as indicated in the Tank Data Sheet.

Each nozzle shall be flanged, with flange diameter and drilling conforming to ANSI B16.5, Class 150. Nozzles shall extend at least 4 inches from outside face of tank to face of flange.

Flanged nozzles shall be fabricated of the same material as the tank and shall be gusseted to the tank or otherwise reinforced in accordance with the governing standard.

The mounting flange for ultrasonic type transmitters shall be not less than 18 inches above the maximum liquid level. The center line of the nozzle shall be at least 24 inches from the tank sidewall, fill nozzle, and other obstructions.

2-5.05. Vents. The tank shall be provided with a vent of the size recommended by the manufacturer, but not less that the size indicated on the Tank Nozzle Schedule, to prevent pressurizing the tank during filling or drawing a vacuum inside the tank during pumping or draining. The vent shall be as specified in the Tank Data Sheet.

2-5.06. Tank Insulation. Not used.

2-5.07. Tank Heater. Not used.

2-5.08. Ladders and Handrail. Not used.

2-5.09. Sight Level Gauge. Each tank shall be provided with a sight level gauge. The gauges shall be clear type or magnetic flag type, as specified in the Tank Data Sheet.

2-5.09.01. Clear Type Level Gauge. When specified in the Tank Data Sheet, a chemical-resistant valve and gauge tube assembly shall be mounted on the tank. The exterior tube of the gauge tube shall be fabricated of 1 inch diameter clear PVC, polycarbonate, or borosilicate glass. The interior wetted tube shall be clear PFA Teflon or other material, as specified. An epoxy coated steel or fiberglass shield which does not obstruct the gauge shall be provided the full length of the gauge. Alternatively, the gauge tube shall be fabricated of 1 inch diameter FEP (Fluorinated Ethylene Propylene) with flair through flange end connections. The FEP gauge tube shall have a wall thickness of 0.1 inch and the flanges shall be epoxy-coated ductile iron. A graduation strip shall be mounted adjacent to or integral with the sight level gauge. The strip shall run the full length of the level gauge and shall be graduated in gallons using 1 inch high black lettering over a range from zero gallons to the rated capacity of the tank. The gauge tube assembly shall be Jogler Inc. Model ULSS, Pureflex Inc. Model Puresite, or equal.

2-5.09.02. Magnetic Flag Type Gauges. Not used.

2-5.10. Saddles. Not used.

PART 3 - EXECUTION

3-1. INSTALLATION. Equipment furnished under this section shall be installed in accordance with the Chemical Storage Tank Installation section.

End of Section

SECTION 46 22 00

PACKAGED FINE SCREENS

PART 1 GENERAL

1.01 SCOPE

A. This section covers two (2) tank mounted rotary perforated plate screens for removing floating, particulate, or fibrous material and transferring washed and dewatered screenings to a screw conveyor as shown on the Drawings and described herein. Screening units are designated as follows.

Equipment designation.	Packaged Fine Screens
Number of units.	2
Equipment tag numbers.	SCR-SCR-1101 SCR-SCR-1201
Equipment location.	Headworks Area

B. The equipment, material, piping, valving, ancillary systems, instrumentation, analyzers, and services specified in this section shall be designed, integrated, and provided as a cohesive and fully-functional system by a single Original Equipment Manufacturer (OEM), hereafter referred to as the Packaged Fine Screen Supplier (PFSS). Tank mounted fine screens shall be designed and furnished as complete systems requiring minimal on-site assembly, connection, or terminations. The PFSS shall provide a screw conveyor with chute to convey screenings from the Packaged Fine Screens to the discharge location as shown on the Drawings.

1.02 GENERAL

A. Equipment furnished under this section shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Design-Builder.

B. Coordination. The PFSS shall coordinate all details of the equipment with screening conveyor, including verification that all structures, piping, wiring, and equipment components are compatible.

C. Manufacturer's Experience. Unless specifically named in the Specifications, a manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years.

D. Workmanship and Materials. PFSS shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

1. All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests.

2. Except where otherwise specified, structural and miscellaneous fabricated steel used in equipment shall conform to AISC standards. All structural members shall be designed for shock or vibratory loads. Unless otherwise specified, all steel which will be submerged, all or in part, during normal operation of the equipment shall be at least 1/4 inch thick.

E. Power Supply. Unless otherwise indicated, power supply to the equipment will be480 volts, 60 Hz, 3 phase. If other voltage levels are required other than 480Vac, transformers shall be furnished as required.

1.03 SUBMITTALS

A. Drawings and Data. Complete assembly and installation drawings, together with detailed specifications and data covering materials used and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals section. Each drawing shall be identified with the corresponding screen number.

The drawings shall include separate wiring diagrams for each screen and its electrical control equipment. Contractor shall provide the following information:

1. Fine Screens
   a. Name of manufacturer.
   b. Type and model.
   c. Number of units.
   d. Speed.
   e. Screen size.
   f. Net weight.
   g. Drive unit.
   h. Power supply.
   i. Data on shop painting.
   j. Anchor bolt details.
   k. Detailed fabrication drawings.

l. Control component data.

2. Motors
   a. Name of manufacturer.
   b. Type and model.
   c. Rated size of motor, hp and service factor.
   d. Insulation class and temperature rise.
   e. Full load rotative speed.
   f. Net weight.
   g. Efficiency at full load.
   h. Full load current.
   i. Locked rotor current.

3. Control Panel

   a. Control panel enclosure layout, dimensions, and weight.
   b. Electrical schematics and wiring diagrams.
   c. Overcurrent characteristics and details of motor control.
   d. Enclosure rating.
   e. Catalog and data sheets on all components.
   f. A recommended sequence of operation, including values and ranges for time delays, speeds, and other set points for use in the initial startup of the system.

B. Manufacturer's Certificates:

1. The PFSS shall be responsible to obtain and submit to Design-Builder for review and approval all manufacturer certificates and to see that the Scope of Work is performed in accordance with Manufacturers' requirements for all equipment furnished.

2. The PFSS representative shall certify in writing that the equipment or system has been installed in accordance with the Manufacturer's recommendations, that it has been inspected by a Manufacturer's authorized representative, that it has been serviced with the proper initial lubricants, that applicable safety equipment has been properly installed, and that the proper electrical and mechanical connections and adjustments have been performed.

3. System Certification: The PFSS shall provide a written certification of proper installation of the System components, and for the System overall. The PFSS shall submit such certificates to the Design-Builder for approval.

C. Operation and Maintenance Manuals

1. The PFSS shall provide operation and maintenance (O&M) manuals for the rotary drum fine screen, drive motor, lubrication pump, valves, and

instruments and associated appurtenances in accordance with the requirements of Submittal Procedures section.

1.04 REFERENCED STANDARDS

A. Reference to standards, specifications, manuals or codes of any technical society, organization, or association, or to the laws or regulations of any governmental authority, whether such reference be specific to, or by implication, shall mean the standard, specification, manual, code, laws, or regulations in effect on the last day for receipt of the proposal for the System.

B. The provisions of these specifications shall take precedence in resolving any conflict, error, ambiguity, or discrepancy between the provisions of these specifications and the provisions of any such standard, specification, manual, code, or instruction (whether or not specifically incorporated by reference in this specifications); the provisions of any such laws or regulations applicable to the performance of the work (unless such an interpretation of the provisions of this specifications would result in violation of such law or regulation).

C. No provision of any such standard, specification, manual, code, or instruction shall be effective to change the duties and responsibilities of Owner, PFSS, Design-Builder, or any of their subcontractors, consultants, agents, or employees from those set forth in the Contract Documents.

D. The following, but not limited to, the reference standards listed hereinafter will apply to the Packaged Fine Screens and associated specified equipment.

1. American Society for Testing and Materials (ASTM)

    i. ASTM A36 - Standard Specification for Carbon Structural Steel

2. American Welding Society (AWS)
    i. AWS D1.0 – Welding in Building Construction for Gas-Tight Welding
    ii. AWS D1.1 - Structural Welding Code Steel
3. Society for Protective Coatings (SSPC)
    i. SSPC SP-10 - Surface Preparation Specification No. 10 Near-White Blast Cleaning
4. American Bearing Manufacturers Association Standards (ABMA)
5. National Electrical Manufacturers Association (NEMA)
6. American Institute of Steel Construction (AISC)
7. National Electric Code (NEC)
8. Institute of Electrical and Electronic Engineers (IEEE)
9. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All of the equipment specified herein shall be furnished by the PFSS who shall be responsible for the satisfactory performance of the equipment.

B. All materials and equipment, which will become a part of the installed work, shall be new and unused.

C. Like items of equipment provided herein shall be the products of one manufacturer in order to achieve standardization of facilities, operation and maintenance, spare parts and manufacturer's service.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Equipment shipping, storage and handling shall be in accordance with the general Terms and Conditions.

1.07 SPARE TOOLS AND SPARE PARTS

The PFSS shall provide spare parts per the general Terms and Conditions. The following shall be provided as a minimum:

- Any special tools required for installation or maintenance of any of the furnished equipment shall be furnished.
- A complete itemized price list of all recommended special tools, spare parts, and consumables shall be submitted.
- A set of recommended spare parts and consumables for system startup and testing shall be furnished.
- A set of recommended spare parts and consumables for one year of operation from Date of Substantial Completion or Acceptance of Final Testing, whichever is later, shall be furnished.

1.08 ACCEPTABLE MANUFACTURER

A. The following are the only acceptable PFSS: Kusters Zima, Huber, Smith & Loveless, Vulcan, Headworks Inc, Westech, Parkson, Duperon, and Hydrodyne.

PART 2 PRODUCTS

2.01 SERVICE CONDITIONS

Each screen shall be suitable for the conditions listed in the Meteorological and Seismic Design Criteria section including the seismic zone and site elevation. It shall also be suitable for the following:

Liquid service.	Headworks (Coarse Screening and Grit Removal) Effluent

Site elevation, above mean sea level.	127 ft

2.02 PERFORMANCE AND DESIGN REQUIREMENTS

A. The screening equipment shall perform under the following conditions:

Channel width.	Minimum 3 ft
Operating floor elevation.	See Drawings ft
Elevation of channel floor upstream of screen.	TBD by PFSS ft
Elevation of channel floor downstream of screen.	TBD by PFSS ft
Height of screenings discharge above operating floor.	120 in
Screening perforation.	2 mm
Nominal screening basket diameter.	TBD by PFSS in
Minimum nominal screenings conveyor diameter.	10 in
Average flow through each screen.	0.97 mgd
Maximum flow through each screen	1.88 mgd
Minimum flow through each screen	0.28 mgd
Maximum differential head.	8 in
Maximum upstream high liquid level (at maximum flow).	See Drawings ft
Minimum downstream low liquid level (at minimum flow).	See Drawings ft
Minimum Free Board at Maximum Flow	2 ft
Drive motor.	Maximum 2 hp
Maximum wash water flow rate available.	55 gpm

B. Each unit of screening equipment shall be designed to withstand, without damage or permanent distortion, the maximum specified differential head at any channel water depth.

All components of the Packaged Fine Screens shall be covered for odor control. Odor control covers shall be 316 SS or FRP and provide with suitable sealing

gaskets and latches to maintain a good seal and hold the panels securely in place during operation and against wind and weather. Odor control outlets shall be flanged for connection to PVC odor control suction piping by Design-Builder. Outlets shall be located to not require dissemble of connected odor control piping to remove covers and access the basins to the maximum extent possible. In cases where this cannot be achieved, PFSS shall coordinate alternate outlet nozzle connection detail with Design-Builder to facilitate easy access to basins and equipment. Design-Builder will furnish an odor control system with PVC suction piping sized to furnish 6 air-changes per hour.

1. Screen

    a. The rotary perforated plate screen shall be designed and built to withstand static and hydraulic forces exerted by the liquid to the screen. All structural and functional parts shall be sized for the loads encountered during the screening, conveying and pressing operations. All submerged components and all components of the rotary perforated plate screen in contact with the screened solids shall be of 316 stainless steel construction.

    b. The screen basket shall be of a cylindrical shape. The perforations shall go around the entire basket.

    c. The nominal perforation size shall be as noted in Paragraph 2.02. Bar screens or wedge wire will not be an acceptable screen media.

    d. The rotating screen basket upper support ring shall be a minimum of $^{3}/_{8}$ inch thick and shall be machined to match the transport tube main support flange to ensure proper alignment of the basket. Designs which do not provide this machined main upper support ring will not be acceptable. The main screen basket lower support ring shall be $^{6}/_{10}$ inch minimum.

    e. The basket diameter shall be matched with a sufficient number of clear openings to ensure the maximum flow rate is achieved and to provide less than the maximum headloss noted in Paragraph 2.02.

    f. The width of the screening channel shall be as noted in Paragraph 2.02.

    g. A protective guard shall be provided to cover the exposed top of the screen basket.

2. Rotating Basket and Cleaning Brush

    a. The rotating basket assembly shall be cleaned by a stainless steel high pressure spray bar and a backed nylon brush with bristles that penetrate the depth of the perforated screen to ensure positive screenings removal. Brush bristles shall be high-strength nylon for superior life.

b. The screen basket shall continuously rotate in one direction and pass through the topmost position were it shall be cleaned by the stainless steel backed cleaning brush and the spray bar. The brush shall be designed to ensure cleaning of the spaces to the full depth of the perforations. The cleaning brush shall be mounted upon a holding device which keeps the brush in constant contact with the basket and will automatically adjust to allow for brush wear.

c. The rotating basket and the screw conveyor shall be fixed to the same shaft and driven by a common drive.

d. A stainless steel backed nylon brush shall be attached to the rotating basket and positioned to make contact with the screening trough to sweep material caught on the edges of the trough.

3. Screenings Conveyor and Screenings Dewatering Press

a. The screenings screw conveyor transport tube nominal diameter shall be as noted in Paragraph 2.02 with a minimum wall thickness of $^{1}/_{10}$ inch (<780=1/10). A minimum of two (2) anti-rotation bars with ¼ inch minimum thickness and 1 $^{1}/_{5}$ inch wide shall be welded to the inside of the transport tube along the longitudinal axis. The screenings screw conveyor shall not depend on support from the anti-rotation bars during normal operation.

b. A $^{4}/_{5}$ inch minimum thickness basket support plate flange shall be attached to the screenings transport tube to attach the screen basket rollers and to provide for attachment of the screenings collection hopper. A ½ inch minimum thickness drive support flange shall be welded to the upper end of the screenings transport tube for attachment of the drive assembly. The basket shall be mounted to the machine via a solid support arm at the lower end of the basket which bolts directly to the screenings transport shaft. A series of roller bearings will support the top end of the basket (<780=3 rollers).

c. The dewatering screw shall be designed to transport and dewater the screened material. Screw flights shall be of decreasing pitch approaching the compaction zone to provide a pre-dewatering stage and shall have a minimum thickness of 3/16 inch.

d. The upper and lower screw conveyor torque tube shall be fitted with solid stub shafts. Stub shaft and screw conveyor torque tube shall be accurately machined to allow a shrink-fit design.

g. A compaction zone shall be an integral part of the screenings screw conveyor and transport tube design. The compaction zone shall be

designed to form a screenings plug of material and to return water released from the screened material back to the wastewater channel through circular holes that are machined into the screenings transport tube.

i. The compaction zone housing shall be furnished with a bolted access cover with gasket, as well as a bolted dewatering section panel, to allow access to the screw conveyor. Designs which require removal of the drive assembly, discharge head, or screw conveyor to gain access to the compaction zone will not be acceptable.

4. Drive

a. The basket mechanism and transport screw shall be driven by a shaft mounted geared motor. The geared motor shall have a minimum service factor of 1.0 equivalent to an AGMA Class I rating.

5. Spray Wash Systems

a. Automatic spray wash systems shall be provided for the screens and shall be constructed of a minimum of 1/2-inch diameter minimum piping and flexible reinforced PVC hose. Spray wash systems shall be operated only while the screen basket is rotating. The spray wash system shall include a solenoid valve for flow control.

b. The screenings spray wash systems shall be designed for water supply noted in Paragraph 2.02.

c. The dewatering section shall be provided with a ring flush water header system to ensure complete flushing of the compaction zone. Header design shall be oriented to completely wash the full surface of the transport tube drainage area.

d. The solenoid valves shall be operated via the programmable controller and/or manually.

C. The equipment shall be so arranged that all components can be serviced from the operating floor. All components shall be balanced so that jamming at any point will not result in structural failure, but will cause the drive motor to stall.

D. All components, including the gear reducer, shall be designed to withstand, without damage or permanent distortion, the full stalling torque of the drive motor.

2.03 MATERIALS

A. Construction materials shall be specified and as follows:

Screen Basket	Stainless steel, AISI Type 316.
Discharge Chute	Stainless steel, AISI Type 316.
Spray Wash Header and Nozzles	Stainless steel, AISI Type 316
Cleaning Brush	Nylon Bristles, Stainless steel hardware, AISI Type Ste
Side Frames, Guides, Seal Plate	
Pin Rack Bushings and Rollers	Carbon steel hardened and ground. Non-lubricated type.
Seal Gasket	Polyurethane
Shafting	Carbon steel, cold rolled, solid.
Bearings	Antifriction, rolling element type, grease lubricated.
Grease Line	Stainless steel tubing, ASTM A269, Grade TP 304, with stainless steel compression fittings; or stainless steel pipe, ASTM A312, Grade TP304, Schedule 40S, with threaded stainless steel fittings.
Anti-Seize Thread Lubricant	Jet-Lube "Nikal", John Crane; "Thred Gard Nickel"; Never-Seez "Pure Nickel Special;" or Permatex "Nickel Anti-Seize".
Anchor Bolts and Hardware	Stainless steel, AISI Type 316L.

2.04 DRIVE UNITS

A. Each screen screw conveyor and screen basket assembly shall be driven by an electric motor through a flexible coupling. Drive units shall be designed for 24 hour continuous service and shall be single speed.

B. Drive units shall be in full compliance with the specifications and shall be of the general type and arrangement regularly furnished by the named manufacturer. The drive unit shall be arranged to protect all screen components from overload and shall stop in the event the screen assembly engages an object which it cannot dislodge.

C. Gear Reducers. Gear reducers shall be as specified in the General Equipment Stipulations except that the use of permanently sealed, grease lubricated bearings will not be acceptable.

2.05 ELECTRICAL

A. General. Electrical package including outdoor rated air-conditioned (if required) NEMA rated according to the classified area electrical enclosure, motor starters, variable frequency drives, circuit breakers, disconnect switch, etc. shall be furnished and installed for the Packaged Fine Screens to provide a completely functional fine screening systems.

   See electrical sections as identified in 01100 Section for electrical requirements

B. Electric Motor. See motor section as identified in 01100 Section for motor requirements.

C. Controls. Controls for the screen shall be furnished by the screen manufacturer. The fine screen system shall be furnished with the following items:

   1. Main control panel.
   2. Local control panels.
   3. Local Control Stations
   4. Limit switches.
   5. Torque overload switch.
   6. High Differential water float switch.

D. Electrical equipment in the screen area shall have NEMA rated according to the classified area.

E. The screen controls shall permit either manual or automatic operation of the unit.

F. Limit switches shall be provided for the following functions:

   1. To alarm and stop operation for a torque overload.
   2. The manufacturer shall provide other limit switches as needed for a complete and functional operating system.
   3. The differential water level control system for the screen is specified in Pressure Level Instruments. When the system senses a predetermined head loss across the screen, an isolated contact will close as a signal to start the backwash cycle.

G. Main Control Panel. A stand-alone main control panel shall be provided for the Fine Screen System for automatic controls and monitoring, and plant interface. The main control panel shall be completely prewired and checked. The main control panel shall be provided with the following minimum requirements:

   1. Programmable Logic Controller (PLC). The PFSS shall be responsible for the design of the Packaged Fine Screen control system. In addition, the

Packaged Fine Screen control system programmable logic controller (PLC) system design shall have the capability of communicating with the plant control system (PCS) system to send and receive information over an Ethernet-based communication link.

2. The control system supplied by the PFSS shall conform to the requirements of Section 01100.
3. The PFSS shall be responsible for the design of the process control logic for all equipment, systems, operations, alarms, and reporting systems required for the complete Packaged Fine Screen system.

H. Local Control Panel. A single control panel shall be furnished for each pair of screens and each pair of screen conveyors. The local control panels will be mounted in the adjacent to the Packaged Fine Screens. Each screen local control panel shall be and shall contain at a minimum the following devices:

Disconnect switch with door handle
Motor starter for each screen
Control transformer for each screen
Motor starter for each screen conveyor
Elapsed time meter for each screen
Transient voltage surge suppressor
Power on pilot light
Running pilot light for each screen
Running pilot light for each conveyor
Fault pilot light for each screen
Fault pilot light for each conveyor
Reset Switch
Emergency Stop button
Controller

I. The local control panel shall be provided with the following:

1. Motor starters shall be combination type, full voltage, reversing, not smaller than NEMA Size 1. Each starter shall include a circuit breaker, reversing magnetic contactor, overload relays, and a 480 volt to 120 volt, 60 Hz control power transformer with one lead fused and the other lead grounded.

2. Programmable controller shall communicate with the PLC in the main control panel via Ethernet.

J. Local Control Station. A local control station shall be provided per each screens and conveyors hardwired to its corresponding local control panel. Each local control station shall be provided with Local-Off-Remote (LOR), Forward-Off-Reverse (FOR), and Emergency Stop switches. The local control station shall be NEMA 4X enclosure mounted near the equipment.

K. System Operation. Each local control panel shall control two screens and two screen conveyors. With the Local-Off-Remote switch in Remote (on the local control station), the control panel shall receive a signal from the PLC to run. With the Local-Off-Remote switch in Local, the screen shall be controlled by Start/Stop push buttons on the local control panel and at the screen.

The emergency stop push button shall stop the screen in any control mode.

L. Device Identification. Equipment, identification and tagging shall be per the Equipment and Valve Identification section, per the Scope of Work section, and as specified herein. Equipment identification numbers and tags shall be provided for all equipment furnished by the PFSS including:
   a. Packaged Fine Screens
   b. Screw Conveyors

2.06 FABRICATION

A. Assembly Fasteners. All bolts, nuts, and washers shall be stainless steel.

B. Edge Grinding. Sharp projections of cut or sheared edges of ferrous metals, except stainless steel, which will be submerged in operation and are not to be welded, shall be ground to a radius as required for satisfactory paint adherence.

C. Stainless Steel. All stainless steel shall be pickled in accordance with ASTM A380 at the mill before being shipped. Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. After fabrication, pickled surfaces shall be subjected to a 24 hour water test or a ferroxyl test to detect the presence of residual embedded iron. All pickled surfaces damaged during fabrication including welded areas shall be repickled or passivated in accordance with ASTM A380 as needed to remove all traces of iron contamination. All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces.

2.07 WARRANTY

A. All the equipment supplied by PFSS shall be warranted by the PFSS in accordance with the Terms and Conditions in this procurement package.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation will be in accordance with PFSS recommendations and as specified herein.

3.02 FIELD QUALITY CONTROL

3.02.01 INSTALLATION CHECK.

experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily and in accordance with the specified performance requirements.

All costs for these services shall be included in the contract price.

3.02.02. EQUIPMENT SHOP/FACTORY TESTS AND INSPECTION.

PFSS shall submit documentation of what shop and factory tests are proposed for the Packaged Fine Screen system and its components. The Design-Builder and/or Owner representatives shall be permitted to conduct shop inspections or witnessing of any shop testing at their choice at their cost.

The Design-Builder shall witness Factory Acceptance Testing of the Packaged Fine Screen to verify proper system function and setup for interoperability with the PCS prior to releasing the equipment for shipment to the site. The Design-Builder shall also inspect the Packaged Fine Screen system equipment at that time to verify it is suitable for shipment to the site. PFSS is not responsible for Design-Builder travel costs for this trip.

3.03 STARTUP AND FIELD TESTING

3-3.01. Onsite Functional Testing. The PFSS and Design-Builder shall conduct functional testing of all Packaged Fine Screen System equipment. Functional testing shall include, but not be limited to, the following activities:

1. Manufacturer’s certifications of proper installation have been accepted by the Design-Builder.
2. Leakage tests, electrical tests, and adjustments have been completed.
3. Individual instrumentation loops (analog, status, alarm, and control) have been verified functionally.

4. Pressure switches, flow switches, timing relays, level switches, process analyzers, pressure regulating valves, and other control devices to the settings determined by the PFSS have been adjusted for accuracy and have been field calibrated or been provided with a calibration certificate.
5. Individual interlocks between the field-mounted control devices and the motor control circuits, control circuits of variable-speed controllers, and packaged system controls have been verified. This includes verifying communications and programming interfaces between the Packaged Fine Screen PLC and the PCS/SCADA system.

PFSS will remove and replace all defective equipment, components and systems supplied by the PFSS at no cost to Design-Builder, the operator or the owner. All costs will be borne by the PFSS.

3-3.02. Startup of the Packaged Fine Screen System. The PFSS will assist the Design-Builder with the startup of the Packaged Fine Screen system. The PFSS will assist the Design-Builder with the operation of the Packaged Fine Screen System during startup.

The Design-Builder will be responsible for startup of the Packaged Fine Screen System components as in coordination with the PFSS who will assist the Design-Builder with startup of the combined Packaged Fine Screen System.

3-04. ONSITE PACKAGED FINE SCREEN SYSTEM ACCEPTANCE TESTING.

3-4.04.A. Overview of Onsite Acceptance Test. The objective of the onsite Acceptance test is to validate the design, installation and operation of the Packaged Fine Screen system in accordance with the guarantees and warranties provided by the PFSS.

3-4.04.B. PFSS Responsibilities During the Onsite Acceptance Test. The PFSS responsibilities during the onsite Acceptance test include, but are not limited to:

1. Ensure that all mechanical, electrical and I&C equipment for the Packaged Fine Screen system are fully tested and debugged prior to the start of the Onsite Acceptance Test.
2. Review daily operating data during the Acceptance test and provide the requisite support to the Design-Builder and site personnel as required. Ensure that equipment failures are resolved in a timely manner.
3. Compile a final Acceptance test report for the Packaged Fine Screen system summarizing all activities, tests, results and conclusions.
4. Provide the necessary assistance on all issues relevant to the Packaged Fine Screen system on a case-by-case basis.

3-4.04.C. Design-Builder Responsibilities during the Onsite Acceptance Test. The Design-Builder's responsibilities during the onsite Acceptance test include, but are not limited to:

1. Coordinate operations personnel (to be provided by Owner).
2. Coordinate or provide utilities for plant operation.

3-4.04.D. Schedule and Duration of Onsite Acceptance Test.

1. The onsite Acceptance test shall be carried out after successful completion of the Onsite Functional Test of the Packaged Fine Screen system, startup and functional testing of all other systems in the Morro Bay WRF.
2. Duration of Onsite Acceptance Test = 2 days (1 day per Packaged Fine Screen)
3. When failure, shutdown, or interruption occurs, the test shall be terminated and corrective action undertaken by the PFSS or by the Design-Builder, depending on the source of failure, shutdown, or interruption.
4. Upon resumption of operation, the Acceptance Test will be restarted on a date mutually agreed to by the Owner, Design-Builder and the PFSS with no credit given for the operating time achieved before the system failed, shut down, or was otherwise interrupted, if the failure, shut down or interruption is the PFSS' responsibility.
5. Testing shall be conducted by the Design-Builder and representatives from the PFSS, with the assistance of the Design-Builder and the Owner's operation and maintenance staff. Any labor required for the testing that is above normal plant operating requirements shall be provided by the Design-Builder and paid for separately by the PFSS.
6. Within 20 days following completion of Acceptance testing, the PFSS shall submit a written report summarizing the test and all data and results.

3-4.04.E. Onsite Acceptance Test Protocol.

1. A detailed onsite Acceptance test protocol shall be jointly developed by Design-Builder and the PFSS at least 90 days prior to the Onsite Acceptance Test.

2. The detailed Acceptance testing protocol shall provide information on the following:
   - Acceptance testing conditions and durations proposed by the PFSS.

3-4.04.F. Onsite Acceptance Test Acceptance Criteria.

A. The Packaged Fine Screen system will be accepted only if all the following acceptance criteria are fully satisfied during the Acceptance testing period:

   - Water levels and flows specified in paragraph 2.2 in this section are achieved and observed to the extent possible in coordination with the Design-Builder and Owner.
   - Screenings discharge into dumpster receptacles.
   - Packaged Fine Screen effluent is observed by the Design-Builder to be consistent with the performance requirements.

3-05. TEST REPORTS. The equipment manufacturer shall prepare a test report, including all installation check and performance tests and other recorded data and

observations. A PDF copy of the report shall be submitted to Design-Builder after completion of the specified tests.

3-06. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer's expense.

3-07. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-07.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-07.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

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Section 46 41 23

SUBMERSIBLE MIXERS

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of submersible propeller mixers as specified herein. Each mixer shall be provided with a submersible electric motor, a motor mounting bracket for installation, a control panel, and all other appurtenances specified or otherwise required for proper operation.

Equipment designation.	BNR Anoxic Zone Mixers	BNR Deox Zone Mixer	Sludge Holding Tank Mixers
Number of mixers.	2	1	2 (1/tank)
Mixer tag numbers.	BNR-MXR-1001, BNR-MXR-2001	RAS-MXR-0001	WAS-MXR-0101, WAS-MXR-0201
Mixer location.	BNR Anoxic Zone	BNR Deox Zone	Sludge Holding Tank

Each mixing unit shall be complete with a submersible electric motor and gear box, adjustable frequency drive, mounting assembly for installation, and all other appurtenances specified or otherwise required for proper operation, including special tools.

1-2. GENERAL. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the Design-Builder. Definition of terms and other hydraulic considerations shall be as set forth in the Hydraulic Institute Standards.

Each unit shall be furnished complete with all anchors and supports, all mechanical equipment required for proper operation, and all additional materials or construction required by the manufacturer's design.

The mixing equipment specified herein shall be designed and manufactured by a single manufacturer which shall have sole responsibility for the equipment. The manufacturer shall have mixing equipment of this design and of comparable capacity in successful operation in the field.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this

specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.03. Power Supply. Unless otherwise indicated, power supply to the equipment shall be 480 volts, 60 Hz, 3 phase.

1-2.04. Identification. Equipment specified herein shall be identified in accordance with the Equipment and Valve Identification section.

1-2.05. Spare Parts. A list of recommended spare parts shall be provided by the manufacturer.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete fabrication and assembly drawings, together with detailed specifications and data covering materials used, parts, devices, and other accessories forming a part of the equipment furnished as well as the proposed performance test procedure, shall be submitted in accordance with the Submittals Procedures section. The data and specifications for each unit shall include, but shall not be limited to, the following:

Submersible Mixers

- Name of manufacturer.
- Type and model.
- Tag number and mixer designation.
- Mixer Location.
- Rotative speed.
- Type of bearings.
- Net weight of submersible mixer and motor.
- Complete performance curves showing capacity versus speed, efficiency, and kW input.
- Data on shop painting.
- Anchor bolt details.

Motors

- Name of manufacturer.
- Type and model.
- Type of bearings and lubrication.
- Rated size of motor, hp.
- Temperature rating.
- Full load rotative speed.
- Net weight.
- Efficiency and power factor at full load and rated operating condition.

Full load current.
Locked rotor current.
Data on cable.
Moisture sensing protection characteristics, including wiring schematics.

Variable Frequency Drives

As specified in the Variable Frequency Drives section.

Seismic Design Requirements

Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-3.02. Operations and Maintenance Data and Manuals. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. The mixers shall be capable of completely mixing the liquid in the BNR Anoxic zone containing mixed liquor and also in the Sludge Holding Tanks containing Waste Activated Sludge. Mixers shall be suitable for the following conditions:

Basin application.	BNR Anoxic Zone	BNR Deox Zone	Sludge Holding Tank	
Liquid(s) to be mixed.	Mixed Liquor	Return Activated Sludge	Waste Activated Sludge	
TSS Concentration	5,000-8,000	6,500-10,000	6,500-10,000	mg/L
Liquid temperature range.	18-24	18-24	18-24	°C
Influent and recycle mixed liquor to be mixed together.	No	No	No	
Average flow rate.	2 mgd/zone[1]	3 mgd	26 gpm	
Seismic design requirements and site elevation.	See Meteorological and Seismic Design Criteria section			

1. Includes RAS and influent flows

The propeller mixers shall be provided with a mounting system which enables the mixer to be raised, lowered, and easily removed without the need for personnel to enter the basins.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. The mixers shall be designed for operation in the basins and storage tanks as indicated on the Drawings.

The mixers in the BNR tanks are used to keep the MLSS from settling. The mixers in the sludge tanks will alternate on and off with coarse bubble aeration to keep the sludge well-mixed as the tank levels vary.

Mixer Tag Number.	BNR-MXR-1001, BNR-MXR-2001	RAS-MXR-0001	WAS-MXR-0101, WAS-MXR-0201	
Nominal basin dimensions.	See drawings	See drawings	See drawings	ft
Water depth				
At average flow	18.5	18.5	6 - 20	ft
At maximum month flow	18.9	19.0	6 - 20	ft
At peak flow	19.2	19.3	6 - 20	ft
Liquid volume to be mixed.	4300	1000	N/A	ft^3
Maximum power input	2.0	2.0	N/A*	bhp
Thrust/momentum	30 to 120	5 to 20	N/A*	N
Mixer speed requirements.	Variable Speed	Variable Speed	Variable Speed	
Maximum propeller diameter.	15	15	15	in
Mixer mast and hoist required	Yes	Yes	Yes	

The propeller water horsepower requirements, gear losses, and an ample allowance for buildup on the propeller of the mixer shall be included in determination of the brake horsepower requirements.

2-3. ACCEPTABLE MANUFACTURERS. The submersible propeller pumping equipment shall be as manufactured by Flygt Corporation, Landia, ABS, KSB, or equal.

2-4. MATERIALS.

Mixer Mast Assembly	
Mast Brackets (Upper, Intermediate, and Lower).	Stainless steel, AISI Type 316.
Mast.	Stainless steel, AISI Type 316.
Lifting Cable.	Stainless steel, AISI Type 316.
Retaining Chain.	Stainless steel, AISI Type 316.
Lifting Bracket or Bridle Chain.	Stainless steel, AISI Type 316.
Mixer	
Stator Housing and Oil Chamber.	Stainless steel, AISI Type 304 or 316 or Cast iron, ASTM A48
Propeller Shaft.	Alloy steel, hard chrome plated; or stainless steel AISI Type 316.
Propeller Shaft Mechanical Seal.	Stainless steel with tungsten carbide or silicon carbide rings.
Motor Shaft Mechanical Seal.	Stainless steel with tungsten carbide or silicon carbide rings.
Propeller Blades.	Same as stator housing.
All Assembly Fasteners	Stainless steel, AISI Type 316.
Coatings (Primer and Finish Coat).	
Epoxy	PPG Amercoat "Amercoat 385 Epoxy", Carboline "Carboguard 890", ICI Devoe Devran "224HS", Tnemec "Series N69 Hi-Build Epoxoline II", or Sherwin-Williams "Macropoxy 646".

Note: The manufacturer's coating recommended for the specified service that is equivalent to the specified coating will be acceptable.

Where stainless steel components are welded, the stainless steel shall be AISI Type 316L.

All stainless steel shall be pickled in accordance with ASTM A380 at the mill before being shipped. Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. After fabrication, pickled surfaces shall be subjected to a 24 hour water test or a ferroxyl test to detect the presence of residual embedded iron. All pickled surfaces contaminated or damaged during fabrication including welded areas shall be repickled or passivated in accordance with ASTM A380 as needed to remove all traces of iron contamination and heat tint. All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces.

2-5. CONSTRUCTION.

2-5.01. Mixing Unit. The mixing unit shall be of the close-coupled**,** direct driven or integral-gear driven submersible type. All components of the mixer, including motor and gear box, shall be designed for the specified service conditions and be capable of continuous underwater operation.

A sliding guide bracket shall be an integral part of the mixer unit. The entire weight of the mixer unit shall be guided by a single bracket which shall be capable of handling all thrust created by the mixer.

Cast components, shall have smooth surfaces devoid of blow holes and other irregularities.

2-5.02. Propeller. Each propeller shall have a certain number of blades as determined by the mixer supplier, each integrated with a stainless steel shaft for mounting in a cast iron or stainless steel hub. The blades shall be dynamically balanced and of non-clogging backward curve design.

2-5.03. Oil Chamber Housing. The oil chamber shall contain an inspection plug, drain plug, and vent plug.

2-5.04. Mechanical Seals. Each mixer shall be provided with a lapped end face type mechanical seal (propeller shaft) and two lip seals (gear box for gear-driven mixers), running in oil reservoirs for cooling and lubrication. The mechanical seal between the propeller and propeller shaft oil chamber shall contain one stationary and one positively driven rotating face ring running in an oil reservoir for cooling and lubrication. The seals between the shaft and gear box, and gear box and motor chamber shall be of the lip style. All seal springs shall be isolated from the pumped liquid.

Four seals separating the various parts as specified herein will also be acceptable. The outer seal in the propeller hub shall be either a viton or nitrile rubber lip seal, sealing propeller shaft and grease chamber from the mixed media. The two inner seals on the propeller shaft shall be either viton or nitrile

rubber lip seals insulating the propeller shaft grease chamber from the gearbox oil chamber. The fourth seal shall be a mechanical seal running in the oil for cooling and lubrication. It shall be mounted on the motor shaft to insulate the gear box oil chamber from the dry motor stator housing.

The seals shall require neither maintenance nor adjustment, but shall be easy to check, relap, and replace. Neither shaft seals lacking positively driven rotating members, nor conventional double mechanical seals which use a common single or double spring and require a pressure differential to offset external pressure and effect sealing, will be acceptable.

2-5.05. Sealing of Mating Surfaces. All mating surfaces shall be machined and fitted with nitrile rubber O-rings where watertight sealing is necessary. Fitting shall be such that sealing is accomplished by metal-to-metal contact between machined surfaces. The use of elliptical O-rings, gaskets, or seals requiring a specific fastener torque value to obtain and maintain gasket or seal compression and watertightness will not be acceptable. The use of secondary sealing compounds, gasket cement, grease, or other devices to obtain watertight joints will not be acceptable.

2-5.06. Mixer Mast Assembly. A mixer mast assembly shall be provided for each installed mixer and shall be used to mount the mixer during operation and to guide the unit during installation and removal from service. The assembly shall include an upper mast bracket, hoist, mast, intermediate mast bracket, lower mast bracket, lifting cable, and retaining chain.

2-5.06.01. Upper Mast Bracket. The upper mast bracket shall connect the top of the mast to the structure and shall include a hoist socket and position locking plate. The upper mast bracket shall be constructed with a position locking plate in conjunction with a lock pin to positively lock the mast in place at various operating angles and allow rotation of 180 degrees of the hoist and mast about a pivot point.

2-5.06.02. Manual Hoist. Each mixer assembly shall be provided with one manual hoist with a load rating as indicated. The hoist shall raise and lower the mixers for installation and service. The hoist shall consist of a mast, davit arm, and hand winch, and AISI Type 316 stainless steel lifting cable, with diameter and length as indicated in the Mixing Mast Assembly Design Requirements. The hoist shall be constructed of AISI Type 316 stainless steel and shall be mounted to the upper mast bracket. The davit arm shall center the lifting cable over the mixer. A folding handle, permanently attached to the mast, shall be provided to rotate the mast, mixer mast, mixer, and hoist assembly as one unit about the pivot point. A hand winch shall be attached to the mast or davit arm and shall be equipped with a disc brake for load control.

The hoists shall be capable of being moved to any mixer location and shall not weigh more than 225 pounds. Suitable lifting handles shall be provided.

The mixer mast assembly shall be compatible with the hoist and provide a lifting cable quick disconnect feature, Flygt "Grip-Eye", or equal.

2-5.06.03. Mast. The mast shall be constructed of structural tubing, extending from the lower mast bracket to the upper mast bracket. The size of the tubing shall be as specified herein.

The intermediate mast bracket shall support and connect the mast to the structure wall, and shall include a mast pivot pin.

The lower mast bracket shall support the entire weight of the mixer mast, mixer, and hoist assembly, shall connect the mixer mast to the floor, and shall include a mast pivot pin.

2-5.06.04. Lifting Cable. The mast assembly shall include a lifting cable, of the same size specified for the hoist cable, which will connect to the hoist lifting cable using the quick disconnect feature as previously specified.

The power cord shall be tethered to the lifting cable using stainless steel hardware. The tether hardware shall include heavy-duty rubber hose to protect the power cord and, sliding carabiner that allows power cord to slide freely on the lifting cable.

The lifting cable shall be attached to the mixer with a lifting bracket or bridle chain which will allow the lifting cable to be centered over the mixer. A stainless steel bridle chain shackle shall be provided to connect the lifting cable to the lifting bracket or bridle chain.

2-5.06.05. Retaining Chain. A retaining chain shall extend from the top of the mixer mast to the mixer, and shall allow the mixer to be located at any intermediate point on the mast. The retaining chain shall be connected to the top of the mast with a stainless steel shackle. The shackle shall allow adjustment of the retaining chain to fix the mixer at any intermediate position on the mast. The bridle chain shackle shall connect the retaining chain to the mixer.

2-5.06.06. Mixing Mast Assembly Design Requirements. The hoist and mast shall be designed to meet the following:

Tag Number.	BNR Deox Mixer	BNR Anoxic Mixers (one removable hoist to share with the two mixers)	Sludge Holding Tank Mixers	
Hoist load rating.	TBD by mixer supplier	TBD by mixer supplier	TBD by mixer supplier	lb
Hoist lifting cable diameter.	TBD by mixer supplier	TBD by mixer supplier	TBD by mixer supplier	in
Hoist lifting cable length.	TBD by mixer supplier	TBD by mixer supplier	TBD by mixer supplier	ft
Mast structural tubing size.	TBD by mixer supplier	TBD by mixer supplier	TBD by mixer supplier	

2-5.07. Bolts and Nuts. Field assembly bolts and nuts and anchor bolts and nuts shall be provided for each item of equipment. Anti-seize compound will be applied to the threads of all stainless steel bolts before assembly.

2-6. FABRICATION AND MANUFACTURE.

2-6.01. Welding. All welded joints which will be fully or partially submerged shall be sealed watertight with continuous welds.

2-6.02. Edge Grinding. Sharp projections of cut or sheared edges of ferrous metals which will be submerged during operation shall be ground to a radius as necessary to ensure satisfactory paint adherence.

2-6.03. Surface Preparation. All welds shall be thoroughly cleaned and ground smooth in preparation for painting. All ferrous metal surfaces, except motors, speed reducers, and stainless steel, shall be solvent cleaned in accordance with SSPC-SP1 before shop primer is applied.

2-6.04. Shop Painting. All iron and steel parts, except for stainless steel parts, which will be in contact with liquid or submerged after installation shall be shop cleaned in accordance with the coating manufacturer's recommendations and painted with an epoxy coating system. The coating shall have a dry film thickness of at least 10 mils [250 µm] and shall consist of a prime (first) coat and finish coats. At least one quart of the finish coat material shall be furnished with each mixer for field touchup painting.

All ferrous metal surfaces which will not be submerged or in contact with liquid, except motors, speed reducers, and stainless steel, shall be given a shop coat of universal primer. The requirements for additional field coating are covered in the Protective Coatings section.

See the General Equipment Stipulations for other shop painting requirements.

2-7. BALANCE AND VIBRATION. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable at normal operating speed. Excessive vibration shall be sufficient cause of rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. At any operating speed, the ratio of rotative speed to the critical speed of a unit or components thereof shall be less than 0.8 or more than 1.3.

2-8. DRIVE UNITS.

2-8.01. Electric Motors. Each propeller mixer shall be driven by a totally submersible, electric motor manufactured and furnished by the mixer manufacturer. Motor nameplate rating shall exceed the maximum power required by the mixer at the operating range. Each motor shall be rated for the power supply provided to the mixer, and shall have a service factor of 1.10. The stator housing shall be an air-filled, watertight casing. A cooling jacket shall encase the motor housing for each mixer where needed to maintain adequate cooling. The cooling jacket shall require no external source of cooling water. Motor insulation shall be moisture resistant, Class F, 155°C. Each motor shall be NEMA Design B for continuous duty at 40°C ambient temperature, and designed for at least 10 starts per hour.

The motor bearings shall be antifriction, permanently lubricated type. The bearings shall have a calculated ABMA L_{10} Life Rating of 40,000 hours when operating at maximum operating point. Maximum shaft run-out at the mechanical seals shall not exceed 2 mils [50 µm] at any point in the operating range.

The water seal design for cable entry shall not require a specific fastener torque to ensure a watertight and submersible seal. The use of epoxies, silicones, or other secondary sealing systems will not be acceptable. The cable entry junction box and motor shall be separated by a stator lead sealing gland or terminal board. The junction box shall isolate the motor interior from moisture gaining access through the top of the stator housing.

Each mixer shall be provided with a separate or combined submersible power cable and submersible control cable. The power cable shall contain a ground conductor and one conductor per power phase. All submersible cables shall have a legend or code permanently embossed on the cable indicating the cable is suitable for submersible use. Cable sizing shall conform to NEC requirements.

The cable lengths shall be sufficient to extend to the junction boxes specified below plus an extra 10 feet [3 m]. Each cable shall be provided with stainless steel Kellems grips and stainless steel support brackets to help prevent damage to the cable insulation.

Motors shall be specifically selected for service with an adjustable frequency type speed controller and shall be derated to compensate for harmonic heating effects and reduced self-cooling capability at low speed operation so that the motor does not exceed Class B temperature rise when operating in the installed condition at load with power received from the adjustable frequency drive. All motors driven by adjustable frequency drives shall be supplied with full phase insulation on the end turns and shall meet the requirements of NEMA MG 1, Part 31. In addition to the requirements of NEMA MG 1, Part 31, motors shall be designed to be continually pulsed at the motor terminals with a voltage of 1600 volts ac.

2-8.02. Variable Frequency Drives. The VFDs will be purchased separately outside of the mixer supplier scope of work.

2-9. MOTOR CONTROLS.

2-9.01. Junction Box. Each mixer shall be provided with a junction box for power and control cable termination. The junction box shall be mounted as indicated on the Drawings. The power and control cables to the mixer shall be terminated in the junction box. A Kellems grip or other suitable strain relief device shall be provided on each submersible cable to prevent excess strain between the submersible cable and the junction box.

The junction box shall be as specified in the Electrical section.

2-9.02. Moisture Detection System. Each submersible mixer housing shall be provided with a moisture detection system complete with all sensors, control power transformers if required, and relays. The moisture detection system shall be rated for a 120-volt ac supply voltage. If the system operates on a voltage other than 120 volt ac, the manufacturer shall provide the necessary control power transformer. The moisture detection system shall provide one normally open dry output contact rated 5 amps at 120 volts ac. The contact shall close when moisture is detected in the submersible mixer motor housing or motor pre-chamber as recommended by the equipment manufacturer. All moisture detection system components shall be furnished by the submersible mixer supplier and components not integral to the mixer shall be shipped loose for installation into the motor controller enclosure.

2-9.03. Temperature Detection System. Each motor shall be protected by one motor temperature switch embedded in each phase winding. Each switch shall be designed to operate at 125°C (±5°C). Each switch shall be normally closed

automatic reset type rated 5 amps at 120 V ac. The switches shall be wired in series with end leads wired to terminals within the motor housing.

PART 3 - EXECUTION

3-1. INSTALLATION. Each unit shall be installed in accordance with Equipment Installation section and as specified herein.

Installation of the equipment shall be in accordance with the Hydraulic Institute Standards. Location, elevation, and the direction of the mixer (horizontal and vertical angle) shall be as determined by the manufacturer and accepted by Design-Builder.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the contract price.

3-2.02. Installation Supervision. Installation supervision by the manufacturer is not required.

3-2.03. Preliminary Field Tests. Preliminary field tests, as described in the Equipment Installation and Startup Requirements sections, will be performed on equipment specified in this section. The following additional tests shall be conducted on the equipment specified in this section as part of the preliminary field tests.

After installation of the units, and after all accessories are in operable condition, a mechanical test will be performed by the Design-Builder under the supervision of the manufacturer. Each unit shall be submitted to complete normal start, normal stop, and emergency stop cycles. Each unit with a hoist system shall also be checked to ensure that the hoist and mixer mast assembly are installed properly and that each mixer can be removed from the basin without binding of the mixer on the mixer mast. For each unit with a hoist system the mixer, hoist, and mast

shall be rotated 180 degrees about its pivot point. Each mixer with a hoist system shall be located and operated for 30 minutes at least two intermediate points on the mast without any excessive movement or vibration as determined by Design-Builder.

3-2.04. Field System Operation Tests. Field system operation tests, as described in the Startup Requirements sections, will be performed on the equipment specified in this section. As an exception, the length of the test for equipment specified under this section shall be 30 days rather than 7 days as specified in the Startup Requirements section.

3-3. PERFORMANCE TEST. Performance tests shall be run on the submersible propeller mixing equipment after the installation check is completed, the units are operating properly as determined by the representative of the equipment manufacturer, and after acceptance of the Field System Operation Tests. The performance tests shall be conducted by a capable representative of the manufacturer and accepted by Design-Builder. All costs for these services shall be included in the contract price.

Owner's operating personnel will assist the manufacturer's representative in the performance test. A designated representative of Design-Builder will observe the performance tests.

Preliminary performance tests shall be conducted using the submersible mixer under the design conditions specified. Once the appropriate operation parameters are established, extended duration performance tests shall be conducted to demonstrate the equipment's ability to consistently perform at the design conditions specified.

Performance tests shall be conducted on the mixing equipment in Deox zone and the Anoxic zones. The performance tests shall be performed after the biological processes have reached a mixed liquor suspended solids concentration in the range of 6,000 to 8,000 mg/l for the Anoxic zones and 8,000 mg/L for the Deox zone.

The test results will be used to prove compliance with the performance requirements prior to acceptance of the equipment. Consistent compliance with design conditions shall be defined as the average of sample values meeting or exceeding the specified design conditions.

The equipment manufacturer shall detail the proposed performance testing procedure and analyses, subject to approval by Design-Builder. If more than one day of testing is required, the testing shall be done on consecutive days.

3-3.01. Suspended Solids Distribution Test.

In order to evaluate the ability of the mixing equipment to maintain mixed liquor solids in suspension and uniformly distributed throughout the basins, two suspended solids distribution tests shall be performed.

The suspended solids distribution test shall be performed after the biological processes have reached the operational conditions specified herein. Testing shall be conducted under the biological nutrient removal (BNR) mode of operation of the biological treatment basins. Flows shall be as indicated below. The influent flow will be maintained by adjusting the basin outlet weir.

Basin/Cell	Flow
Deox	0.97*3 mgd
Anoxic.	0.97*3 mgd

A suspended solids instrument shall be used to measure the suspended solids for the test. Each round of measurements shall consist of one measurement at each of eight points in each test basin/cell as indicated on Fig 1-11515. A minimum of two rounds of measurements shall be taken The measurements shall be averaged and at least 2/3 of the data points shall be within ± 10 percent of the average.

As each sample or measurement is collected the time (month, day, hour and minute) shall be recorded. In the report submitted for review, the collection or measurement times shall be included with the analytical results for each sample or the value of each measurement. The influent flow, RAS flow and MLSS recycle flow shall be recorded at the beginning and end of each round of sampling, and the recorded values shall be included in the report.

For each round of measurements, measurements shall be collected from all eight points in the test basin/cell sequentially or simultaneously. When a round is complete, the subsequent round may begin. Measurements shall be take between 8 a.m. and 5 p.m., but after the influent high flows in the morning stabilize to minimize the chance of changing influent characteristics.

Design-Builder will be responsible for collecting all measurements and ensuring that they are representative. The measurements shall be taken in as short a period as possible, not to exceed 2 hours, to minimize the potential effect of aeration basin influent composition variability.

3-4. TEST REPORTS. The equipment manufacturer shall prepare a formal test report, including all installation check and performance tests and other recorded

data and observations. A PDF copy of the report shall be submitted to Design-Builder within 30 days after completion of the specified tests.

3-5. MODIFICATIONS. If the submersible propeller mixing system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at Submersible Mixer Manufacturer's expense.

3-6. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is directly employed by the manufacturer to instruct Owner's operating personnel in the proper operation and maintenance of the equipment. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-6.01. Operations Training. Classroom instruction covering the theory of operation, site specific operation of the equipment and optimization of the submersible propeller mixer operation.

3-6.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

3-6.03. Maintenance Assistance. Not used.

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Section 46 51 21

COARSE BUBBLE DIFFUSERS

PART 1 - GENERAL

1.1. SCOPE. This section covers furnishing, installing, and performance testing of coarse bubble diffused aeration equipment for the sludge holding tanks as indicated on the Drawings and as specified herein.

Number of basins. 2

The equipment shall be furnished complete with all concrete foundations as required, baseplates, diffusers, supports, anchor bolts, air piping, air valves, pipe anchors, and any additional materials or construction required by the manufacturer's design.

The diffused aeration equipment manufacturer shall be responsible for supplying all air piping in the basins from the butterfly valve at each drop pipe as indicated on the Drawings, including the drop pipes, manifolds, laterals, and all accessories and appurtenances required for proper installation and operation. Air piping, permanent flow meters, and valves beyond the limits indicated on the Drawings are not required to be provided as part of the diffused aeration equipment manufacturer’s package.

1-2. GENERAL. Equipment furnished under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with Drawings, Specifications, engineering data, and instructions.

1-2.01. Coordination. All equipment provided in this section shall be furnished by or through a single manufacturer who shall coordinate the design of the diffused aeration system with the requirements of the blower manufacturer.

Air supply to the diffused aeration equipment shall be provided by blowers as specified in the blowers section.

All air supply piping to the basins, including supports and stands, will be as specified in other sections.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-3. SUBMITTALS. Complete fabrication, assembly, foundation, layout, and installation drawings, detailed specifications and data covering material used, parts, and other accessories forming a part of the equipment furnished, together with the diffuser headloss curve, system performance and headloss data, spare parts list, and welder qualifications, shall be submitted in accordance with the Submittals Procedures section.

Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-4. OPERATION AND MAINTENANCE DATA AND MANUALS. Not used.

1.5. QUALITY ASSURANCE.

1-5.01. Welding Qualifications. All welding procedures and welding operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of Section IX of the ASME Code. Accurate records of operator and procedure qualifications shall be maintained by Design-Builder and made available to Owner's Representative upon request.

1-5.02. Welder Certification. Not Used.

1-5.03. Tolerances. The system shall be designed and manufactured in such a manner that all diffuser elements are within ±0.5 inches [12 mm] of the specified elevation.

1-7. SPARE PARTS. A list of recommended spare parts shall be provided by the Coarse Bubble Diffuser supplier.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. All diffused aeration equipment shall be designed to operate satisfactorily under the conditions in the Meteorological and Seismic Design Criteria sections and under the following service conditions.

Type of wastewater treatment prior to aeration.	Degritted, Screened
Type of basin for aeration use.	Sludge holding/mixing
Number of air supply blowers.	2

Air temperature range at top of drop pipe.	100 to 275	°F

All equipment furnished shall be designed to meet all specified conditions and to operate satisfactorily at the specified elevation.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Aeration units shall be designed for the following operating conditions:

Number of aeration basins (parallel trains).	2	
Basin dimensions (for rectangular basin, length x width).	38’-10” x 38’-10”	ft
Sidewater depth (varying).	6 to 22	ft
Total volume per train.	31,480	ft^3
Number of aerated zones per train.	1	
Design mixed liquor temperature.		
Winter (minimum).	17	°F
Summer (maximum).	22	°F
Annual average.	19	°F

Condition	Start-Up Minimum Month	Annual Average	Maximum Month	
Plant flow.	29,500	29,500	38,800	gpd
TSS Concentration	6,500	9,200	7,700	mg/L
VSS/TSS	0.7	0.7	0.7	--
BOD Concertation	< 5	< 5	< 5	mg/L
NH4-N Concentration*	Target of 6	Target of 6	Target of 6	mg/L

*Ammonia Based Aeration Controls will be implemented in the biological treatment process.

Condition	Start-Up Minimum Month	Annual Average	Maximum Month

Condition	Start-Up Minimum Month	Annual Average	Maximum Month	
Oxygen uptake rate	10	20	35	mg/L/hr
Liquid temperature	17	19	22	°F
Side Water Depth	6	9.5	16	ft
Minimum basin oxygen concentration, C min	0.5	1.5	2	mg/L
Alpha factor	0.85	0.85	0.85	--
Beta factor	0.9	0.9	0.9	--
KLa, 20ºC	1.5	3.2	5.7	hr^{-1}
Standard oxygen transfer rate (SOTR)*	8	28	88	pph
Airflow rate	250	450	700	SCFM
Maximum airflow rate per diffuser	25	25	25	SCFM/ ft
Minimum number of diffusers	28	28	28	
Minimum number of diffuser grids	1	1	1	

* Standard condition is at 20°C and 1 atm clean water.
Airflow will be stopped intermittently and a submersible mixer will be employed for mixing.

2-2.01. Design and Performance Criteria. The aeration equipment shall convey air from the air mains to the air diffusers. The air distribution lines shall be designed and installed so that adding air to the lines will expel all water or waste therefrom. The air diffusers shall diffuse the air uniformly into the basins in which they are submerged.

The aeration system shall be designed to transfer the required amount of oxygen and shall have sufficient mixing capacity to thoroughly mix the entire contents and to keep all solids in suspension.

The diffused aeration equipment shall be designed to meet the design criteria and performance requirements specified herein. The capability of the aeration equipment to meet the oxygen transfer rates specified shall be determined by shop or field performance tests specified herein.

2-2.02. Supplemental Mixing. A supplemental mixing system will be installed in the sludge holding tanks along with the diffused coarse bubble aeration system. The mixer manufacturer will set the elevation of the mixer so as not to interfere with the aeration diffuser grid piping, and will recommend the area under the mixer where diffusers are not to be installed to prevent diffuser damage from mixer pumping action and air bubbles from causing mixer impeller cavitation. The recommended area shall have diffuser grid headers installed without diffuser assemblies. The Design-Builder shall coordinate between the mixer manufacturer and the diffuser manufacturer for a installation that protects the equipment supplied by each.

2-3. ACCEPTABLE MANUFACTURERS. Acceptable manufacturers of coarse bubble diffused aeration units are Environmental Dynamics, Inc., Sanitaire, or equal.

2-4. MATERIALS.

Diffuser Assembly	AISI 316L stainless steel equivalent to Schedule 80 pipe with an end cap of cast equivalent of AISI 304L stainless steel with a 3/4 inch NPT male pipe thread connection.
Drop Pipes	Stainless steel ASTM A312 or ASTM A778 with longitudinal seams, Grade TP304L, Schedule 10S.
Air Distribution Manifold	Stainless steel ASTM 240, Type 304L, Schedule 10S.
Flanges	Sized to match the diameter and drilling of the ANSI B16.5, 150 psi standard for steel flanges.
Diffuser Header Laterals	Stainless steel ASTM 240, Type 304L, Schedule 10S.
Supports, Clamps, and Anchors	ASTM A240, Type 304L stainless steel.
Bolts, Nuts, and Washers	AISI Type 304, Bolts ASTM F593, Alloy Group 1; Nuts ASTM F594, Alloy Group 1; Washers ANSI B18.22.1. Minimum diameter of anchor bolts shall be ½" for air distribution manifolds and 3/8" for diffuser header laterals.

Flange Bolts	ASTM A193 Class 2, AISI Type 304, ANSI B18.2.1, heavy hex head, length such that, after installation, the bolts will project 1/8 to 3/8 inch [3 to 10 mm] beyond outer face of the nut.
Flange Nuts	ASTM A194, AISI Type 304, ANSI/ASME B18.2.2, heavy hex pattern.
Welded Parts and Assemblies	Sheets and plates of ASTM A240, Type 304L.
Nonwelded Metals	Sheets and plates of stainless steel ASTM A240, Type 304.
Gaskets	45-55 durometer (Shore A) neoprene.
Tubular Products and Fittings	Grade TP304L, fabricated in conformance with ASTM A774 and ASTM A778.

Contact between dissimilar metals is not acceptable.

2-5. CONSTRUCTION.

2-5.01. Diffused Aeration Equipment. The diffused aeration equipment shall consist of drop pipes, air piping, diffuser assemblies, pipe supports, and all accessories indicated on the Drawings, specified or required for proper installation and functioning of the diffused air system.

2-5.02. Diffusers. Diffusers shall be designed to provide full aeration. Air shall be released uniformly along a minimum air band of 2 feet beyond the air header. Air exiting the diffuser shall clear the air header.

Diffuser assemblies shall be wide band or Sparger type.

Each diffuser shall consist of one inverted air reservoir of the size as recommended by the manufacturer, deflector, air exit ports, and balancing nozzle. The balancing nozzle shall provide the proper head loss to assure uniform air distribution throughout the aeration system. The exit ports shall be located on each side of the diffuser in horizontal planes on two levels to discharge air into the liquid. The deflector shall be located below the open bottom of the inverted air reservoir, shall direct the liquid being aerated along the inverted air reservoir's outer walls, shall prevent rags or other material from entering the diffuser, and shall be supported by connection directly to the diffuser. The air exiting the ports shall be sheared into small bubbles and shall be well distributed into the liquid.

Connections of the diffuser to the header shall require only one fitting. A combination of tees, elbows and nipples will not be an acceptable method of connection.

2-5.03. Diffused Aeration Piping. A diffused aeration piping system shall be furnished to distribute air from the aeration air supply piping to the diffusers. The piping system shall begin at the drop legs as indicated on the Drawings. The piping system shall include the entire air distribution system, including all drop pipes, air distribution manifolds and diffuser header laterals. The piping shall be provided complete with all fittings, specials, flanges, couplings, slip joints, anchors, gaskets, bolts and nuts, pipe supports, end caps, connections, appurtenances, and accessories which are indicated on the Drawings or are required for proper installation and functioning of the diffused aeration system.

The diffused aeration drop pipes shall be in the locations as indicated on the Drawings. The minimum size of drop pipes shall be as recommended by the manufacturer, but in no case smaller than the minimum diameter specified herein. The diffused aeration system manufacturer shall provide a reducer with a flanged connection if required for connection of the drop pipe to the piping furnished by the Design-Builder.

All air distribution manifolds and diffuser header laterals shall be stainless steel and shall be sized by the manufacturer to evenly distribute the flow to all diffusers with a minimum pressure drop. The size of the piping shall be as recommended by the manufacturer. Flanged or union type joints shall connect the distribution header to the diffuser lateral. All piping shall be supported with stainless steel pipe stands.

All subsurface connections, yokes, baseplates, supports and fasteners, shall be free from protrusions, sharp angles, and excessively long bolts to which rags or stringy materials may become attached.

Each air distribution header shall be fabricated in section lengths as recommended by the manufacturer. The bottom elevation of each air distribution header shall be the same throughout the basin. Changes in diameter shall be accomplished by using eccentric reducers. Air headers shall be designed and installed so that adding air to the lines will expel all water and waste from the lines. The end of each header shall have welded end caps. Connections between sections of the air distribution headers shall be designed so that individual header sections can be rotated independently of adjacent header sections for alignment purposes.

Each air distribution header shall include an expansion-contraction system consisting of expansion joints, fixed supports and flanged header connections. Fixed supports shall be designed to anchor the header against longitudinal

movement at the support. Intermediate supports between fixed supports and expansion joints shall allow for longitudinal movement. The entire system shall be designed to allow for expansion and contraction over the specified air temperature range at the top of the drop pipe without air leakage.

The diffuser connectors shall be factory welded to the bottom (on center line) of the air distribution header. The connectors shall be of such length and so positioned to allow air exiting the diffuser to clear the air header. All connectors shall be installed on a common horizontal plane. Diffuser connectors and piping shall be of adequate strength to withstand a vertical load applied at the threaded end of the connector which results in a bending moment of 1,000 in-lbs at the diffuser connector without any permanent deformation. All diffuser connectors shall have provisions for placement of two diffusers to allow for future expansion.

2-5.04. Pipe Supports. Pipe supports shall be fabricated as specified herein and shall be provided complete with all bases, anchor bolts and nuts, plates, rods, and other accessories required for proper installation.

Pipe supports shall be fabricated from stainless steel components in conformance with the material and fabrication requirements specified in the section pertaining to diffused aeration piping.

Pipe supports shall be the manufacturer's standard support system and shall be comprised of fixed and simple floor supports as required by the piping configuration. Pipe supports shall be constructed of angle members welded together forming a frame and bolted to the floor with expansion anchors. A clamp around the header or manifold piping shall be bolted to the support.

Each horizontal and vertical portion of the air distribution section headers shall have a minimum of two supports. Supports shall be spaced as recommended by the manufacturer. All supports shall include a mechanism to provide for a minimum of ±2 inches (vertical and ±1/2 inch lateral adjustment for alignment of the piping.

One support for each section of piping shall include an integral device for rotational adjustment during installation. All adjusting devices and mechanisms shall have provisions to be locked in place to secure the piping in position after final adjustment and alignment.

2-5.05. Bolts and Nuts. Assembly bolts and nuts shall be provided as required for each aeration system. Anti-seize compound will be applied to the threads of all stainless steel bolts before assembly.

2-6. FABRICATION

2-6.01. Welding. All welding shall be completed in the factory using the shielded arc, inert gas, MIG or TIG method. Field welding will not be allowed. Filler wire shall be added to all welds to provide for a cross section and weld metal equal to or greater than the parent metal. Butt welds shall have full penetration to the interior surface and gas shielding shall be provided to the interior and exterior of the joint. Interior weld beads shall be smooth, evenly distributed with an interior projection not exceeding 1/16 inch beyond the inside diameter of the air header or fitting. Face rings and flanges shall be continuously welded to pipe and fittings. Stitch welds will not be acceptable.

2-6.02. Surface Preparation. Unless otherwise specified or permitted, all items fabricated from stainless steel shall be thoroughly cleaned, degreased, and pickled following fabrication as specified in ASTM A380. Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. Pickled surfaces shall be subjected to a 24 hour water test or ferroxyl test to detect the presence of residual embedded iron and shall be repickled as needed to remove all traces of iron contamination. Pickled surfaces shall be adequately protected during shipping and handling to prevent contact with iron or steel objects or surfaces. Blast cleaning of stainless steel will not be acceptable.

2-7. SPECIAL TOOLS AND ACCESSORIES. The manufacturer shall furnish all special tools required for the assembly, disassembly, adjustment, and maintenance of all components of the diffused aeration equipment. One set of special tools shall be provided.

PART 3 - EXECUTION

3-1. INSTALLATION. The diffused aeration system shall be installed in the locations as indicated on the Drawings, in accordance with the Equipment Installation section and as specified herein.

Diffusers shall be installed as shown on the Drawings, and shall be level with a maximum allowable variance of 0.25 inch per foot of diffuser length. Deforming of air header, diffuser connectors, diffusers, or pipe supports to align or level the system will not be allowed. The connection of the drop pipe to the air distribution header shall be made using a flexible joint to allow ease of installation and alignment. Field connections in the diffused aeration system shall be flanged, threaded, mechanically coupled, or grooved end couplings. Field welding of the diffused aeration equipment will not be allowed.

All diffusers shall be attached to the diffused aeration piping using stainless steel welding connectors as recommended by the manufacturer.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with the Start-up Requirements section, and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report certifying that the equipment has been properly installed; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; and has been operated under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the contract price.

3-2.02. Installation Supervision. Installation supervision by the manufacturer is not required.

3-3. PERFORMANCE TESTS. Prior to equipment acceptance, field performance tests shall be conducted on the diffused aeration equipment in the sludge holding tanks to demonstrate that the equipment meets specified oxygen transfer and airflow rate requirements.

Personnel in charge of the tests shall be competent, authorized representatives of the equipment manufacturer who are familiar with operation of the equipment furnished and who have previous satisfactory experience in conducting tests of the type specified. Qualified personnel shall perform the tests, record the data, make the required calculations, and prepare a report on the results.

The equipment manufacturer shall provide support facilities which shall include, but not be limited to, power, equipment, chemical storage tanks, mixing equipment, chemicals for dissolved oxygen determinations by the modified Winkler method, chemicals for K_La determination by the nonsteady state sulfite method, DO probes, scales, and such other equipment and facilities as may be necessary.

Dissolved oxygen concentration measurements shall be made with direct reading instruments which have been standardized against a laboratory determination of dissolved oxygen as described in the latest edition of "Standard Methods for Examination of Water and Waste Water," with appropriate modification for interfering substances. One direct reading instrument shall be provided for each point shown on Figure 2-46 51 31. Each instrument shall have a probe cord of adequate length.

3-3.01. Test Procedures. The performance tests shall be performed in accordance with the requirements specified herein, in water from a potable water source, and a water temperature between 59°F and 77°F.

A minimum of three tests shall be conducted at the maximum airflow conditions. One test shall be conducted at the minimum airflow condition, and one additional test at an airflow rate approximately midway between the minimum and maximum conditions shall be performed to plot the specified performance curves. The tests at the maximum airflow conditions shall be conducted first. No pre-conditioning tests are allowed.

The data to be determined in each test shall include, but not be limited to:

Airflow rate in scfm.

Air supply temperature and pressure.

Continual recording of centrifugal blower power.

Rate of change of the dissolved oxygen concentration preceding, during, and following DO depletion.

Liquid temperature.

Uncorrected barometric pressure.

Pressure at top of drop pipe.

Additional data as necessary to determine compliance with the specifications.

Before each test, the aeration system should be operated for a period of time at the test airflow rate to achieve steady state conditions.

In each test, sodium sulfite solution shall be added to the water to deplete the oxygen concentration to zero. A 10 percent, by weight, solution of sodium sulfite (Na_2SO_3) shall be prepared in sufficient quantity to deplete and maintain the zero condition for one minute on all probe readouts simultaneously.

Stoichiometrically, about 75 lbs of 96 percent pure sodium sulfite will be required per million gallons to deplete the oxygen concentration one milligram per liter. A minimum of 150 percent of the stoichiometric concentration is typically required to achieve and maintain zero conditions for one minute. Technical grade sodium sulfite, free of catalyst, shall be used.

Data shall be recorded that shows oxygen depletion. The data shall also show that all test points remained at zero dissolved oxygen for at least one minute simultaneously. The test shall be considered invalid if zero dissolved oxygen is not reached for at least one minute at all test points simultaneously.

A 10 percent, by weight, solution of cobalt chloride ($CoCl_2$ $6H_2O$) shall also be prepared for the initial series of tests. About 34 lbs of cobalt chloride will be required per million gallons to obtain a cobalt ion concentration of one milligram per liter. For test purposes, the cobalt ion concentration shall be 0.5 mg/L or less.

For the initial series, the cobalt chloride solution shall be introduced into the tank with the diffused aeration system operating. After a minimum of 15 minutes of operation, addition of the sodium sulfite solution shall be started slowly. It will not be acceptable to turn down the air to achieve better deoxygenation with sodium sulfite. The entire quantity of sodium sulfite solution shall be added to the tank within a period of approximately 5 minutes in a manner achieving uniform dispersion throughout the tank.

After the first tests have been completed, another batch of sodium sulfite shall be prepared and the procedure repeated. No additional cobalt chloride solution should be required after the first series. Should additional chemicals be required, they shall be provided at no additional cost to Owner. No more than ten tests shall be made with the same test water.

The equipment shall be operated to reaerate the water until oxygen saturation is reached. Dissolved oxygen concentrations shall be monitored continuously and recorded during the depletion and the reaeration periods. Dissolved oxygen concentrations shall be recorded at equal increments of approximately one minute, or at a time interval which provides at least 15 readings between 10 and 90 percent of the measured DO saturation value. DO-time data shall be recorded during DO depletion and over the full aeration time. The temperature of the test liquid shall be recorded before and after each test run. Cobalt ion concentration of the test water will be measured after completion of tests by an independent testing laboratory and the test paid for by Owner. Points of dissolved oxygen measurements shall be as shown on Figure 2-11572.

3-3.02. Flow Meters. Flow meters are not provided for the sludge holding tank blowers.

3-3.03. Data Analysis. The dissolved oxygen deficit from saturation (C_s-C_t) for each measurement point shall be calculated and plotted on semilog paper versus time (t) where C_t is the measured oxygen concentration at any time (t), and C_s is the average dissolved oxygen concentration, at temperature T, attained by aerating the basin contents until no further increase in dissolved oxygen concentration is detected.

A line of best fit shall be drawn utilizing regression analysis on all points. A sample of such a plot is provided for reference only on Figure 1-46 51 31.

The overall oxygen transfer coefficient $(K_La)_T$ for each point of measurement specified shall be computed by determining the slope of the line of the best fit by using the following equation:

$$(K_La)_T = \frac{\ln [(C_s-C_1) / (C_s-C_2)]}{t_2-t_1} \quad (hr^{-1})$$

where:

	T	=	water temperature, centigrade
	C_s-C_1	=	initial (t_1) dissolved oxygen deficit, (mg/L)
	C_s-C_2	=	final (t_2) dissolved oxygen deficit, (mg/L)
	t_2-t_1	=	time span, (hr)
	C_s	=	average of all dissolved oxygen concentrations, liquid temperature T, attained at each test location by aerating the basin contents until no further increase in oxygen concentration is detected, (mg/L)

The oxygen transfer rate constant for each measurement point shall be corrected to 20 C by the following formula:

$$(K_La)_{20} = (K_La)_T(\mu_T/\mu_{20})^{1.065}(hr^{-1})$$

where:

	μ	=	absolute viscosity, (lb-sec/ft^2)

The individual values of $(K_La)_{20}$ from each test location for all three tests at maximum airflow shall be averaged and at least two-thirds of the individual $(K_La)_{20}$ values shall be within 10 percent of the average value. If not, additional tests shall be conducted until two-thirds of the $(K_La)_{20}$ values are within 10 percent of the average of all $(K_La)_{20}$ values.

The standard oxygen transfer rate by the aeration system shall be calculated by using the average value of $(K_La)_{20}$ in the following equation:

Standard Oxygen Transfer Rate		=	$8.34\ (K_La)_{20}\ V_B\ C_s(std)$ (lb/hr)
where:	V_B	=	aeration basin volume tested in million gallons
	$C_s(std)$	=	the measured C_s value during the performance testing corrected to standard conditions (20 C and sea level) and shall be determined by
	$C_s(std)$	=	$[C_s] \times [9.09/C_s(a)]^{0.913}$
where:	$C_s(a)$	=	theoretical surface oxygen saturation value at test site barometric pressure and liquid temperature T, (mg/L)

C_s = measured oxygen saturation value at test site conditions, (mg/L)

The standard oxygen transfer rates, as determined by the performance tests, shall not be less than the values specified herein. The airflow rates used in the performance tests to meet the specified peak standard oxygen transfer rate values shall not exceed the values specified herein.

3-3.04. Test Performance Curve. The equipment manufacturer shall furnish a performance curve showing the relationship between oxygen transfer in pounds of oxygen per hour as a function of airflow in scfm over the full operating range of the equipment.

3-4. TEST REPORTS. The equipment manufacturer shall prepare a test report, including all installation check and performance tests and other recorded data and observations. A PDF copy of the report shall be submitted to Design-Builder after completion of the specified tests.

3-5. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer's expense.

3-6. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-6.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-6.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

End of Section

Section 46 51 31

FINE PORE DIFFUSED AERATION EQUIPMENT

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing and performance testing of fine pore diffused aeration equipment for the basins as indicated on the Drawings and as specified herein.

Aeration basin tags.	Aerobic Grid 1: 1101, 2101
	Aerobic Grid 2: 1201, 2201
Number of basins.	2, 2 aeration zones in each

The equipment shall be furnished complete with all aeration diffusers, supports, anchor bolts, air piping, pipe anchors, portable pressure monitoring control panels and pressure monitoring equipment, and any additional materials or construction specified or otherwise required for proper operation.

The diffused aeration equipment manufacturer shall be responsible for supplying all air piping in the aeration basins from the butterfly valve at each drop pipe as indicated on the Drawings, including the drop pipes, manifolds, laterals, pressure monitoring equipment, and all accessories and appurtenances required for proper installation and operation. Air piping, permanent flowmeters, and valves beyond the limits indicated on the Drawings are not required to be provided as part of the diffused aeration equipment manufacturer package.

1-2. GENERAL. Equipment furnished under this section shall be fabricated and assembled in full conformity with drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Design-Builder.

1-2.01. Coordination. All equipment provided in this section shall be furnished by or through a single manufacturer who shall coordinate the design of the diffused aeration system with the requirements of the blower manufacturer and shall be referred to as the Process Air Blower System Supplier (PABSS).

Air supply to the diffused aeration equipment will be from blowers that are specified in the applicable blower section.

All air supply piping to the basins, including supports and stands, will be as specified in other sections.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-3. SUBMITTALS. Complete fabrication and assembly drawings, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section.

Additionally, the manufacturer shall submit a letter sealed and signed by a professional engineer registered in the state where the Project is located, certifying that under all specified operating conditions:

> The design provides sufficient cooling in the stainless steel portion of the pipe in each drop leg, so the temperature of the inside wall at any point in the PVC or CPVC pipe to be installed, is below the rated continuous operating temperature of the pipe, and
>
> The design provides sufficient cooling to reduce the process air temperature to the rated continuous operating temperature of the PVC diffuser components.

Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-4. OPERATION AND MAINTENANCE DATA AND MANUALS. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-5. QUALITY ASSURANCE.

1-5.01. Welding Qualifications. All welding procedures and welding operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of Section IX of the ASME Code. All procedure and operator qualifications shall be in written form and subject to Design-Builder's review. Accurate records of operator and procedure qualifications shall be maintained by Design-Builder.

1-5.02. Welder Certification. Not Used.

1-5.03. Tolerances. The system shall be designed and manufactured in such a manner that all diffuser elements are within ± 0.5 inches of the elevation indicated herein.

1-6. WARRANTY. The membrane material shall be capable of providing a 5 year life in the plant wastewater environment. The equipment manufacturer shall guarantee all membrane diffuser elements for a 5 year period following the substantial completion date of this contract and shall replace at no expense to Owner all membrane diffuser elements that fail to meet this requirement.

1-7. SPARE PARTS. The PABSS shall provide a list of recommended spare parts.

Spare parts shall be packaged in accordance with the general Terms and Conditions with labels indicating the contents of each package. Each label shall indicate manufacturer's name, equipment name, part nomenclature, part number, address of nearest distributor, and current list price. Spare parts shall be delivered to Owner as directed.

Spare parts subject to deterioration, such as ferrous metal items and electrical components, shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. All diffused aeration equipment shall be designed to operate satisfactorily under the conditions in the Meteorological and Seismic Design Criteria section and under the following service conditions:

Type of wastewater treatment prior to aeration.	Degritted, Screened	
Type of basin for aeration use.	Activated sludge	
Number of air supply blowers.	3	
Air Temperature range at top of drop pipe.	100 to 275	°F

All equipment furnished shall be designed to meet all specified conditions and to operate satisfactorily at the specified elevation.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Aeration units shall be membrane disc type without PTFE coating designed for the following operating conditions:

Number of aeration basins (parallel trains).	2	
Basin dimensions (for rectangular basin, length x width).	57'-6" x 23'-3"	ft
Typical Sidewater depth.	18	ft
Maintenance Condition Sidewater Depth	19.5	Ft
Total volume per train.	28,200	ft^3
Oxic volume per train.	24,060	ft^3
Number of aerated zones per train.	2	
Design mixed liquor temperature.		
Winter (minimum).	17	°F
Summer (maximum).	22	°F
Annual average.	19	°F
Range of sludge recirculation (percent of annual average design flow)	300 to 500	%

Condition	Peak Day	Maximum Month	Annual Average	Start-Up Minimum Month	StartUp Minimum Day	
Plant flow.	1.45	1.16	0.97	0.74	0.59	mgd
BOD concentration to aeration basin.	386	375	355	330	320	mg/L
BOD load to aeration basin.	4,668	3,628	2,872	2,037	1,575	ppd
TKN concentration to aeration basin.	70	68	57	53	51	mg/L
TKN load to aeration basin.	847	658	461	327	251	ppd

	Peak Day Summer	Maximum Month Summer	Annual Average, Average	Start-Up Minimum Month Winter	Start-Up Minimum Day Winter	
Zone 1						
Oxygen uptake rate.	60	50	40	28	22	mg/L/hr
Liquid temperature .	22	22	19	17	17	°F
Typical oxygen concentration, C min.	<0.3	<0.3	<0.3	<0.3	<0.3	mg/L
Alpha factor.	0.63	0.63	0.63	0.63	0.63	mg/L
Beta factor.	0.9	0.9	0.9	0.9	0.9	--
KLa, 20ºC.	10.4	8.4	6.5	4.7	3.6	hr^{-1}
Standard oxygen transfer rate (SOTR)*	165	135	105	75	58	pph
Airflow rate.	575	460	345	225	170	SCFM
Minimum number of diffusers .	220	220	220	220	220	--
Minimum number of diffuser grids.	1	1	1	1	1	--
Zone 2						
Oxygen uptake rate.	52	43	31	25	20	mg/L/hr
Liquid temperature .	22	22	19	17	17	°F
Typical oxygen concentration, C min.	<0.5	<0.5	<0.5	<0.3	<0.3	mg/L
Beta factor.	0.9	0.9	0.9	0.9	0.9	--
KLa, 20ºC.	9.0	7.3	5.3	4.0	3.1	hr^{-1}

	Peak Day Summer	Maximum Month Summer	Annual Average, Average	Start-Up Minimum Month Winter	Start-Up Minimum Day Winter	
Standard oxygen transfer rate (SOTR)*	145	120	85	64	50	pph
Airflow rate.	500	400	285	200	150	SCFM
Minimum number of diffusers .	200	200	200	200	200	--
Minimum number of diffuser grids.	1	1	1	1	1	--

*Standard conditions are 20°C and 1 atm clean water.

2-2.01. Design and Performance Criteria. The aeration equipment shall convey air from the air mains to the air diffusers. The air distribution lines shall be designed so that adding air to the lines will expel all water or waste. The air diffusers shall diffuse the air uniformly into the basins in which they are submerged.

The aeration system shall be designed to transfer the required amount of oxygen and shall have sufficient mixing capacity to thoroughly mix the entire contents and to keep all solids in suspension.

The diffused aeration equipment shall be designed to meet the performance and design requirements specified herein. The capability of the aeration equipment to meet the specified oxygen transfer rates shall be determined by shop performance tests specified herein.

2-2.02. Supplemental Mixing. No supplemental mechanical mixing will be provided in any zone.

2-3. ACCEPTABLE MANUFACTURERS. Acceptable manufacturers of fine pore diffused aeration units are Environmental Dynamics, Sanitaire, or equal if approved.

2-4. MATERIALS.

Drop Pipes and Air Distribution Piping Where Required for Heat Dissipation	Stainless steel, ASTM A312 Grade TP 304L and AISI Type 304L, Schedule 10S.

Air Distribution Manifolds	ASTM D1785 Cell Classification 12454 Schedule 40 PVC, ultraviolet resistant or ASTM F441 Cell Classification 23447 Schedule 40 CPVC ultraviolet resistant.
Diffuser Header Laterals	
Discs	ASTM D3034 and D3915 SDR min. 35 PVC, ultraviolet resistant or, ASTM D1784, ASTM D1785 Cell Classification 12454, Schedule 40 PVC, ultraviolet resistant.
Fittings	ASTM D2466 Cell Classification 12454 Schedule 40 PVC, ultraviolet resistant or ASTM F438 Cell Classification 23447 Schedule 40 CPVC ultraviolet resistant.
Joints and End Caps	Ultraviolet-resistant PVC, compression type with neoprene seals; thickness class to be the same as the pipe.
Supports, Clamps, and Anchors	ASTM A240 and A276, Type 304 L stainless steel.
Bolts, nuts, and washers	AISI Type 304, Bolts ASTM F593, Alloy Group 1; Nuts ASTM F594, Alloy Group 1; Washers ANSI B18.22.1. Minimum diameter of anchor bolts shall be 1/2” for air distribution manifolds and 3/8” for diffuser header laterals.
Flange Bolts	ASTM A193 Class 2, AISI Type 304, ANSI B18.2.1, heavy hex head, length such that, after installation, the bolts will project 1/8 to 3/8 inch [3 to 10 mm] beyond outer face of the nut
Flange Nuts	ASTM A194, AISI Type 304, ANSI/ASME B18.2.2, heavy hex pattern.
Diffuser Assembly	
Membrane Disc	EPDM membrane disc with an ultraviolet inhibitor; ultraviolet-resistant PVC or polypropylene holder.
Moisture Blowoff Assembly	ASTM D1784 and ASTM D2241, Type 1, Grade 1, Schedule 80 PVC piping and fittings, solvent welded, with PVC ball valves, ultraviolet resistant.

Welded Miscellaneous Metals	ASTM A240, Type 304L stainless steel.
Nonwelded Miscellaneous Metals	ASTM A240, Type 304.
Gaskets	Neoprene, 45 to 55 Type A durometer, tested in accordance with ASTM D2240.
Tubular Products and Fittings	Grade TP304L, fabricated in conformance with ASTM A778 and ASTM A774.

Contact of dissimilar metals is not acceptable.

2-5. CONSTRUCTION.

2-5.01. Diffused Aeration Equipment. The diffused aeration equipment shall consist of drop pipes, air piping, diffuser assemblies, pipe supports, moisture blowoff assemblies, and all accessories indicated on the Drawings, specified, or required for proper installation and functioning of the diffused air system.

2-5.02. Ceramic Disc Diffuser Assemblies. Not used.

2-5.03. Membrane Disc Diffuser Assemblies. Each disc diffuser assembly shall consist of a round, flexible membrane diffuser element, a disc membrane holder with integral backflow prevention mechanism, and an independent retaining system to attach the membrane to the holder. The material used for both the membrane diffuser element and the membrane holder shall be noncorrosive and UV resistant.

The membrane diffuser element shall be an EPDM material with an ultraviolet inhibitor and compounds designed for resistance to chemical attack, weathering, and aging. Data shall be provided to show the chemical resistivity of the membrane material proposed for installation. The surface of the membrane must be smooth to prevent biological growth from attaching.

The diffuser assembly shall be connected to the air distribution piping using a connection saddle or casting. Direct connection of the diffuser assembly to the air distribution piping shall not be acceptable. The connection saddle or casting shall be one piece construction, high strength PVC, polypropylene or other suitable material, and must be either threaded or provided with an alternative mechanism for mounting of diffuser assemblies.

Connection saddles or castings that are solvent welded to the crown of the air distribution piping shall be attached in the factory. Field installation of connection saddles or castings shall not be acceptable. For connection saddles that consist of an independent saddle/wedge assembly, installation may be completed in the field.

2-5.04. Tube Diffuser Assemblies. Not used.

2-5.05. Diffused Aeration Piping. A diffused aeration piping system shall be provided to distribute air from the aeration supply piping to the diffusers. The piping system shall begin after the butterfly valve as indicated on the Drawings. The piping system shall include the entire air distribution system, including all drop pipes, air distribution manifolds and diffuser header laterals. The piping shall be provided complete with all fittings, specials, flanges, couplings, slip joints, anchors, gaskets, bolts and nuts, pipe supports, end caps, connections, appurtenances, and accessories indicated on the Drawings, as required, or needed for proper installation and functioning of the diffused aeration system.

The diffused aeration drop pipes shall be in the locations as indicated on the Drawings. The minimum size of drop pipes shall be as recommended by the manufacturer but in no case smaller than the minimum diameter specified herein. The diffused aeration system manufacturer shall provide a reducer with a flanged connection if required for connection of the drop pipe to the piping furnished by the Design-Builder.

If sufficient cooling of the process air can be achieved in the drop pipe, the air distribution manifolds and the diffuser header laterals shall be ultraviolet-resistant PVC, and shall be sized by the manufacturer to evenly distribute the flow to all diffusers with a minimum pressure drop. If cooling of the air to the maximum operating temperature of the PVC pipe under all specified conditions cannot be achieved in the drop pipe, stainless steel shall be extended into the manifold and laterals in sufficient length to achieve the required cooling, and PVC pipe shall be installed for the remainder of the air distribution system. Alternatively, ultraviolet-resistant CPVC pipe may be used. The manufacturer shall engage a professional engineer registered in the state where the Project is located, to certify that under all specified operating conditions

The design provides sufficient cooling in the stainless steel portion of the pipe in each drop leg, so the temperature of the inside wall at any point in the PVC or CPVC pipe to be installed, is below the rated continuous operating temperature of the pipe, and

The design provides sufficient cooling to reduce the air temperature to the rated continuous operating temperature of PVC diffuser components.

A stainless steel band coupling shall connect stainless steel pipe to PVC or CPVC pipe. Flanged or union type joints shall connect the manifold to the PVC diffuser headers. All piping shall be supported with stainless steel pipe stands.

All subsurface connections, including supports and fasteners, shall be free from protrusions and sharp angles to which rags or stringy materials may become attached.

Each air distribution header shall be fabricated in sections having a maximum length as recommended by the manufacturer. Changes in diffuser header diameter shall not be acceptable. Connections between sections of the air distribution headers shall be designed so that individual header sections can be rotated independently of adjacent header sections for alignment purposes.

Each air distribution header shall include an expansion-contraction system consisting of expansion joints, fixed supports, and flanged header connections. Fixed supports shall be designed to anchor the header against longitudinal movement at the support. Intermediate supports between fixed supports and expansion joints shall allow for longitudinal movement. The entire system shall be designed to allow for expansion and contraction over the specified air temperature range at the top of the drop pipe, without air leakage.

All pipe diameter transitions between header pipe and laterals shall be made using eccentric tees such that the pipe inverts remain the same throughout the horizontal grid system.

2-5.06. Field Connections and Expansion Provisions. All field connections shall be flanged or made with a threaded union or as determined by the Design-Builder. Expansion joints or loops shall be furnished, to allow for expansion and contraction of the diffused aeration piping. For a system with fixed joints, the joints shall be located between supports where the piping is longitudinally fixed. The joints shall provide for full movement of the piping over the specified temperature range, without air leakage.

2-5.07. Pipe Supports. Pipe supports shall be fabricated as specified herein and shall be provided complete with all bases, anchor bolts and nuts, plates, rods, and other accessories required for proper installation. Support anchors shall be 3/8 inch diameter minimum and shall be suitable to resist all loads, including vibratory loads.

One support for each section of piping shall include an integral device for rotational adjustment during installation. All adjusting devices and mechanisms shall have provisions to be locked in place to secure the piping in position after final adjustment and alignment. Clamps used to fasten manifold and lateral piping to pipe supports shall have a minimum width of 1-1/2 inch.

All supports shall include a mechanism to provide for a minimum of ± 2 inches vertical and ± 1/2 inch lateral adjustment for alignment of the piping. The spacing between supports shall be as recommended by the manufacturer. For grids located on sloped tank bottoms, additional adjustment shall be provided.

2-5.08. Moisture Blowoff Assemblies. A moisture blowoff assembly shall be provided for each grid to drain the entire submerged aeration piping. All components of the piping shall be supported along the aeration basin wall. The size of purge piping and valves shall be as recommended by the manufacturer. The assembly shall include a sump or drop pipe for the collection of moisture, purge piping extending to near the top of the basin wall, and a blowoff valve. Blowoff valves shall be ball valves as specified in the Miscellaneous Ball Valves section.

2-5.09. Cleanouts. A cleanout with a threaded or other easily removable end cap shall be provided at the ends of each diffuser lateral.

2-5.10. Bolts and Nuts. Assembly bolts and nuts shall be provided as required for each aeration system. Anti-seize compound will be applied to the threads of all stainless steel bolts before assembly.

2-6. FABRICATION.

2-6.01. Welding. All welding shall be completed in the factory using the shielded arc, inert gas, MIG or TIG method. Field welding will not be allowed. Filler wire shall be added to all welds to provide for a cross section and weld metal equal to or greater than the parent metal. Butt welds shall have full penetration to the interior surface and gas shielding shall be provided to the interior and exterior of the joint. Interior weld beads shall be smooth, evenly distributed with an interior projection not exceeding 1/16 inch beyond the inside diameter of the air header or fittings. Face rings and flanges shall be continuously welded to pipe and fittings. Stitch welds will not be acceptable.

2-6.02. Surface Preparation. Unless otherwise specified or permitted, all items fabricated from stainless steel shall be thoroughly cleaned, degreased, and pickled following fabrication as specified in ASTM A380. Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. Pickled surfaces shall be subjected to a 24 hour water test or ferroxyl test to detect the presence of residual embedded iron and shall be repickled as needed to remove all traces of iron contamination. Pickled surfaces shall be adequately protected during shipping and handling to prevent contact with iron or steel objects or surfaces. Blast cleaning of stainless steel will not be acceptable.

2-7. ACCESSORIES.

2-7.01. Special Tools and Accessories. The manufacturer shall furnish all special tools, instruments, and accessories required for the assembly, disassembly, adjustment, and maintenance of all components of the diffused aeration equipment. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices.

2-7.02. Portable Pressure Monitoring Control Panel. Not used.

PART 3 - EXECUTION

3-1. INSTALLATION. Installation shall be in accordance with the Equipment Installation section and as specified herein.

Diffusers shall be leveled to within plus or minus 1/8 inch of a common horizontal plane. Deforming of air headers, diffuser connectors, diffusers, or pipe supports to align or level the system will not be allowed.

All diffusers shall be connected directly to the diffused aeration piping as recommended by the manufacturer.

The connection of the drop pipe to the air distributor header shall be made using a flexible joint to allow ease of installation and alignment. Field connections in the diffused aeration system shall be flanged, threaded or as determined by the Design-Builder. Field welding of the diffused aeration equipment will not be allowed.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with the Start-up Requirements section and shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report certifying that the equipment has been properly installed; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; and has been operated under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the contract price.

3-2.02. Installation Supervision. Installation supervision by the manufacturer is not required.

3-3. SHOP PERFORMANCE TESTING. Prior to equipment acceptance, shop performance tests shall be conducted on the diffused aeration equipment to demonstrate that the equipment meets specified oxygen transfer and airflow rate requirements. Shop performance tests shall be conducted on the aeration

equipment in the diffuser configuration representative of the full-scale system. Only the configuration used for Zone 1 shall be tested. The diffusers used in the shop test shall be from the same manufacturing run from which the diffusers used for the full installation are supplied.

Personnel in charge of the tests shall be competent, authorized representatives of the equipment manufacturer who are familiar with operation of the equipment furnished and who have previous satisfactory experience in conducting tests of the type specified. Qualified personnel shall perform the tests, record the data, make the required calculations, and prepare a report on the results.

All testing shall occur at the manufacturer's test facility or at a facility identified by the manufacturer. All costs associated with the testing are the responsibility of the manufacturer. The equipment manufacturer shall provide all other support facilities which shall include, but not be limited to, power, equipment, chemical storage tanks, mixing equipment, chemicals for dissolved oxygen determinations by the modified Winkler method, chemicals for K_La determination by the nonsteady state sulfite method, DO probes, scales, and such other equipment and facilities as may be necessary.

Dissolved oxygen concentration measurements shall be made with direct reading instruments which have been standardized against a laboratory determination of dissolved oxygen as described in the latest edition of "Standard Methods for Examination of Water and Waste Water", with appropriate modification for interfering substances. One direct reading instrument shall be provided for each point as shown on the Figure 2-46 51 31. Each instrument shall have a probe cord of adequate length.

At least two weeks prior to the proposed testing date, the equipment manufacturer shall notify Design-Builder of the testing date and shall submit a report detailing the proposed performance testing and analyses.

3-3.01. Test Procedures. The shop performance tests shall be performed in accordance with the requirements specified herein, in water from a potable water source, and a water temperature between 59°F and 77°F. With permission from Design-Builder, the manufacturer may proceed with the test at water temperatures outside this range; however, no changes in the test procedures or data analysis will be allowed to compensate for changing the temperature

A minimum of three tests shall be conducted at the maximum airflow conditions specified. One test shall be conducted at the minimum airflow condition, and one additional test at an airflow rate approximately midway between the minimum and maximum conditions, in order to plot the specified performance curves. The tests at the maximum airflow conditions shall be conducted first.

The data to be determined in each test shall include, but not be limited to:

Airflow rate in scfm.

Air supply temperature and pressure.

Rate of change of the dissolved oxygen concentration preceding, during, and following DO depletion.

Liquid temperature.

Uncorrected barometric pressure.

Pressure at top of drop pipe.

Additional data as necessary to determine compliance with the specifications.

Before each test, the aeration system should be operated for a period of time at the test airflow rate to achieve steady state conditions.

A 10 percent, by weight, solution of cobalt chloride ($CoCl_2$ $6H_2O$) shall also be prepared for the initial series of tests. About 34 lbs of cobalt chloride will be required per million gallons to obtain a cobalt ion concentration of one milligram per liter. For test purposes, the cobalt ion concentration shall be 0.5 mg/L or less.

For the initial series, the cobalt chloride solution shall be introduced into the tank with the diffused aeration system operating. After a minimum of 15 minutes of operation, addition of the sodium sulfite solution shall be started slowly. It will not be acceptable to turn down the air to achieve better deoxygenation with sodium sulfite. The entire quantity of sodium sulfite solution shall be added to the tank within a period of approximately 5 minutes in a manner achieving uniform dispersion throughout the tank.

In each test, sodium sulfite shall be added to the water to deplete the oxygen concentration to zero, and maintain the zero condition for at least one minute. A 10 percent, by weight, solution of sodium sulfite (Na_2SO_3) shall be prepared in sufficient quantity to deplete and maintain the zero condition for one minute on all probe readouts simultaneously. Stoichiometrically, about 75 lbs of 96 percent pure sodium sulfite will be needed per million gallons to deplete the oxygen concentration one milligram per liter. A minimum of 150 percent of the stoichiometric concentration is typically required to achieve and maintain zero conditions for one minute. Technical grade sodium sulfite, free of catalyst, shall be used.

Data shall be recorded that shows oxygen depletion. The data shall also show that all test points remained at zero dissolved oxygen for at least one minute simultaneously. The test shall be considered invalid if zero dissolved oxygen is not reached for at least one minute at all test points simultaneously.

After the first tests have been completed, another batch of sodium sulfite shall be prepared and the procedure repeated. No additional cobalt chloride solution should be required after the first series. Should additional chemicals be required, they shall be provided at no additional cost to Owner. No more than ten tests shall be made with the same test water.

The equipment shall be operated to reaerate the water until oxygen saturation is reached. Dissolved oxygen concentrations shall be monitored continuously during the depletion and the reaeration periods. Dissolved oxygen concentrations shall be recorded at equal increments of approximately one minute, or at a time interval which provides at least 15 readings between 10 and 90 percent of the measured DO saturation value, but DO-time data shall be recorded during DO depletion and over the full aeration time. The temperature of the test liquid shall be recorded before and after each test run. Cobalt ion concentration of the test water will be measured after completion of tests by an independent testing laboratory and the test paid for by Owner. Points of dissolved oxygen measurements shall be as indicated on Figure 2-11570.

3-3.02. Flow Meters. The measurement of airflow rate shall be made with suitable flow metering equipment provided by the equipment manufacturer. The flowmeter shall be acceptable to the Design-Builder.

3-3.03. Data Analysis. The dissolved oxygen deficit from saturation (C_s-C_t) for each measurement point shall be calculated and plotted on semilog paper versus time (t) where C_t is the measured oxygen concentration at any time (t), and C_s is the average dissolved oxygen concentration, at temperature T, attained by aerating the basin contents until no further increase in dissolved oxygen concentration is detected. A line of best fit shall be drawn utilizing regression analysis on all points. A sample of such a plot is provided for reference only on Figure 1-46 51 31.

The overall oxygen transfer coefficient $(K_La)_T$ for each point of measurement specified shall be computed by determining the slope of the line of the best fit by using the following equation:

$$(K_La)_T = \frac{\ln [(C_s-C_1) / (C_s-C_2)]}{t_2-t_1} \ (hr^{-1})$$

where:

T	=	water temperature, centigrade
C_s-C_1	=	initial (t_1) dissolved oxygen deficit, (mg/L)
C_s-C_2	=	final (t_2) dissolved oxygen deficit, (mg/L)
t_2-t_1	=	time span, (hr)

Cs = average of all dissolved oxygen concentrations, liquid temperature T, attained at each test location by aerating the basin contents until no further increase in oxygen concentration is detected, (mg/L)

The oxygen transfer rate constant for each measurement point shall be corrected to 20°C by the following formula:

$(K_La)_{20} = (K_La)_T(\mu_T/\mu_{20})^{0.62}(h^{-1})$

where: μ= absolute viscosity, (lb-sec/ft^2)

The individual values of $(K_La)_{20}$ from each test location for all three tests at maximum airflow shall be averaged and at least two-thirds of the individual $(K_La)_{20}$ values shall be within 10 percent of the average value. If not, additional tests shall be conducted until two-thirds of the $(K_La)_{20}$ values are within 10 percent of the average of all $(K_La)_{20}$ values.

The standard oxygen transfer rate by the aeration system shall be calculated by using the average value of $(K_La)_{20}$ in the following equation:

Standard Oxygen Transfer Rate = $8.34\ (K_La)_{20}\ V_B\ C_s$ (std) (lb/hr)

where: V_B = aeration basin volume tested in million gallons

C_s (std) = the measured C_s value during the performance testing corrected to standard conditions (20°C and sea level) and shall be determined by

C_s (std) = $[C_s] \times [9.09 / C_s(a)]^{1.146}$

where: C_s (a) = theoretical surface oxygen saturation value at test site barometric pressure and liquid temperature T, (mg/L)

C_s = measured oxygen saturation value at test site conditions, (mg/L)

The standard oxygen transfer rates, as determined by the performance tests, shall not be less than the values specified herein. The airflow rates used in the performance tests to meet the specified peak standard oxygen transfer rate values shall not exceed the values specified herein.

3-3.04. Test Performance Curve. The equipment manufacturer shall furnish a performance curve showing the relationship between oxygen transfer in pounds of oxygen per hour as a function of airflow in scfm over the full operating range of the equipment.

3-3.05. Modifications. If the diffused aeration equipment fails to satisfy the performance requirements, it shall be modified as needed. Modifications shall be made or additional equipment shall be furnished and installed as necessary to produce an installation which will satisfy the performance requirements. Additional airflow will not be an acceptable modification. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided and retesting shall be performed at no additional cost to Design-Builder. All structural or piping modifications necessary to accommodate the modified equipment shall be made at the equipment manufacturer's expense.

3-4. FIELD PERFORMANCE TESTING. Prior to equipment acceptance, field performance tests shall be conducted on the installed diffused aeration equipment to demonstrate that the equipment meets specified initial pressure loss through the system under design conditions, including water submergence from the top of the drop pipe.

Field performance tests shall be conducted at each diffuser grid under maximum month air flows. Temporary pressure gauges shall be installed in each grid drop leg for the test. A minimum of 3 readings per grid shall be taken for the test, with the average of these readings used for report purposes. The three readings shall be taken at 5 minute intervals, after 5 minutes of operation at the specified air flow.

Personnel in charge of the tests shall be competent, authorized representatives of the equipment manufacturer who are familiar with operation of the equipment furnished and who have previous satisfactory experience in conducting tests of the type specified. Qualified personnel shall perform the tests, record the data, make the required calculations, and prepare a report on the results. The report shall be submitted to the Design-Builder.

In the event of greater pressure losses than specified in any of the aeration grids during the initial test period, the manufacturer shall make approved modifications and retest at no additional cost to the Design-Builder. The equipment may be rejected if the specified pressure drop is not achieved following approved modifications and retesting.

3-4. TEST REPORTS. The equipment manufacturer shall prepare a test report, including all installation check and performance tests and other recorded data and observations. A PDF copy of the report shall be submitted to Design-Builder after completion of the specified tests.

3-5. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be

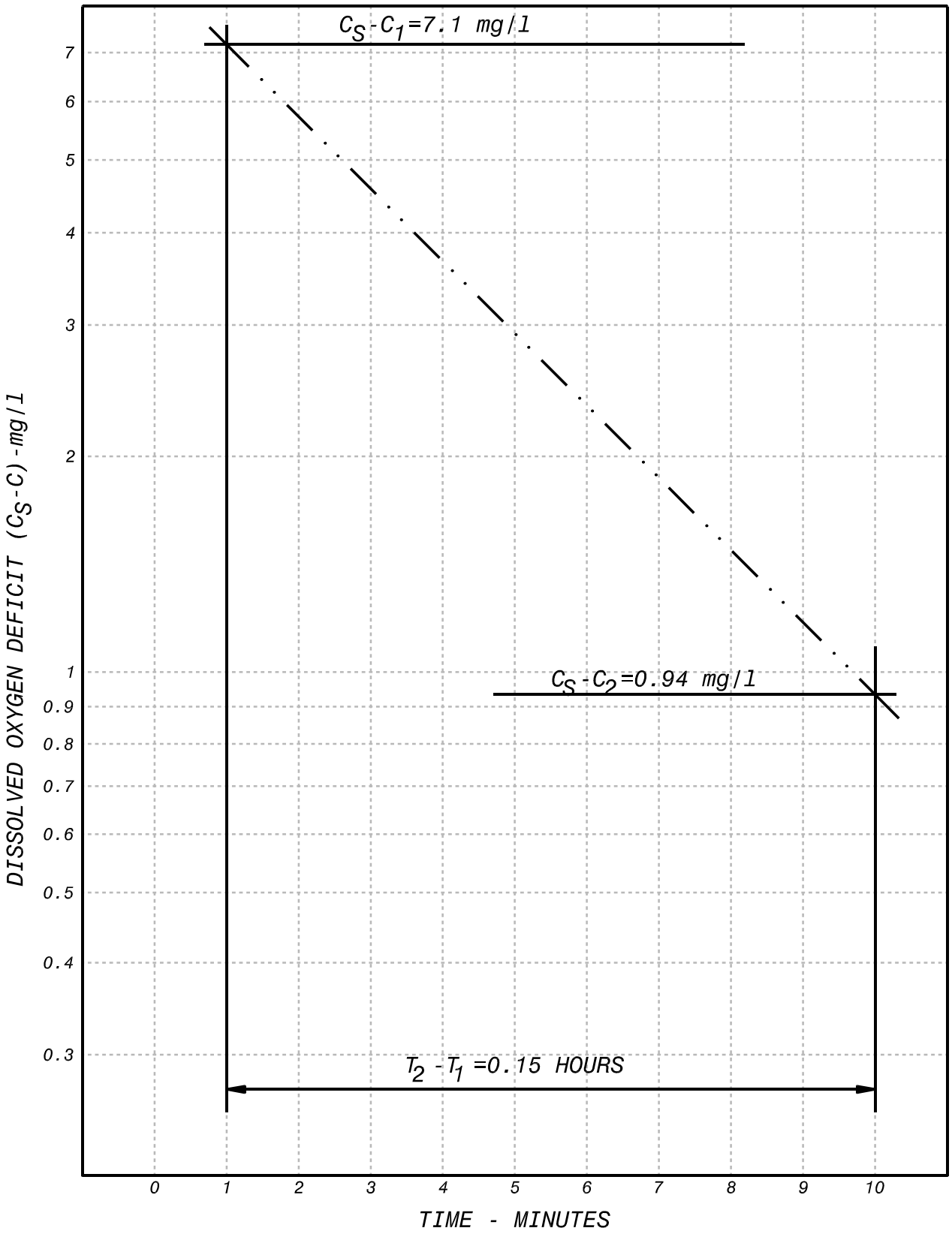
completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer's expense.

3-6. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-6.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

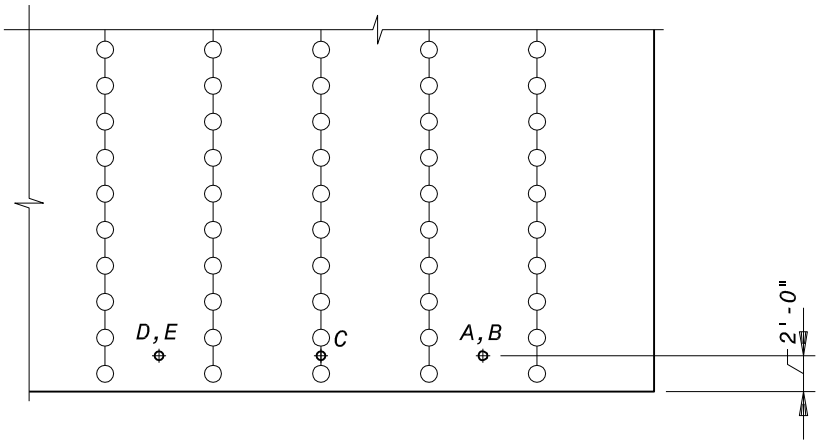
3-6.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

End of Section



SAMPLE PLOTTING OF OXYGEN TRANSFER DATA

BLACK & VEATCH	FLEXIBLE MEMBRANE DISC DIFFUSERS	FIG 1-46 51 31



POINT	LOCATION
A	2'-0" OFF BOTTOM, MIDWAY BETWEEN HEADERS
B	4'-0" BELOW SURFACE, MIDWAY BETWEEN HEADERS
C	BELOW DIFFUSER ASSEMBLY
D	MID-DEPTH, MIDWAY BETWEEN HEADER
E	2'-0" OFF BOTTOM, MIDWAY BETWEEN HEADERS

DISSOLVED OXYGEN MEASUREMENTS

BLACK & VEATCH	FLEXIBLE MEMBRANE TUBE DIFFUSERS	FIG 2-46 51 31

Section 46 61 41

DISK CLOTH FILTER

PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing, installing, testing, and placing into operation a disk cloth filter, also referred to on this Project as the SAFE Filter.

Equipment designation.	SAFE Filter
Number of units.	1
Equipment tag numbers.	73-FLT-0001
Equipment location.	Area 70

The equipment shall be furnished through a single manufacturer and shall include, but not be limited to filter units, backwash pumps, sludge pumps, electrical system, all piping internal to the filter basins and valves required for automatic operation. Design-Builder shall provide piping to equipment as indicated on the Drawings. PLC based control systems, motor starters for all package driven equipment shall be included as part of the package.

Principal items included are:

Basin mounting brackets and hardware or structural frame
Steel Tank
Access platform along edge of tank
Access platform inside the tank for maintenance
Tie-off points for davits
Center tube
Disk drive assemblies
Backwash discharge assembly
Sludge discharge assembly
All valves and actuators
Filter local control panel (FLCP)
PLC, software and documentation
Instruments
Electrical and controls

Other components required for a complete functional system shall be provided by the filter manufacturer.

1-2. GENERAL. The filtration system shall be a disk cloth filter system specially designed for the removal of suspended solids and reduction of BOD to treat screened and degritted wastewater. The filtration system, including all equipment and appurtenances, shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with Drawings and Specifications, and engineering data, instructions, and recommendations of the filter manufacturer, unless exceptions are noted by Design-Builder.

1-2.01. General Equipment Requirements. The General Equipment Requirements shall apply to all equipment furnished under this section. If requirements in this specification differ from those in the General Equipment Requirements Section, the requirements specified herein shall take precedence.

1-2.02. Seismic Design Requirements. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria Section.

1-2.03. Power Supply. Unless otherwise specified, the power supply to the equipment will be 480 volts, 60 Hz, 3-phase, 3-wire. Where control voltage lower than the power supply voltage is required, a suitable control power transformer shall be furnished.

1-2.04. Equipment Identification. Equipment specified herein shall be tagged in accordance with the Equipment and Valve Identification Section.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete assembly and installation drawings, together with detailed specifications and data covering material used, parts, devices, and other accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section. The data and specifications shall include, but not be limited to the following:

Dimensions and installation requirements.

Descriptive information, including catalog cuts and manufacturers' specifications for major components and effective filtration surface area.

Copy of Letter from California State Water Resources Board indicating conditional acceptance of the filter technology

Electrical schematics, connection and interconnection wiring diagrams, and layouts.

Complete motor information as specified in the Common Motor Requirements for Process Equipment Section.

Certification by a professional engineer registered in the state of California that the hydraulic calculations prepared by the manufacturer at Average Day, Peak hour, and Peak Day Flow are correct.

Submit confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

For system Controls, the data and specifications shall include, but not be limited to the following:

- Disk cloth filter control panel layout including interior and exterior views including dimensions.
- Accessory device data including catalog cut sheets on all control components.
- Bill of Materials.
- Detailed narrative on the filtration system operation.
- Wiring diagrams.
- Manufacturer and model.
- Catalog cuts of instrument data sheets.
- Materials of construction.
- Temperature rating.
- Special requirements.
- Operation and maintenance manuals.
- Installation details.

Values submitted for performance, headloss and power consumption will be verified during the performance testing of the equipment and prior to acceptance of the equipment by the Owner. Any exceptions or deviations to these specifications shall be listed and fully described in the submittal.

1-3.02. Operation and Maintenance Data and Manuals. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-4. COORDINATION. The filtration system shall be furnished by the filter manufacturer who shall coordinate the items of equipment, appurtenant systems, interconnecting piping, and controls to ensure the compatibility and proper operation of all items.

The filter manufacturer shall prepare system installation drawings, panel layouts, and other data required for complete system description and installation. The filter manufacturer shall verify that each system component is compatible with all other components of the system, that all pipe materials and sizes are appropriate, and that all devices necessary for a properly functioning filtration system have been provided.

1.5. SPARE PARTS. The SAFE Filter supplier shall propose a list of typical spare parts and pricing per the general Terms and Conditions.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. The SAFE Filter system will receive screened and degritted wastewater from the WRF Headworks Facility. The SAFE Filter shall perform as a means of primary treatment to meet the performance and design requirements listed below. The filter is located outdoors and shall be supplied with a cover that is easily removable for maintenance.

2-2. ACCEPTABLE MANUFACTURERS. Filter equipment shall be manufactured by Aqua Aerobics Systems, Inc. or approved equal.

2-3. SYSTEM DESIGN. The SAFE System is designed to treat the influent flow downstream of the coarse screens and grit removal that exceeds the BNR-MBR treatment capacity. The flow enters a large settling tank and when the settling tank fills, it overflows a weir and passes to the SAFE Filter. The SAFE Filter then treats the water by reducing BOD and TSS and sends to the effluent to the outfall balancing tank, which then blends with the MBR filtrate before being disinfected and going to the ocean discharge under the NDPES permit. The system design shall be as follows:

	Required	Proposed
Total Number of Filter Units	1	<FILL IN>
Disk Filter Model Reference/Number	N/A	<FILL IN>
Number of Disks per Filter	N/A	<FILL IN>
Filter Disk Size	N/A	<FILL IN>
Disk Cloth/Media Type	N/A	<FILL IN>

2-4. PERFORMANCE AND DESIGN REQUIREMENTS. Performance and design requirements to produce SAFE Filter effluent shall be as follows:

2-4.01. SAFE System Influent Flow And Pollutant Concentrations. Flows in excess of the design capacity of the BNR-MBR system (1.88 MGD) will be

treated in the SAFE System. The anticipated influent flow and pollutant concentrations during these high flow events is noted in the Table below.

	10th Percentile	50th Percentile	70th Percentile	90th Percentile	100th Percentile	Units
Design Flow	0.11	0.98	1.55	3.22	6.26	mgd
Influent Parameters						
BOD	≤400	≤385	≤350	≤100	≤100	mg/L
Suspended Solids	≤500	≤430	≤390	≤100	≤100	mg/L

2-4.02. SAFE System Performance Effluent Quality Requirements. The performance of the SAFE system will meet the requirements shown in the Table below.

SAFE Filter Effluent TSS	
If SAFE System Influent TSS > 40 mg/L	80% TSS Removal
If SAFE System Influent TSS <= 40 mg/L	<= 40 mg/L
SAFE Filter Effluent BOD	
If SAFE System Influent BOD > 40 mg/L	50% BOD Removal
If SAFE System Influent BOD <= 40 mg/L	<= 40 mg/L

2-4.03. SAFE System Operating Summary. The SAFE system will operate at the hydraulic and solids loading rates shown in the Table below.

	10th Percentile	50th Percentile	70th Percentile	90th Percentile	100th Percentile	Units
Design Flow	0.11	0.98	1.55	3.22	6.26	mgd
Hydraulic Loading Rate	<FILL IN>	<FILL IN>	<FILL IN>	<FILL IN>	<FILL IN>	gpm/sf
Solids Loading Rate	<FILL IN>	<FILL IN>	<FILL IN>	<FILL IN>	<FILL IN>	lb/d/sf

2-5. FILTER SYSTEMS. Filter equipment shall be factory mounted on a support frame within a steel tank. Backwash and solids pumps may be field installed where required by the filter manufacturer's design.

2-5.01. Mounting Brackets. Mounting brackets for attachment of the filter components to the inside of the steel filter tank shall be 304 stainless steel. Stainless steel hardware required for installing the brackets shall be furnished by the filter manufacturer.

2-5.02. Drive Mechanism. Each filter shall include a drive with gearbox, drive sprocket, non-metallic drive chain with 304 stainless steel link pins, and a chain guard where the chain is exposed during normal operation. The gearbox shall be parallel in-line helical type, AGMA class 1. The drive motor shall have a maximum speed of 1800 rpm, shall be rated for 460 volt, 3 phase, 60 HZ, and shall be in accordance with the requirements of the Common Motor Requirements for Process Equipment Section.

2-5.03. Center Tube Installation. Each center tube shall be 3/16" thick 304 stainless steel, with driven sprocket, wheel assemblies and frame and cloth assemblies. The driven sprocket shall be multi segment made of U.H.M.W. polyethylene.

2-5.04. Filter Cloth Assemblies. Each disk cloth assembly shall be comprised of individual segments, each consisting of a cloth media sock supported by an injection molded polypropylene co-polymer or 304 stainless steel frame. Cloth/frame assemblies shall be constructed to allow easy on site removal and cloth replacement without use of special tools. All fasteners shall be 304 or 316 stainless steel.

During filtration, the filter unit shall operate in a static condition with no moving parts. The filter flow path shall be from the outside of the disk to the inside.

2-5.05. Backwash/Sludge Discharge Installation. The backwash system shall include a pump that draws filter effluent through the cloth, thereby removing accumulated solids from the cloth surface.

Each backwash and sludge discharge assembly shall include an external piping assembly, backwash system assembly, one backwash pump, and one solids pump as specified in Horizontal End Suction Centrifugal Pumps section. The external piping assembly shall include backwash valves, a 0-30 inches mercury vacuum gauge, and a pressure gauge. Vacuum and pressure gauges shall have a minimum 2.5 inch dial and shall be by Ashcroft or equal. The Design-Builder shall coordinate the provision of the backwash/sludge discharge assembly piping and the assembly installation with the filter manufacturer and coordinate the pump sizing. Piping within the filter basin shall be type 304L stainless steel as specified in Stainless Steel Pipe, Tubing, and Accessories Section and as

indicated on the drawings.

The backwash assembly shall include 304 stainless steel backwash shoe supports with end springs, backwash shoes, 304 stainless steel backwash manifold, and a sludge collection manifold. Manually operated valves shall be manufactured by TCI, Nibco or equal. Gauges shall be manufactured by Ashcroft or equal.

The backwash water shall be pressurized by the filter's backwash pump for discharging through the filter system. Filtering shall not be interrupted during normal backwashing and sludge discharge. Backwash isolation valveses, and throttling valve shall be provided as needed on the discharge of each backwash pump. These valves shall be tagged in accordance with Equipment and Valve Identification Section.

All valves shall be Cast iron, ASTM 126, Class B; or ductile iron, ASTM A536, Grade 65-45-12 body plug valves body plug valves with 115 volt, 1 phase, 60 Hz open/close electric actuators. Valves shall be manufactured by DeZurik, Pratt, Milliken, Val-Matic, Clow, Victaulic, or equal. Valve actuators shall be by the valve manufacturer, RCI by Rotork, TCI, or equal, and shall include a compartment heater and open and closed position limit switches.

2-5.06. Effluent Weir. The filter shall be provided with an effluent weir sized for the 100th Percentile Flow listed above and to fit into the overall Plant Hydraulic Profile as indicated in the Drawings.

2-5.07. Filter Disk Tank. The filter shall be provided with a painted steel tank assembly with a minimum thickness 10 gauge. Tank coating and lining shall be finished with manufacturer's standard materials.

2-5.08. Maintenance Appurtenances. The filter supplier shall provide davit tie off locations for workers to connect while inside the tank. In addition, the interior of the tank shall have a step for workers to stand on while maintaining disks.

2-6. CONTROLS.

2-6.01. Filtration System Control Panels. A filter master control panel (MCP) shall be located adjacent to the SAFE Filter. A single local control panel or kiosk shall be provided with an operator interface terminal (OIT) (also referred to as a touch screen) to provide local control of filters. Provisions shall be made to shield the OIT by installing it flush mounted on an interior swing out or with appropriate sun shields. LCP enclosures shall be NEMA 4X and shall meet all requirements indicated in the Panels, Consoles , and Appurtenances section. The control panel shall be integral to the filter package and shall be suitable for the conditions specified herein. The filter control panel shall contain the necessary equipment, instruments, ancillary control devices, and programmable logic

controllers (PLC) to perform the automation functions of the filtration system. The PLCs and OITs provided shall meet the requirements listed in Programmable Logic Controllers Section and herein. The cloth media filter MCP and LCPs shall be preassembled and pre-tested at the factory as a complete assembled unit. The control panels shall contain all necessary controls to control each cloth disk filtration unit provided. PLC controls shall be accessible through a touch screen control panel.

2-6.01.01 Control Panel Configuration. The filter control panel PLCs shall be programmed by the cloth media filter manufacturer to control the filters and send and receive signals to the Plant Control System (PCS). The cloth media filter supplier shall furnish to the Owner a computer file copy of the PLC program, including an annotated version, and a printout of the PLC logic. The printout shall be documented to clearly indicate the function of each portion of the logic. In addition, the printout shall include memory usage documentation to indicate all memory locations used.

The cloth media filter manufacturer's PLC programmer or a representative of the manufacturer shall attend the initial configuration review meeting to be coordinated with the Design-Builder, with the meeting to be held at the Owner's facility. This meeting shall establish the configuration standards and conventions to be utilized by OEM suppliers and the PCS configuration contractor. Graphic screen development, address usage/naming conventions and report format standards shall be established as part of this meeting. Additionally during these meetings, data to be shared with the PCS from the cloth media filter PLC shall be identified and data sharing procedures, address locations, and communications protocols shall be established. The shared information should be made available in contiguous registers in the PLC to facilitate communications.

All control system equipment shall meet applicable requirements of the Instrumentation and Control System section.

2-6.02. Controllers and Displays.

2-6.02.01. Programmable Logic Controllers. The Master filter control panel PLC shall include inputs and outputs as shown on the drawings, listed in the Input/Output listing, or as required by the cloth media filter manufacturer for control of the filters and the associated control valves and equipment. The PLC shall be provided with an Ethernet communications module and/or port and shall utilize the preferred communications protocol. CAT-6 Ethernet cables required for the MCP to make connection to the PCS will be supplied and installed by Design-Builder. The PLCs shall be provided as a complete, standalone system for comprehensive control of the disk cloth filtration system. The PLC's shall include all necessary modules and ancillary devices for communications to the PCS.

2-6.02.02. Operator Interface Terminals. Each cloth media filtration system master control panel and local control panel shall be supplied with an OIT installed flush mounted on the enclosure door. The OIT shall provide graphic screens that shall be used by the operators to access all functions and setpoints necessary for comprehensive control of each cloth media filter and the entire filter system (filter control panel). The Manufacturer shall be responsible for developing and configuring the custom graphic displays. Each piece of major process equipment that is monitored by the control system shall be displayed on one or more graphic screens. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. The manufacturer shall use the configuration standards and conventions to be established by direct coordination with the Design-Builder and Owner that shall describe and define such items as proposed graphic display process line colors/representations; color standards for “on”, “off”, “opened”, “closed”, and “alarm” conditions; alarm handling conventions; how items will be selected for control; methods for navigation between displays; address usage/naming conventions; and security setup.

One licensed copy of the OIT software used to create the screens shall be turned over to the Owner upon successful startup and commissioning of the system.

An operator interface terminal (OIT) shall provide the following control and monitoring functions:

Backwash sequence initiation.

Filter out of service selection.

On-Off (red and green) indication for each motorized piece of equipment.

Alarm indication for failure of each piece of driven equipment and filter high level.

Local-Off-Auto selection for the filter and Start-Stop selection for each piece of motorized equipment and Open-Close selection for each valve, where applicable.

Filter backwash in progress indication.

Scum removal in progress indication.

Filter level indication where applicable.

Elapsed time since last wash.

Backwash interval and duration setpoint entry.

Sludge wasting interval and duration setpoint entry where applicable.

In service/out of service selection. When out of service is selected, the filter functions shall be inhibited.

Timer settings and analog values shall be retained when power fails.

In addition to the OIT, the following electromechanical controls and devices shall be provided on the face of the cloth media filter master control panel. Control shall be provided for each filter supplied:

Backwash sequence initiation push button.

Elapsed time meters for each piece of motorized equipment excluding valves.

On-Off (red and green) indicating lights for each motorized piece of equipment.

Amber alarm indicating lights for failure of each piece of driven equipment and filter high level.

Local-Off-Auto selector switch for the filter and Start-Stop selector switch for each piece of motorized equipment and Open-Close selector switch for each valve, where applicable.

White Backwash in Progress light.

Filter level indicator where applicable.

Elapsed time meter for time since last wash.

Backwash interval and duration setpoint devices.

Sludge wasting interval and duration setpoint devices where applicable.

In service/out of service selector switch. When out of service is selected, the filter functions shall be inhibited.

2-6.02.03. Filter Controls. The backwash cycle shall be initiated on one of the following conditions:

Operator specified time interval elapses

Operator selects a manual backwash cycle

High level

Where applicable, the sludge cycle shall be initiated on one of the following conditions:

Operator specified time interval elapses

Operator specified backwash counts elapses

Operator selects a manual sludge cycle

The scum cycle shall be initiated on Operator specified time interval elapses.

Each motor and valve shall be operated in the following modes:

Automatic mode through the filter PLC.

Manual mode through the filter control panel.

Open/Close limit switches for electric actuated valves shall be wired to the PLC for position monitoring.

2-6.02.04. Interface to Plant Control System. In addition to performing the disk cloth filter control functions, the MCP PLC shall be directly connected to the PCS. Data to be transmitted between the MCP PLC and the PCS shall meet the requirements indicated in the Software Control Block Description section and as indicated herein. Data to be communicated with the PCS shall be stored in contiguous blocks of memory in the MCP PLC to facilitate the data transfer.

The following data points from the filter control panel to the PCS shall be provided via an Ethernet data network connection:

Inputs:

Backwash pump running and fail – each pump.

Drive running and fail.

Backwash Initiation

Backwash in progress.

Backwash sequence fail.

Filter out of service.

Filter level high.

Filter Level

Filter Elapsed Time Since Last Backwash

Outputs:

Initiate Backwash

In Service/Out-of-Service Initiation

Enable Backwash

Additionally, the controls shall accept a remote “Emergency Backup Power” signal from the plant control system. When this contact has been asserted or enabled, the disk cloth filter control system shall only allow one disk cloth filter unit to backwash at a time. Simultaneous backwash sequences shall not be permitted.

A list of recommended data point addresses to be monitored by and written to by the PCS shall be provided by the Manufacturer prior to the coordination meeting for MCP/PCS coordination specified above.

An industrial Ethernet switch that meets the requirements as listed in the Network Systems Section shall be provided in the MCP to allow for a single connection to the PCS. All CAT 6 cabling, terminations, jumper cables and other pertinent devices for complete and operational disk cloth filter PLC network communications shall be provided by the disk cloth filter system supplier.

The disk cloth filter system supplier shall coordinate with the Design-Builder’s Configuration Contractor to establish a secure network access to the disk cloth filter system equipment via a VPN connection. Any additional hardware required to implement VPN access to the disk cloth filter system provided equipment shall be provided by the disk cloth filter system supplier.

2-6.02.05. Fiber to Copper Converters. Fiber optic to copper media converters for the LCP networks shall convert twisted pair 10/100BaseT cable transmissions to 10/100BaseFX fiber optic cable transmissions. Converters shall provide auto-sensing detection of network speed and full duplex or half duplex signaling. Converters shall have diagnostic LEDs for network speed and network traffic. Converter copper port shall be 100BaseTX (RJ-45). Converter fiber port shall be compatible with connectors provided with fiber cable jumpers and compatible with fiber cable type and light wavelength. Transmission Speed shall be

100Mbps on both ports. The converter shall be powered from 120 volts ac, or shall be provided with a plug-in transformer to provide the required voltage to the device. Converters shall be as manufactured by Transition Networks, D-Link, Black Box, or equal.

2-6.02.06. Uninterruptible Power Supply. An uninterruptible power supply (UPS) shall be furnished for each MCP to power the equipment in the PLC cabinet on a power loss.

A relay or other means of indication shall be provided and connected to the respective PLC which will alert the Plant Control System of a power loss and PLC cabinet is operating on UPS power. Disk cloth filter manufacturer shall be responsible for coordinating the size of the UPS unit with the equipment furnished herein to provide backup power for a minimum of 30 minutes. A ground fault protected convenience outlet shall also be included in the panel.

2-6.02.07. Device Tagging. All devices shall be provided with permanent identification tags. The tag numbers shall agree with the Instrument Device Schedules and with the supplier's equipment Drawings. All field-mounted transmitters and devices shall have stamped stainless steel identification tags. Panel, subpanel, and rack-mounted devices shall have laminated phenolic identification tags securely fastened to the device. Hand-lettered or tape labels will not be acceptable.

Permanent nameplates shall be as specified in the Equipment and Valve Identification Section 01615.

2-6.03.01. Electrical Requirements. Each Electrical panel shall include a main 480 volt, 60 Hz, 3 phase circuit breaker, combination thermal-magnetic circuit breaker type motor starters for each constant speed motor, and variable frequency drives for variable speed motors where applicable. All circuit breakers shall be rated 42,000 amperes interrupting capacity at 480 volts ac. Control voltage for motor starters, relays, timers, and auxiliary devices shall be 120 volts, single phase from control power transformers in the panel. The control circuit shall have both primary leads fused, one secondary lead fused and the other secondary lead grounded. Motor starters shall have three overload relays, one in each phase correctly sized for the motors furnished. Motor starters shall be NEMA rated for the horsepower of the motor. Electrical panel main circuit breaker shall be sized for the three filters specified herein and for a fourth future filter. Electrical panel shall have sufficient space within the enclosure to house additional motor starters, fuses, contactors, and branch circuit breakers to power the future fourth filter equipment.

Auxiliary relays shall be heavy-duty, industrial type with 120-volt ac coil and output contacts rated 10 amperes at 120 volts ac.

Selector switches, indicating lights, and push buttons shall be heavy-duty, oil tight, push-button station type with contacts rated 10 amperes at 120 volts ac and shall have engraved or etched nameplates identifying the application and each switch action. Indicating lights shall be push-to-test, full voltage type with LED lamps. All pilot devices shall be 30.5 mm and shall be rated in accordance with the enclosure.

Elapsed time meters for equipment shall be synchronous motor drive, 99,999.9 hours span, non-resettable, and 120 volts ac. Elapsed time meter for time since last wash shall be 120 volts synchronous motor driven, resettable, and shall display time in minutes.

The panel shall be factory tested by the panel fabricator before shipment.

The panel shall be a NEMA Type 4X 316 stainless steel enclosure and shall be sized for four filter units. If individual LCPs are not provided, then electromechanical controls are to be provided on the face of the panel and space shall be allocated for a future fourth filter unit.

All outdoor panels shall have panel mounted air-conditioning unit to cooling.

2-6.03.02. Power and Control Wiring. The control panel shall be completely wired with provisions for terminating all remote wiring on terminal blocks. The terminal blocks shall be marked to agree with the panel wiring diagram. Control terminal blocks shall be sized for No. 14 AWG or No. 16 AWG copper wire. All interconnecting wiring and wiring to terminals for external connection shall be not less than No. 14 AWG copper for control and No. 12 AWG for power, insulated for not less than 600 volts with a moisture and heat-resistant material and flame-retardant nonmetallic covering. All wiring shall be grouped or cabled and firmly supported to the panel, and shall be numbered at each termination with permanent labels corresponding to the schematic. Not less than 10 percent spare terminals shall be provided.

2-7. FILTER INSTRUMENTATION. The filter manufacturer shall provide all instrumentation required for operation of the filter.

All instrumentation used in the filter system for control or monitoring shall be individually fused or circuit breaker protected to minimize the effects of any single point of failure. Instrumentation shall be installed in accordance with filter manufacturer's instructions.

2-7.01. Fixed-Mount Float Type Level Switches. Float switches shall be furnished in accordance with Pressure and Level Instruments section.

2-7.02. Submersible Pressure Sensing Level Transmitters. Submersible pressure sensing level transmitters shall be furnished in accordance with the

Pressure and Level Instruments section.

2-7.03. Ultrasonic Level Transmitters. Ultrasonic level transmitters shall be furnished in accordance with the Pressure and Level Instruments section.

PART 3 - EXECUTION

3-1. INSTALLATION. This equipment shall be installed in accordance with the Equipment Installation section and the Disk Cloth Filter manufacturer's requirements and recommendations.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily and in accordance with the specified performance requirements.

All costs for these services shall be included in the contract price.

3-3. PROCESS PERFORMANCE GUARANTEE AND TESTING.

3-3.01. Guarantee. The cloth filter system shall be guaranteed to produce the filter effluent water quality requirements in accordance with the performance and design requirements specified herein at all listed flow conditions. To assess compliance with the specified effluent requirements, performance testing shall be conducted. All pre-checks, mechanical tests and preliminary tests will need to be completed and approved by the Design-Builder and manufacturer prior to performance testing.

3-3.02. Mechanical Test. A mechanical test shall be conducted by the Design-Builder under supervision of the filter manufacturer's representative after the equipment start up is complete.

The manufacturer shall provide a detailed mechanical testing protocol and procedure with the requisite checklists prior to the mechanical testing.

Any malfunctions or defects appearing during the tests shall be corrected and additional testing performed, as directed by the filter manufacturer's representative, to demonstrate satisfactory operation.

3-3.03. Field Performance Test (Effluent Quality). Acceptance of the mechanical test results is required before field performance testing can begin. The performance test shall demonstrate the system performs in accordance with the requirements specified in section 2-4. Prior to commencing performance test, vendor must provide to Design-Builder the description of how filter system will operate during the performance test including descriptions of where excess water will be discharged. The testing protocol shall have been developed by a qualified registered Civil Engineer with prior experience in filter testing and commissioning. Hydraulic loading rate (gpm/sf) shall be determined using the effluent flow rate divided by the number of filters in service divided by the effective submerged filtration area of each filter. Filtered water shall be pumped to the head of the plant during the test period.

The performance test shall be supervised by an authorized representative of the filter manufacturer familiar with operation of the equipment furnished and having experience in conducting tests of the type specified. Qualified personnel shall operate the filtration equipment, record the data, make the required calculations, and prepare the test report. Sampling and sample analysis shall be provided by the Design-Builder through a laboratory certified in the state of California.

Test protocol detailing test procedures, analyses to be performed, name of laboratory completing the analysis, and testing schedule shall be made available prior to the testing.

3-3.03.01. Test Procedures.
The test procedure requirements, including the flow scenarios, duration, and sampling points will be determined in the future with input from the filter manufacturer.

Discrete samples shall be taken each day of testing on both the filter influent and effluent. Each sample, whether influent, effluent, or backwash shall be tested for total suspended solids (TSS) and BOD. Sampling and field quality control procedures shall be in accordance with the requirements of 40 CFR part 136.

The data to be obtained in each test shall include:

Backwash flow rate based on actual pump rate.
Backwash duration.
Hydraulic loading rate (gpm/sf).

Maximum solids loading rate (ppd/sf).
Total suspended solids removal (pounds per day).
Total BOD removal
Backwash frequency (backwash/day).
Total forward flow (calculated)
Power consumption for each phase throughout the testing period

The performance requirements of the filtration process will be met when the system produces an effluent within the specified limits 100 percent of the time for the specified duration and hydraulic loading of the test.

3-4. TEST REPORTS. The equipment manufacturer shall prepare a test report, including all installation check and performance tests and other recorded data and observations. A PDF copy of the report shall be submitted to Design-Builder within 30 days after completion of the specified tests.

3-5. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer's expense.

3-6. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is qualified to instruct Owner's operating personnel in the proper operation and maintenance of the equipment in accordance with the equipment manufacturers recommendations. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-6.01. Operations Training. Classroom instruction covering the theory and practical application of operation, site specific operation and inspection of the equipment and optimization of the equipment operation.

3-6.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

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Section 46 76 21

BELT FILTER PRESSES

PART 1 - GENERAL

2-1. SCOPE. This section covers furnishing and installing of one belt filter press (BFP) unit, including accessories and appurtenances, in the sludge dewatering facility at the residual area. The press shall be used to dewater waste activated sludge from the sludge holding tanks or directly from the MBR system to increase total solids concentration. The A single Dewatering System Supplier (DSS) shall provide all equipment listed herein for a fully functioning dewatering system. The Design-Builder shall coordinate the design of the BFP system with the requirements specified herein.

2-2. GENERAL. Equipment furnished and installed 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, unless exceptions are noted by the Design-builder.

Each belt filter press system shall consist of, but not necessarily be limited to, a dewatering belt filter press, sludge conditioning unit, belt alignment/tensioning system, belt wash spray water booster pump, electrical and control system, and appurtenances required by the Manufacturer's design and in compliance with the intent and purpose of the sludge dewatering system. Control equipment furnished herein shall meet the requirements specified in the Programmable Logic Controllers section.

All appurtenances required for proper operation of the belt filter press equipment and not otherwise specified shall be furnished and installed as recommended by the MANUFACTURER.

1-2.01. Acceptable Manufacturers. BFP equipment Manufacturer shall be Komline-Sanderson, BDP, Charter Machine Company, Ashbrook or equal if approved.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section.

1-2.03. Coordination. The responsibilities for both Design-Builder and manufacturer shall include, but not limited to, the following:

Item	DESIGN-BUILDER	MANUFACTURER
Transportation and Unloading	Responsible	Coordinate
Installation	Responsible	Supervise
Performance Testing	Coordinate	Responsible
Startup	Coordinate	Responsible
Training	Coordinate	Responsible
Submittals	Coordinate	Responsible
Layout	Coordinate	Confirm layout with process piping, mechanical and electric/ electronic equipment.
Drawings	Coordinate	Furnish fully coordinated set of drawings with all proposed changes for proper installation
Chemical Feed Systems	Coordinate	Responsible
Conveyors	Coordinate	Responsible
Process feed and drain piping	Responsible	Coordinate
Chutes and Hoppers into dumpster	Coordinate	Responsible
Process equipment (feed/discharge pumps)	Coordinate	Responsible

Item	DESIGN-BUILDER	MANUFACTURER
Electric Equipment	Coordinate	Responsible for all related controls, motors, VFD's, appurtenances and enclosures

The responsible party shall provide equipment and arrange installation.

1-2.04. Power Supply. Power supply to the equipment will be 480 volts, 60 Hz, 3 phase.

1-2.05. Hardware. All hardware, including but not limited to anchor bolts, nuts, washers, cotter pins, adjustment screws and rods, sidecover hardware, handles, and hinges, shall be Type 316 stainless steel and shall comply with the Anchorage in Concrete and Masonry section.

1-2.06. Piping Connections. All connections to piping (except drain pans) shall be flanged connections and shall conform to the diameter and drilling of ANSI/ASME B16.1, Class 125. Flanges shall be flat faced.

1-2.07. Coating Repairs. Damage to coating systems prior to acceptance by the Design-Builder at delivery shall be repaired by the MANUFACTURER at no additional cost. Any coating repairs after delivery and acceptance onsite and due to installation of the BFP equipment shall be the responsibility of the Design-Builder and shall be performed according to the paint MANUFACTURER's recommendations.

1-2.08. Welding. All welded joints exposed to view or in contact with the process shall be sealed watertight by continuous welds.

1-2.09. Edge Grinding. Sharp corners of cut or sheared edges shall be dulled by at least one pass of a power grinder.

1-2.10. Surface Preparation. All ferrous metal surfaces, except motors, speed reducers, and stainless steel, shall be shop cleaned by sandblasting or equivalent, in conformance with the paint MANUFACTURER's recommendations. All mill scale, rust, and contaminants shall be removed before shop primer is applied.

1-2.11. Maintenance Equipment. The MANUFACTURER shall supply all special tools required for servicing and disassembly of the equipment.

1-2.12. Corrosion Protection. All surfaces shall be made of corrosion-resistant materials or shall be protected with shop applied corrosion protection systems. The materials or protection systems shall adequately protect the equipment and appurtenances from corrosion caused by the service environment including sewage sludge.

Information regarding the proposed corrosion protection systems shall be submitted to the Design-Builder. Sole responsibility for choice of materials and corrosion protection systems, including application, shall rest with the MANUFACTURER. The information provided to the Design-Builder shall include materials, methods of application, maintenance requirements, and other pertinent data.

1-2.13. WARRANTY. All equipment shall be new shall be in accordance with the general Terms and Conditions.

1-3. SUBMITTALS.

1-3.01. DRAWINGS AND DATA. Complete fabrication, assembly, foundation, and installation drawings, together with detailed specifications and data covering material used, parts, devices, schematic wiring diagrams, and other accessories forming a part of the equipment furnished, shall be submitted in accordance with the submittals section.

Detailed information regarding the corrosion protection systems shall be provided for record purposes, including materials, methods of application, maintenance requirements, and other pertinent data.

Electrical connection diagrams and schematics identifying and describing all items required for operation of the equipment shall be submitted for review. Submittals shall verify each applicable feature in this specification and in the General Equipment Stipulations.

The data and specifications for the unit shall include, but shall not be limited to, the following:

Belt Filter Press

Name of Manufacturer.
Type and model of unit.
Weight and dimensions of major equipment components.
Guaranteed produced solids concentration
Operating weight.
Description of gravity drainage, wedge, and compression zones.
Sludge conditioning unit details.
Wash water strainer, piping, nozzle details.
Sludge feed, wash water, and filtrate drainage connections.

Details of belts, tensioning devices, alignment devices, and speeds.
Type, make, and full details of all bearings.
Certified calculations by bearing MANUFACTURER showing that all bearings comply with the specified requirements for ABMA L_{10} bearing life at maximum dynamic loadings and for the intended service and design conditions.
Gear, chain, shaft, and hydraulic drive unit, if used.
Complete assembly and installation drawings with detailed specifications and data for the hydraulic power.
Lubrication system.
Discharge details.
Drainage system.
All material types, thicknesses, and finishes.
Details of all control and sensing devices.
Details and dimensions of equipment layout and anchor bolt location.

In addition, the following information is to be supplied for the baseplate on each piece of equipment. The loads shall include all horizontal and vertical components.

a. Dead loads due to unit weight empty.
b. Dead loads due to unit weight full of sludge, drain pans full, etc.
c. Dynamic loads.
d. Combination of "b" and "c" above.

Motors

Name of Manufacturer.
Type and model.
Type of bearings and method of lubrication.
Rated size of motor, hp, and service factor.
Temperature rise and insulation rating.
Full load rotative speed.
Net weight.
Full load current.
Locked rotor current.
Efficiency at full, 3/4, and 1/2 loads.
Power factor at no load and at full load.
Motor space heater details.
Base details.

Spray Water Booster Pumps

Name of MANUFACTURER.
Type and model.
Rotative speed.
Size of suction nozzle.
Size of discharge nozzle.

Statement from belt filter press MANUFACTURER outlining wash water requirements, including min and max flow and min and max pressure.
Complete performance curves showing capacity versus head, NPSH required, pump efficiency, and bhp.
Data on shop painting.

Control Panels

Dimension and layout details.
Materials of construction for panels and all associated hardware.
Detailed list of panel components.
Wiring diagrams and control schematics.
List of hardware required for PLC programming.
PLC program file and ladder logic printout program, software and license.
Sequence of operations.
Catalog cut sheets on all components.
Conduit interconnection diagram.
Narrative description of the sequence of operation in the manual and automatic modes.
Operator interface terminal programming and screens.

Variable Frequency Drive.

Name of Manufacturer.
Types and model numbers.
Rated drive input kVA and output kVA.
Percent efficiency at 100 percent speed and 60 percent speed.
Maximum Btu [kJ] heat release data and verification of the drive cooling requirements.
Total weight and lifting instructions, height, mounting, and floor space required.
Panel interior and front and side exterior view details showing maximum overall dimensions of all transformer, bypass contactor, ac line filter, ac line reactor, and drive compartments.
Schematics, including all interlocks.
Wiring diagrams, including all internal and external devices and terminal blocks.
Locations and sizes of electrical connections, ground terminations, and shielded wires.
List of diagnostic indicators.
List of fault and failure conditions that the drive can recognize and indicate for simultaneous occurrence.
List of standard features and options.
List of spare parts to be furnished.
Input line protection model numbers and Manufacturer's data sheets.

Polymer Feeder Blender Equipment

See submittal requirements in the Polymer Feeder Blender Equipment section

Screw Conveyor

See submittal requirements in the Screw Conveyors section

Dewatering Sludge Feed Pumps

See submittal requirements in the Rotary Lobe Pumps section

Miscellaneous

Type of factory-provided conduit and cable.
Six copies of the Field Evaluation Test Report.
Schematics and connection diagrams for all electrical equipment shall be submitted for review. A MANUFACTURER's standard connection diagram or schematic showing more than one scheme of connection will not be accepted, unless it is clearly marked to show the intended connections.
Complete assembly and installation drawings for the platforms and ship's ladders with dimension and layout details.
Materials of construction for the platforms and ship's ladders.

Design-Builder shall store all parts shall as directed by the MANUFACTURER. If any of the spare parts or supplies are used during the installation and testing process, they must be replaced by the MANUFACTURER at no cost to the OWNER or Design-Builder.

1-3.02. Operation and Maintenance Data and Manuals. Adequate operation and maintenance information shall be supplied as required in the Submittals Procedures section.

1-4. QUALITY ASSURANCE.

1-4.01. Manufacturer's Field Services. The equipment DSS shall provide the services of a factory field engineer to initially check installation of the BFP(s) and to place the BFP(s) in service in accordance with the quality control section. The field engineer shall also be responsible for instructing operating personnel as to proper process and maintenance procedures.

1-5. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Shipping section. Handling and storage shall be in accordance with the Handling and Storage section. BFP(s) shall be lifted and handled as recommended and directed by the DSS.

1-6. EXTRA MATERIALS.

1-6.01. Spare Parts. Spare parts shall be furnished as listed below in substantial wooden boxes with identifying labels and delivered with the BFP system to the jobsite.

All spare parts shall be in waterproof packages suitable for export service, labeled with the description and part numbers. Except for fuses and light bulbs, each item or set of parts expected to be installed at one time shall be in an individual package.

a. One complete set of filter cloth belts
b. One complete set of seals for gravity drainage sections, wedge sections, and washwater hoods
c. One set of bearings and seals of each type used
d. Five fuses of each size used
e. One set of spray nozzles
f. One set of doctor blades
g. One printed circuit board of each type used
h. One set of limit switches of each type used
i. Light bulbs of each size used, including enunciators
j. Differential pressure transmitter.
k. Single loop controller of each type used.
l. Analog alarm relay.
m. Any other parts considered as “high wear” items peculiar to the belt filter press furnished

PART 2 – PRODUCTS

2-1. PERFORMANCE AND DESIGN REQUIREMENTS.

2-1.01 Service Conditions. Waste activated sludge (WAS) will be pumped from the Sludge Holding Tanks or directly from the BNR/MBR system to the BFP to perform dewatering to remove water and increase total solids concentration. The Sludge Dewatering System shall convey solids from the dewatering equipment to a rolloff container (container provided by others) with minimal exposure for odor release. The BFP shall be furnished to dewater WAS sludge down to a water content suitable for hauling and disposal as specified below.

Sludge will be pumped to the BFP(s) using rotary lobe positive displacement pumps equipped with variable frequency drives.

A polymer system using a liquid emulsion polymer will be used to aid in dewatering of the feed solids.

Dewatered cake will discharge to a series of screw conveyors as indicated on the Drawings. Filtrate will flow by gravity to the floor drains in the dewater area discharge ports after which it will flow by gravity to the plant sewer.

2-1.02. Sludge Characteristics. Under the majority of conditions, the belt filter press feed is WAS from the BNR-MBR process. During wet weather events, solids from the auxiliary treatment system will be blended with the WAS. Auxiliary treatment consists of a small settling tank and disk filter system. The BFP(s) shall be designed to dewater sludge with the following characteristics:

	Unit	Value
Feed solids percent of total solids	% TS	0.6-1
Feed volatile solids percent of total solids	% VS	60-70
Feed solids temperature[1]	°C	18-24

[1]Note that maximum, minimum, and average temperatures may not correspond with maximum, minimum, and average solids feed conditions.

2-3. POLYMER SELECTION. Polymer selection will be determined by the DSS. Polymer will be supplied by the DSS for performance testing requirements.

2-4. PERFORMANCE AND DESIGN REQUIREMENTS.

2-4.01 Performance Requirements. The dewatering system shall be designed to operate under the following criteria:

Unit designation	DWT-BFPS-0001
Number of units	1
Minimum effective belt width, meters	2.0
Normal operation	
Days per week	2
Hours per day	8
Maximum polymer dose, lb active/dt	25 to 35
Minimum cake solids, % TS	17%
Minimum capture rate, %	95%

	AA	MM
Anticipated Feed Solids, percent total solids	8,400	8,600
Anticipated HLR, gpm/machine	245	325
Anticipated SLR, pph/machine	1,030	1,400
[1]Note that the range of design feed solids may not be identical to the minimum and maximum solids concentrations listed in Section 2.2		

Maximum allowable HLR, gpm/machine	<DSS Fill-in>
Maximum allowable SLR, gpm/machine	<DSS Fill-in>

Exceptions to the capture rate and concentration due to the volatile content or feed solids concentration should be clearly stated in the submittal information.

2-4.02. Design Requirements. Each belt filter press shall be a complete dewatering unit consisting of the following main components:

Structural frame and roll components.
Belts and belt washing system.
Belt discharge.
Drain pans.
Inlet pipe and distribution box assembly.
Automatic belt alignment/tensioning systems.
Sludge conditioning unit.
Terminal box and alarm/control panel.
All other components as illustrated in the Drawings that are required to be provided by the DSS.

The belt filter presses shall consist of multistage dewatering section and shall be factory assembled as completely as possible, including piping and wiring, so that a minimum number of external connections are required. Each unit shall be mechanically tested and adjusted prior to shipment from the factory. The presses shall be shipped and stored, if required, in the disassembled configuration. If disassembly is required the components shall be match-marked to assure that each press is reassembled with the same components as when shop tested.

The reassembly and installation shall be completed by the combined and coordinated efforts of the installation Design-Builder and qualified representatives of the belt press Manufacturer. As a minimum, the qualified representatives shall oversee the procedure and shall assure that the units are properly reassembled.

Sludge shall be conditioned with polymer prior to introduction to the belt filter press. Polymer shall be introduced to the sludge flow through a polymer injection ring at the location as shown on the Drawings. If a different location is

recommended by the Manufacturer, it shall be coordinated with the Design-Builder. Sludge and polymer shall then be further mixed in a sludge conditioning unit prior to introduction to the belt filter press. The mixing shall take place by the turbulence created through the pressure drop as the sludge flows into the conditioning unit, and retention time shall be based on optimum flocculation.

Conditioned sludge shall be evenly distributed onto the independent gravity drainage belt through an inlet distribution assembly. The thickening section in each unit shall allow gravity drainage of the free water through a belt filter. The belt shall be supported on high density polyethylene (HDPE) or ultra high molecular weight (UHMW) polyethylene strips within stainless steel drainage grids. Two deckle strips shall be provided to contain the sludge flow within the gravity drainage zone. The deckle strips shall be fabricated from 316L stainless steel or fiberglass reinforced plastic bars with adjustable neoprene or rubber edge seals. The edge seals shall not damage or cause excessive wear of the belt.

A minimum of six (6) rows of furrowing devices or plows, with lifting handles, shall be employed to promote sludge thickening and to ensure an even distribution of sludge across the entire width of the belt. The plows shall be of a design to minimize belt wear. Each row of plows shall be provided with a single lifting handle, designed to remove the entire row of plows at least 6 inches from the belt, out of the sludge flow, while the unit is operating, to facilitate cleaning. The Manufacturer shall be required to demonstrate that individual plows shall be capable of allowing a 1/2 inch vertical obstruction on the belt to pass under them without deflecting and without damaging the equipment. A mechanical device, excluding cables, shall assist the raising and lowering of the furrowing devices. The rows of furrowing devices shall be capable of being secured in the upright position out of the flow of the sludge. The thickening zone shall have a minimum free drainage area of 88 square feet. No auxiliary vacuum shall be required.

The first dewatering section of the unit shall provide a wedge zone where the upper belt shall converge with the lower belt at an adjustable dewatering angle and generate continuously increasing pressure between both dewatering belts. The complete wedge zone framework, including wear bar support, shall be fabricated of 316L stainless steel. Side seals shall be provided, as necessary, to contain the sludge within the belts. The minimum effective filtration area in the wedge zone shall be 40 square feet. The effective dewatering area shall be calculated using both belts on either horizontal or vertical wedge zones.

The second dewatering section of the unit shall provide a compression zone where the upper and lower belts shall run in an S-roll configuration around a minimum of eight (8) rollers to provide the maximum possible cake dryness. The upper and lower belts shall converge with the sludge cake between, and wrap around the rollers. The first roller in the compression zone shall be a perforated roller designed to allow water to escape out both ends. With belt tension constant, the sludge shall undergo an incremental increase in surface pressure

as the belts wrap around each roll. Belt tension shall be adjustable during operation. The compression zone shall have a minimum drainage area of 120 square feet, calculated utilizing the area where both belts are in contact with a roller.

Facilities shall be provided to ensure correct belt tensioning and alignment. Water sprays shall be provided for cleaning the belts.

2-6. MATERIALS. The belt filter press(s) shall be constructed of materials meeting the following minimum requirements:

Welded Stainless Steel	AISI Type 316L.
Nonwelded Stainless Steel	AISI Type 316.
Steel	ASTM A36, SAE 1020, or equal; hot dipped galvanized after fabrication.
Cast Iron	ASTM A48.
Fiberglass Reinforced Plastic	
Resin	Polyester of a type suitable for the chemicals and conditions.
Reinforcement	Glass fiber with suitable coupling agent.
Plastic Laminate	Polyester or other suitable thermo-setting plastic reinforced with fiberglass.
Finished Thickness	Within ±10 percent of nominal.

2-6.01. Stainless Steel. All stainless steel shall be pickled at the mill in accordance with ASTM A380 before being shipped. Pickling shall produce a modest etch and shall remove all embedded iron and heat tint. After fabrication, pickled surfaces shall be subjected to a 24 hour water test or a ferroxyl test to detect the presence of residual embedded iron. All pickled surfaces damaged during fabrication, including welded areas, shall be repickled or passivated in accordance with ASTM A380 as required to remove all traces of iron contamination. All stainless steel surfaces shall be adequately protected during fabrication, shipping, handling, and installation to prevent contamination from iron or carbon steel objects or surfaces.

2-7. BELT FILTER PRESS CONSTRUCTION.

2-7.01. Main Structural Frame. The main structural frame shall be constructed of wide flange members conservatively designed to minimize deflection. The main structural frame shall be constructed of members having a minimum thickness of 5/16 inch for hot dipped galvanized construction. The belt filter press frame shall provide a minimum safety factor under maximum load of five times the design yield strength of any member. All welds shall be continuous and ground smooth. The frame design shall allow easy access and visual contact with all internal components. All frame beams shall have a minimum moment of inertia of 53 in^4.

The main frame shall incorporate filtrate collection pans. The frame shall be provided with holes for foundation bolts and shall be provided with lifting eyes.

Layout and construction of the frame shall allow easy access to the operating components of the unit for observation, adjustment, and maintenance. Holes for all bolted connections shall be precisely drilled. Slotted holes will not be acceptable.

All hardware throughout the entire dewatering unit shall be of corrosion-resistant materials and shall include, but not be limited to, nuts, bolts, washers, cotter pins, adjustment screw rods, sidecover hardware, handles, and hinges. All hardware shall be stainless steel as a minimum.

2-7.02. Rolls. All rolls shall be of sturdy low deflection design.

Maximum deflection shall not exceed 0.05 inch at 50 pounds per linear inch belt tension and belt speed of 15 feet per minute to prolong bearing and roller life. All rolls shall have a minimum safety factor of four based on fatigue stress.
All rolls shall have through shafts or stub shafts with double end plate or journal construction to ensure structural integrity and reliability and minimize deflection and bearing wear. Rolls shall be mounted to accurately track the belts. All rolls, except the perforated roll, shall have a minimum wall thickness of 1/2 inch for carbon steel construction. The perforated roll shall have a minimum wall thickness of 3/16 inch and shall be of stainless steel construction. Concentricity of all rolls shall be within 0.01 inch.

All roll coatings shall be smooth and uniform to ensure accurate belt travel. All rolls, except perforated rolls, shall be coated. Drive rollers shall be coated with Buna-N rubber, 1/4 inch thick, and all other solid rollers shall be coated with Rilsan nylon to a minimum thickness of 25 mils. Rolls shall be coated up to the point of insertion into the bearing block or shall have shafts and heads of stainless steel. Carbon steel roller surfaces shall not be exposed to sludge or moisture. Shafts in the pressure section shall be minimum 3.5 inch diameter at the bearing.

All rolls shall rotate in antifriction self-aligning bearings especially equipped with

seals to prevent the entrance of water, sludge, and conditioning chemicals. Bearings shall have a minimum ABMA L_{10} rating without adjustment factor of 600,000 hours at the specified operating conditions. This ABMA L_{10} rating shall include all forces applied to the bearings, based on a belt tension of 50 pounds per linear inch, a belt speed of 15 feet per minute, and taking into consideration the roller mass forces and belt tension forces. Bearings shall not be located at points where they will be affected by stress in frame members. Bearings shall require lubrication at intervals no greater than 6 months.

Grease fittings shall be supplied to each bearing with remote stainless steel lines and shall be fastened to the exterior of the belt filter press frame as required to allow lubrication at accessible locations while the unit is operating. All bearing housings shall be split case pillow-block type, and shall have bearing overpressure relief. MANUFACTURER shall provide 5 year unconditional warranty on bearings.

2-7.03. Belts. The belts for the belt filter press shall be woven from polyester monofilament wires. There shall be no joint or overlapping thickness or hinged or seamed connection which would cause wear at the discharge doctor blades. Each belt filter shall be of the split type, and splicing devices shall have a tensile strength at least five times the maximum tension to which the belt is subjected. Subject to the review of the Design-Builder, the belt filter press Manufacturer shall select the belts which will best operate with the anticipated type of sludge and conditioning chemical. The selection of the belts shall be based on actual previous operating experience. Belts shall have heat sealed edges and shall be equipped with easily operated splices. The porosity of the splices shall not exceed the porosity of the belt. Endless/ seamless belts may be acceptable subject to Design-Builder's review.

Minimum belt life shall be 2,000 hours based on the specified service and design conditions. Belts that have failed prior to 2,000 hours shall be replaced with belts that will meet the specified requirements at no additional cost to the Owner.

Spare belts shall be identical to those provided on the unit unless the Owner or Design-Builder agree to a change.

2-7.04. Belt Discharge. Dewatered sludge cake shall be removed from the upper and lower belts by adjustable doctor blades. The doctor blade assembly shall be spring loaded or counterweighted. Springs and counterweights shall be manually adjustable. The doctor blades shall be HDPE or UHMW polyethylene. The lower doctor blade shall also direct the dewatered sludge cake to the receiving screw conveyor COS-7300 as indicated on the Drawings.

2-7.05. Belt Washing System. A belt washing system shall be provided to effectively clean each belt.

Water will be supplied from the plant water supply at the location(s) shown on the

Drawings. The spray wash water system shall be designed to provide the required water to the belt filter press system and shall be coordinated by the belt filter press Manufacturer. A spray water booster pump shall be provided for each press if required. The pump shall be suitable for operation with plant recycled water (MBR filtrate), shall be furnished by the belt filter press Manufacturer, and shall be as specified herein.

Belt cleaning shall be accomplished by water sprays. There shall be one belt spray assembly for each belt. The belt spray assembly shall be comprised of a header pipe equipped with flat recessed, spray nozzles and shall incorporate a wire brush cleaning system operated with a handwheel. The handwheel shall be easily accessible to allow nozzle cleaning during press operation.

All metal components of the belt shower assembly shall be constructed of stainless steel.

Wash water piping at least 1-1/2 inches in diameter shall be provided on each belt filter press. A strainer shall be supplied with a filter element perforated with openings equal to, or smaller than, those in the nozzles. The strainer shall be capable of being cleaned by opening a flushing valve connected to the strainer. A 3/4 inch threaded hose connection shall be provided with the flushing valve. A 1-1/2 inch solenoid valve with NEMA Type 4X enclosure, interlocked with the belt filter press, shall be provided for the wash water system supply line to the belt filter press. A pressure regulating valve to control the wash water pressure at the belt filter press shall be provided for each belt filter press if required by the system provided. A pressure gauge suitable for operation over the pressure range to be encountered with an isolation valve shall be provided for each belt filter press. A flow switch or pressure switch to sense loss of wash water flow or pressure shall be provided for each belt filter press. Switches shall have 10 ampere rated contacts at 120 volts and shall be wired to the belt filter press control panel. Circuit boards shall be provided with an anti-fungal coating. Flow switches shall be Fluid Components "Model 12-64" or equal. Pressure switches shall be Barksdale "Series 96211", SOR "Model 6NN-K3-C2A", or equal.

The belt spray operating assembly shall be housed in a stainless steel hood extending across the full width of the belt, and a matching water collection trough shall be provided beneath the spray head with the belt passing between the two pieces. This housing shall be incorporated to contain the spray around the belt filter press and to separate the belt wash flow from the filtrate into a separate drain connection. Spray drainage shall ultimately discharge into the floor drain located within the containment area below the press. The housing shall be constructed of stainless steel. Spray tubes and nozzles shall be stainless steel. Rubber or brush seals shall be provided to eliminate misting. No spray water or misting shall occur outside the unit.

2-7.06. Drain Pans. Drain pans shall be provided to collect all filtrate and wash water drainage. The pans shall be fabricated from Type 316L stainless steel with

a minimum thickness of 14 gauge. Bolt holes shall be adequately reinforced to prevent cracking or shear failure. A lip at least 1 inch high shall be provided around the perimeter of each drain pan. External ribs, if required, shall be provided to reinforce the pan against distortion under the full hydrostatic load.

Each drain pan shall be provided with a drain line fabricated from solvent welded PVC pipes and conveyed to the floor drain indicated on the Drawings. The pipe shall be oversized to prevent clogging and shall be provided with cleanouts for rodding. Tees with screw plugs for cleanouts may be provided. Corrosion-resistant drain piping from the various troughs shall be drained to the concrete sump below the belt filter press.

The belt filter press and drain pans shall be designed to contain all sludge, drainage, filtrate, and spray water within the unit. If a vertical wedge is supplied a 316L stainless steel splash pan shall be provided to prevent splashing of liquid on to the backside of the filter belt of the pressure section.

2-7.07. Distribution Box. Sludge shall be contained in the gravity section by a stainless steel box-frame assembly with gaskets. Attached to the assembly shall be two parallel deckle strips or wedges to control the flow of sludge in the gravity section. Sludge shall be evenly distributed across the full width of the belt.

A proximity switch shall be provided in the distribution box to detect low or no sludge cake. The proximity switch shall have contacts rated 5 amps at 120 volt ac.

2-7.08. Belt Drive Unit. Each belt filter press shall be provided with a variable speed drive unit. Output speed regulation shall be as required for the Manufacturer's belt filter press. The drive unit shall be protected by corrosion-resistant coatings as a minimum.

Each motor shall comply with the General Equipment Stipulations except as specified herein. Each motor shall be rated 480 volts, three phase, 60 Hz, totally enclosed fan cooled (TEFC), and corrosion-resistant with insulation systems sealed for moisture and mildew resistance.

Each motor shall be provided with a space heater element sized to prevent condensation on the core and windings. The space heater shall be isolated or so located as to prevent heat damage to adjacent painted surfaces and shall be suitable for a 120 volt, 60 Hz, single phase power supply. The space heater shall be wired to the motor terminal box.

Each motor selected for adjustable speed control shall be furnished with at least one automatic reset winding temperature switch per phase. Temperature switch contacts shall be normally closed and rated 5 amperes at 120 volts ac. The contacts shall be wired in series with the end leads brought out to a separate motor terminal box. Switches shall be as recommended by the motor

MANUFACTURER.

Motors shall be specifically selected for service with an variable frequency type speed controller and shall be derated as required to compensate for harmonic heating effects and reduced self-cooling capability at low speed operation. Each motor shall not exceed a Class B temperature rise when operating in the installed condition at load with power received from the variable frequency drive. All motors used with drives shall be supplied with full phase insulation on the end turns and shall meet the requirements of NEMA MG 1, Part 31. In addition to the requirements of NEMA MG 1, Part 31, motors shall be designed to be continually pulsed at the motor terminals with a voltage of 1600 volts ac.

The belt drive shall be capable of varying its output speed from 50 to 150 percent of the speed required for the design conditions, without disassembly.

All gear reducer and motor bearings shall be oil or grease lubricated. All gears and chains shall run in oil or shall have a positive means of constant lubrication. Seals shall be provided to prevent oil leakage around shafts. Lubrication systems shall be protected against contamination and be designed so that the lubricants cannot contaminate the fluid being processed. Each lubrication system shall be provided with an external, visual method of checking lubricant level, without removing parts or fittings.

Lubrication shall be accomplished by means of oil fill and drain plugs or grease fittings which shall be convenient and accessible. Lubrication shall be accomplished without removing parts or dismantling equipment. Oil drains, fill openings, or grease fittings shall allow for convenient collection of oil in containers, either from the platform or from the ground, without removing the unit from its normal installed position.

A warning nameplate shall be provided on each motor to warn the operator to trip the main breaker prior to performing maintenance.

2-3.09. Variable Frequency Drives. The belt filter press shall be furnished complete with a variable frequency drive. The variable frequency drive shall be located in the main control panel and shall be coordinated with the requirements of the belt filter press drive unit. The VFD shall conform to the requirements listed in the Variable Frequency Drives section.

The supplier shall be responsible for furnishing the VFD and for coordinating the VFD and drive components to ensure that a complete and properly operating system is furnished. All equipment shall be derated as recommended by the VFD and motor manufacturers for reduced speed operation with an adjustable frequency controller in addition to any derating requirements specified elsewhere.

2-8. CORROSION PROTECTION. The belt filter press frame and all possible components shall be hot dip galvanized steel. All other surfaces shall be

protected with a corrosion-protection system.

As a minimum, all surfaces that cannot be constructed of hot dip galvanized steel shall be protected by painting as specified herein. All surfaces to be painted shall be blast-cleaned in accordance with SSPC-SP10. All iron and steel surfaces shall be covered with one coat of zinc-rich epoxy primer, an intermediate coat of flat epoxy paint, and a final coat of gloss epoxy paint. The paint shall be as recommended by a single MANUFACTURER for the service intended and applied to provide a final dry film thickness of 10 mils minimum.

As a minimum, all prepainted purchased equipment such as electric motors shall be coated with a final gloss coat of epoxy paint to match the remainder of the unit. An appropriate seal coat over the factory finish shall be applied if recommended by the paint MANUFACTURER.

All fiberglass reinforced plastic surfaces shall be finished to a uniform color which shall be incorporated into the plastic resin.

Machined or polished ferrous surfaces such as pipe flanges shall be provided with a temporary protective coating of a nondrying oil type rust-preventive compound.

2-8.01. Correction Work. Any location where corrosion is identified by OWNER shall be considered a failure of the material or the protection system. Before starting correction work, the belt filter press MANUFACTURER shall submit to the OWNER for review an analysis of the cause of the failure and details of the proposed correction work. The belt filter press MANUFACTURER shall make repairs acceptable to the OWNER at all points where failures are observed within the correction period.

2-8.02. Inspection. The belt filter press shall be inspected at the end of the correction period by representatives of the OWNER and the belt filter press MANUFACTURER to identify any failures that may have occurred. The MANUFACTURER shall establish the date for each inspection and shall notify the OWNER at least 30 days in advance. Scheduled inspections shall not relieve the belt filter press MANUFACTURER from the obligation to perform correction work whenever needed.

The belt filter press MANUFACTURER shall prepare and deliver to the OWNER an inspection report covering each inspection, indicating the number and type of failures observed, material and part where materials have failed, the percentage of the surface area where corrosion-protection system failure has occurred, and the names of the persons making the inspection. Color photographs illustrating each type of failure shall be included in the report.

2-9. SLUDGE CONDITIONING UNIT. The belt filter press shall include sludge conditioning equipment designed to efficiently mix the sludge with the polymer.

The equipment shall consist of an in-line mixer as recommended by the manufacturer and accepted by Design-Builder. The conditioning equipment shall be designed to operate without plugging with sludge containing stringy material. A single sludge inlet connection and separate connection for the conditioning chemical shall be provided.

All parts contacting sludge or chemicals shall be Type 316 stainless steel or equivalent corrosion-resistant materials.

2-9.01. In-Line Mixer. An in-line non-clog venturi mixer designed to efficiently mix the sludge with the polymer shall be provided for the new belt filter press. The mixer shall be recommended by the belt filter press MANUFACTURER and accepted by Design-Builder. The mixer shall be designed to operate without plugging with a combined sludge containing stringy material. A single sludge inlet connection and separate connection for the conditioning chemical shall be provided.

All parts contacting sludge or chemicals shall be stainless steel or equivalent corrosion-resistant materials.

The mixer system shall provide the following performance:

a. Energy for mixing polymer and sludge shall be adjustable while the belt filter press is operating.

b. The polymer and sludge must be instantaneously mixed by the mixer system.

c. The flocculation time shall be adjustable by changing the location of the mixer using the alternate mixer locations. Up to three alternate mixer locations will be provided with input from the belt filter press MANUFACTURER as to these locations.

d. Adjustment of mixing energy shall be independently adjustable.

The mixer shall be equipped with a vortex polymer injection ring with tangentially mounted polymer injectors. The mixer shall be located in the sludge feed line upstream of the belt filter press. The belt filter press MANUFACTURER shall be responsible for the proper layout of the system. Open throat area shall be as recommended by the belt filter press MANUFACTURER, and the open area shall be infinitely adjustable downward with the auxiliary mixing device. Elbows, bends, modified check valves, or special pipe sections will not be considered an acceptable substitute for the specified venturi mixer.

2-10. BELT ALIGNMENT/TENSIONING SYSTEM.

2-10.01. Belt Alignment. Each belt shall be automatically aligned by a pressure-

sensitive belt guidance system. The system shall operate hydraulically and require no further attention or adjustment.

The belt aligning devices shall be hydraulically operated and designed to align each belt and locate it centrally on the roller by means of a sensor which detects the position of the belt edge. The sensor shall operate a pilot valve which in turn affects the position of a hydraulic actuator connected to a pivoted belt alignment roller, causing this roller to skew from its transverse position. The alignment systems shall function as a continuous automatic belt guidance system and shall be an integral part of the belt filter press. The alignment system shall operate with smooth and slow motions resulting in a minimum of belt travel from side to side. The use of electrical servos or similar devices will not be acceptable. A system utilizing a hydraulic cylinder which maintains alignment by a large snap action type alternating movement from the fully closed to the fully extended position of the cylinder will not be acceptable.

In addition, electric limit switches shall be provided to signal belt misalignment (alarm) and gross belt misalignment to automatically stop each unit when necessary.

2-10.02. Belt Tension. Belt tension shall be automatically maintained hydraulically to prevent belt damage while providing adequate pressure for dewatering. The system shall automatically adjust for various cake thicknesses to maintain a constant pressure.

Increasing belt tension shall result in a spontaneous increase in dewatering pressure applied in the high pressure section. Belt tensioning shall ensure even surface pressure in the compression section and shall guarantee proper belt alignment during change in belt tensioning. Separate controls shall be provided for the upper and lower dewatering and gravity section belts to allow independent shutoff for each belt. Belt tension shall be variable up to 50 pounds per linear inch and shall be adjustable without shutdown of the unit. Breast rolls shall have parallel movement. The system shall include a 316L stainless steel rack and pinion assembly to assure movement of thrust arms.

2-10.03. Hydraulic Power Unit. Each belt filter press shall be provided with a hydraulic power unit if required by the MANUFACTURER when hydraulic control of belt alignment and belt tensioning is provided. The hydraulic unit shall be a self-contained unit consisting of an oil reservoir fabricated of 316L stainless steel with a pump, electric motor, pump suction oil filter, and a master pressure regulator. The unit shall be provided with two flexible hoses of sufficient length to connect to the belt filter press. The hydraulic power unit shall be powered from the belt filter main control panel. The belt filter press main control panel shall include the starter and required controls and safety interlocks. A low pressure switch shall be wired to the control panel to indicate low hydraulic pressure. A high pressure switch shall be provided to shut down the unit and provide an alarm at the control panel.

The pump, motor, reservoir, oil filter, and valves shall be mounted on the belt filter press frame on the drive motor side. The reservoir shall be of translucent HDPE to allow visual inspection of the oil level. The pump motor shall be 1 horsepower, 1,200 rpm, 480 volts, three phase, NEMA B design with a "C" face mounting for the hydraulic pump adapter. The hydraulic filter shall be of the reusable, washable screen type, with a nominal rating of 10 microns.

All hydraulic lines shall be AISI Type 316 stainless steel as a minimum, and shall be rigidly supported on the structural frame.]

2-11. SPRAY WATER BOOSTER PUMPS. Each belt filter press requiring a booster pump shall be provided with a single-stage, centrifugal, close-coupled, vertical, in-line pumping unit, designated as a water booster pump, shall be provided as a part of each belt filter press system. The belt filter press MANUFACTURER shall be responsible for coordinating the water booster pumps with each belt filter press.

Each pumping unit shall be securely supported and shall be complete with pump, electric motor, and all other appurtenances that are specified or required for proper operation. A spare mechanical seal shall be furnished with each pumping unit.

2-11.01. Pumping Units. Pumping units shall be designed to provide sufficient flow at the required head to meet the wash water requirements of each belt filter press.

Pump performance shall be stable and free from cavitation and noise throughout the specified operating head range at design suction pressures. The design performance shall be based on a wearing ring diametral clearance of not less than 0.012 inch, or 1 mil per inch of wearing ring diameter, whichever is greater.

2-11.02. Pump Materials. Each pump shall be bronze fitted, using materials as listed below:

Casing	Cast iron, ASTM 48.
Casing Wearing Ring	Cast iron, ASTM 48; or bronze, ASTM B62.
Impeller	Bronze, ASTM B62.
Shaft	Carbon steel.
Shaft Sleeve	Bronze, ASTM B144, Alloy 937; or AISI 416 stainless steel.

Stuffing Box Hardware	Noncorrosive metal.
Mechanical Seal	Durametallic "Type RO", Chesterton "Style 880", or John Crane "Type 21".
Base	Cast iron or fabricated steel.

The casing shall permit the removal of the rotating element without disconnecting the piping. Registered fit between casing parts shall maintain alignment. The nozzles shall have ANSI 125 lb flange and drilling.

A bypass line shall be provided for the mechanical seal between the seal faces and the suction flange to vent the seal chamber and to provide lubrication.

Pipe tapped openings shall be provided for draining and venting the casing.

Impellers shall be enclosed type, shall be one-piece castings completely machined on all exterior surfaces, and shall be dynamically balanced. The interior water passages shall have uniform sections, smooth surfaces, and be free from cracks and porosity.

Impellers shall be keyed to the shaft and positively held in the center of the discharge volute.

Pump shafts shall be completely machined and large enough to hold shaft deflection at the seal to less than 0.002 inch at all operating heads.

The shaft shall be provided with sleeves extending from the impeller through each stuffing box. Each sleeve shall be positively locked against rotation and axial movement and shall be sealed to prevent leakage between the shaft and the sleeve. After assembly on the shaft, total runout shall not exceed 0.002 inch.

Renewable wearing rings shall be provided in the casing. Design running clearance shall be not less than 1 mil per inch of ring diameter. The casing ring shall be positively locked against rotation.

Each stuffing box shall contain a mechanical seal as specified in the materials list. A flushing connection shall be located at the normal position of the lantern ring.

Each pumping unit shall be provided with lifting eyebolts or lugs, plugged gage cock connections at the suction and discharge flanges, and tapped and plugged openings for casing and bearing housing vents and drains. Flushing water connections to mechanical seals shall be equipped with 25 micron reusable, ceramic filters.

2-11.03. Balance. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the vibration displacement (peak-to-peak) as measured at any point on the machine shall not exceed 2.0 mils.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or components thereof shall be less than 0.8 or more than 1.3.

2-11.04. Electric Motors (Spray Water Pumps). Motors, including bearings, shall be self-air-cooled and grease or oil lubricated. Motors shall have antifriction bearings with an ABMA minimum L_{10} life rating of 40,000 hours when carrying the maximum pump load within the specified operating head range. The motors shall be vertical solid shaft as required.

Each motor shall comply with the General Equipment Stipulations except as specified herein. Each motor shall be rated 480 volts, three phase, 60 Hz, totally enclosed fan cooled (TEFC), and corrosion-resistant with insulation systems sealed for moisture and mildew resistance.

Each motor shall be provided with a space heater element sized to prevent condensation on the core and windings. The space heater shall be isolated or so located as to prevent heat damage to adjacent painted surfaces and shall be suitable for a 120 volt, 60 Hz, single phase power supply. The space heater shall be wired to the motor terminal box.

Bearings shall withstand maximum upthrust from the pump. Bearings shall have overgreasing prevention or oil level indication. Bearings and lubricant identities shall be engraved on nameplates. Motor air gaps shall be treated to resist rust in a moist atmosphere below 20 ^{0}C. Motor shafts shall be designed for direct pump impeller attachment and rigid impeller support.

2-11.05. Installation. Each pumping unit shall be leveled, aligned, and wedged into position to fit connecting piping. Installation procedures shall be as recommended by the pump MANUFACTURER, the Hydraulic Institute Standards, and as required herein.

Special care shall be taken to maintain alignment of pumping unit components. No stresses shall be transmitted to the pump flanges. After final alignment and bolting, pump connections shall be tested for applied piping stresses by loosening the flange bolts. If any movement or opening of the joints is observed, piping shall be adjusted to proper fit. Shimming between machined surfaces will not be permitted.

2-12. OBSERVATION PLATFORM. An observation platform and stairs for

access to the platform shall be provided to ease access and maintenance for the facility. All components of the platform, including grating, handrail, supports, and stairs shall meet CalOSHA requirements and shall be constructed of aluminum meeting the requirements of the structural and miscellaneous metals section. All assembly and anchor bolts shall be stainless steel. The maximum elevation of the platform shall be such that the difference in elevation from the top of platform to the top of the belt for the independent gravity zone is less than 40 inches and not more than 24 inches. If the difference in elevation from the top of the filtrate containment curb to the top of the independent gravity zone is less than 40 inches, an observation platform shall only be provided if required by the Manufacturer.

The platform shall be freestanding. The platform shall form a clear walkway at least 42 inches wide, shall be floored with minimum 1-1/4 inch grating, and shall be diagonally braced against lateral movement. Bracing shall be designed to provide for any piping arrangement shown on the Drawings. The walkway shall be designed and constructed so that any deflection will not exceed 1/300 of the span length under consideration considering all dead loads plus a live load of 200 pounds per square foot on the platform.

Three-rail railings 3'-6" high shall be provided along each side of the platform and stair. Railings shall be aluminum as specified in the structural and miscellaneous metals section and as shown on the Drawings. A kickplate at least 4 inches high shall be provided around the entire platform.

The platform shall be provided with the necessary brackets and mounting plates for supporting the electrical conduits and control panels.

2-13. ELECTRICAL. The electrical drawings indicate the anticipated electrical power, control, and instrumentation equipment required for a typical belt filter press. The supplier shall be responsible for supplying and installing any additional equipment, cable, conduit, devices, and controls required or recommended by the belt filter press MANUFACTURER for the safe and satisfactory operation and supervision of the belt filter press and related equipment actually provided.

The belt filter press units shall be prewired to the extent possible with all electrical connections being brought to two (2) junctions boxes as described herein.

2-13.01. 480 Volt Power Terminal Box. All 480 volt power connections for motors and power devices provided with the belt filter press shall be provided prewired to a NEMA Type 4X 316 stainless steel terminal box on the belt filter press assembly. All terminals shall be of the copper compression type suitable for the wire sizes indicated on the Drawings or as determined to be required by the belt filter press MANUFACTURER. All terminals shall be permanently labeled as to device, terminal number, and voltage.

All wiring from the respective devices on the belt filter press to the 480 volt terminal box shall be in PVC-coated galvanized steel conduit as specified in Section 16050 of these specifications.

2-13.02. 120 Volt Control Terminal Box. All 120 volt and below instrumentation and control devices provided with the belt filter press shall be provided prewired to a NEMA Type 4X 316 stainless steel terminal box on the belt filter press assembly. All terminals shall be of the copper compression type suitable for the wire sizes indicated on the Drawings or as determined to be required by the belt filter press MANUFACTURER. All terminals shall be permanently labeled as to device, terminal number, and voltage.

All wiring from the respective devices on the belt filter press to the 120 volt terminal box shall be in PVC-coated galvanized steel conduit as specified in Section 16050 of these specifications.

2-13.03. Controls. The sludge handling system shall be furnished with a Local Control Panel to control the operations of the belt filter press unit and the associated sludge pumping and conditioning equipment.

2-13.03.01. Programmable Logic Controller. Programmable logic controllers (PLCs) shall be provided for control and sequencing of unit operations. PLCs shall conform to the Programmable Logic Controllers section and shall be factory programmed for the operator-initiated automatic startup and shutdown of the system as described herein and in the Programmable Logic Controllers section.

2-13.03.02. Belt Filter Press Local Control Panel. Each Belt Filter Press (BFP) and its associated equipment shall be controlled from its respective individual BFP Local Control Panel. Local control panels shall be provided with a PLC and an operator interface terminal (OIT) which meet the requirements specified in the Programmable Logic Controllers section. Although described as physical devices from hereon, control and indicating devices may be physical switches, pushbuttons, and indicating lights wired to the local PLC or OIT graphics with interface through the OIT touch screen and/or keypad. Each local control panel shall include a system "LOCAL-OFF-AUTO" switch. In the "LOCAL" position, the system shall be controlled by individual "ON-OFF" selector switches or pushbuttons on the local control panel for the following equipment and speed control devices where appropriate. In “AUTO,” the system will start and stop the following equipment automatically:

a. Belt Drive.
b. Belt Tensioning/Alignment System.
c. Bet Speed.
d. Spray Water Pump (if applicable).
e. Spray Water Valve.
f. Discharge Screw Conveyor(s) (if applicable)

The controls shall be provided on the local control panel for the following equipment as specified herein.

a. Belt Filter Press Sludge Feed Pump.
b. Polymer Feeder Blender.

"Run" and "Stop" indicating lights shall be provided on the local control panel for the belt drive, tensioning/alignment system, spray water pump, and hydraulic power unit. "Open" and "Close" indicating lights shall be provided on the local control panel for the spray water valve.

A red "mushroom head" push button shall be provided on the main control panel for emergency stop of the belt filter press system.

The local control panel shall provide an Ethernet signal to the Plant Control System (PCS) for remote belt filter press system shutdown alarm and system running.

The local control panel shall control the spray water valve as required to ensure the valve is open when the press is running. The local control panel shall provide suitable time delays on alarms as required to allow for equipment startup. The local control panel shall provide individual alarm lights for each BFP system alarm.

Each belt filter press shall be provided with instruments and controls to provide the following minimum alarms to the Belt Filter Press Local Control Panel:

a. Belt Tensioning/Alignment System Fail (Low and High, Air, or Hydraulic Pressure).
b. Belt Misalignment.
c. Gross Belt Misalignment (Shutdown).
d. Emergency Stop Actuated (Emergency Stop Switch).
e. Belt Breakage (Shutdown).
f. No Sludge Flow.
g. Loss of Water Pressure (Downstream of Spray Water Valve).
h. Drive Unit Fail.
i. Hydraulic Power Unit Fail. (Shutdown)

Each belt filter press shall be provided with the following control equipment for controlling equipment remote from the belt filter press unit: "START-STOP" push buttons for the associated Dewatering Sludge Feed pumps (DWT-P) and polymer feeder blender (PFB), sludge flow digital panel indicators, polymer feed rate digital panel indicators, belt speed digital panel indicators, speed potentiometers for the associated Dewatering Sludge Feed pump, polymer feeder blender, and belt speed control, and red "Mushroom Head" emergency stop push button. The local control panels shall be a NEMA Type 4X 316

stainless steel enclosure which meets the requirements of the Panels, Consoles and Appurtenances section.

72-DWT-BFPS-0001 local control panel shall include the "START-STOP" push buttons and speed potentiometers and indicating lights for polymer feeder blenders in accordance with the Panel Mounted Instruments section.

Digital indicators shall be provided in accordance with the Panel Mounted Instruments section.

The local control panels shall be provided with electronic signal booster/isolators as required. Electronic signal boosters and isolators shall be provided in accordance with the Panel Mounted Instruments section.

The belt filter press supplier shall coordinate all necessary outputs with the supplier of the polymer feed system and the sludge feed pumps.

2-13.03.04. Emergency Stop Switch. Each belt filter press shall be equipped with an emergency stop safety switch with two normally closed double break contacts. Contacts shall be manually reset. Switches shall be equipped with a latching mechanism and a weight and cable for operation of the switch. Switches shall be opened by cable linkage mounted on all sides of the respective belt filter press frame. Cables shall be plastic covered metal cable (blaze orange color) and shall be located along the belt filter press frame within easy reach of operating personnel who may be maintaining or observing the operating belt filter press.

The switch shall be furnished with standard watertight covered terminal trip junction box 1/2 inch threaded conduit connection. Each switch shall be furnished and mounted as an integral part of the belt filter press framework. Each switch shall have a 10 amp, 115/120 volt ac rating. Switches shall be Clark Controller Co., G. E. Company, or equal, with appropriate enclosure. Action of the emergency safety switch shall immediately deactivate the belt filter press drive and accessories.

2-13.03.05. Variable Frequency Drives. Each variable frequency drive shall be coordinated with the requirements of the driven equipment. Particular attention shall be directed toward the driven equipment torque requirements.

The BFP supplier shall be responsible for coordinating the VFD with the driven equipment to assure compatibility between the drive and motor. All equipment shall be derated as recommended by the VFD and motor manufacturers for reduced speed operation with an variable frequency controller in addition to any derating requirements specified elsewhere.

Each VFD shall be pulse-width modulated type and shall produce an adjustable ac voltage/frequency output. Each VFD shall maintain a minimum displacement

power factor of 0.95 over the entire speed range, and shall be equipped with an output voltage regulator to maintain correct output V/Hz despite incoming voltage variations.

Each VFD shall be equipped with an input line reactor and a full-wave diode bridge rectifier to convert incoming fixed voltage/frequency to a fixed dc voltage. The pulse-width modulation technology shall be of the space vector type, implemented in a microprocessor which generates a sine-coded output voltage.

The VFD inverter output shall be generated by insulated gate bipolar transistors (IGBT) which shall be controlled by six identical base driver circuits. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque, and voltage shall not exceed 1.05 times the rated RMS motor current for pure sine wave operation. Each VFD shall be configurable for automatic and manual reset and shall have an adjustable carrier frequency to at least 6000 Hz.

VFDs shall be manufactured by Allen-Bradley, Square D, Toshiba, or approved equal.

2-13.03.06. Panel Devices. Selector switches, indicating lights, and push buttons shall be heavy-duty, oiltight, push-button station type with contacts rated 10 amperes at 120 volts ac and shall have engraved or etched nameplates identifying application and each switch action. Indicating lights shall be LED push-to-test type.

Auxiliary and time delay relays shall be heavy-duty, industrial type, with 120 volt ac coil and output contacts rated 10 amperes at 120 volts ac. Time meters shall be synchronous motor drive, 99,999.9 hours span, non-reset, and 120 volts ac.

The devices on the local control panel shall be rated NEMA type 4X.

2-13.03.07. Power and Control Wiring. The control panels shall be completely wired with provisions for terminating all remote wiring on terminal blocks. The terminal blocks shall be marked to agree with the MANUFACTURER's wiring diagram. Control terminal blocks shall be sized for No. 12 AWG copper wire. All interconnecting wiring and wiring to terminals for external connection shall be not less than No. 14 AWG copper, insulated for not less than 600 volts with a moisture and heat-resistant material and flame-retardant nonmetallic covering. All wiring shall be grouped or cabled and firmly supported to the panel. Not less than 25 percent spares shall be provided.

All devices within the panel shall be permanently identified. Nameplates shall be provided on the face of the panel or on the individual device as required. Nameplates shall be made of laminated phenolic material. All wires shall be numbered at each termination with permanent labels corresponding to the schematic.

2-14. SHOP TESTING. The belt filter press shall be tested in the Manufacturer's shop for mechanical performance. This shall include operating to check alignment, test for faulty equipment and controls, proper wiring, and proper operation of safety and operating controls. A statement from the belt filter press Manufacturer certifying that the specified shop test has been performed shall be submitted to the Design-Builder prior to shipment.

PART 3 – EXECUTION

3-1. INSTALLATION. Each unit shall be installed in accordance with Equipment Installation section and as specified herein.

3-2. FIELD QUALITY CONTROL.

3-2.01. Installation Check. An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with Startup Requirements section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Design-Builder.

The manufacturer's representative shall furnish a written report 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 under full load conditions and that it operated satisfactorily and in accordance with the specified performance requirements.

All pre-checks and preliminary tests will need to be completed and approved by the Design-Builder and manufacturer prior to performance testing.

All costs for these services shall be included in the contract price.

3-3. PERFORMANCE TEST. The performance tests shall be conducted by a capable representative of the manufacturer and accepted by Design-Builder. All costs for these services shall be included in the contract price.

Owner's operating personnel will assist the manufacturer's representative in the performance test. A designated representative of Design-Builder will observe the performance tests.

Preliminary performance tests shall be conducted using the equipment under the design conditions specified. Once the appropriate operation parameters are established, extended duration performance tests shall be conducted to

demonstrate the equipment's ability to consistently perform at the design conditions specified.

The test results will be used to prove compliance with the performance requirements prior to acceptance of the equipment. Consistent compliance with design conditions shall be defined as the average of sample values meeting or exceeding the specified design conditions.

The equipment manufacturer shall detail the proposed field evaluation and performance testing procedures and analyses, subject to approval by Design-Builder. If more than one day of testing is required, the testing shall be done on consecutive days.

3-3.01. Field Evaluation Tests. The Design-Builder shall perform field evaluation tests of each belt filter press system to demonstrate that the equipment complies with the design conditions specified herein. A minimum of 30 days prior to the testing, the Manufacturer shall perform, at the Manufacturer's expense, the necessary testing to determine the type and dosage of polymer required to meet performance requirements. The results of the polymer evaluation along with the recommendations for the type of polymer and optimum dosage shall be provided to Design-builder. The Manufacturer shall be solely responsible for the polymer dosage used in the belt filter press testing. The tests shall be run at a time acceptable to the Owner and Design-builder. The equipment Manufacturer's representative and the Design-builder shall witness the tests. Design-builder shall initial all data collection sheets.

At least two weeks prior to testing, the Manufacturer shall prepare a schedule for field evaluations and written testing procedures. Proposed data collection sheets and calculation formulas shall be included.

Preliminary field tests shall be conducted using each belt filter press under the design conditions specified. Preliminary field tests shall consist of a series of runs to determine the appropriate belt speed, pressure, and liquid polymer dosage to meet the design conditions. It is the Manufacturer's responsibility to verify calibration of polymer feed equipment feed rates prior to the performance test.

Once the appropriate parameters are established, extended duration field tests shall be conducted to demonstrate the equipment's ability to consistently perform at the design conditions specified. Each belt filter press shall be operated for a minimum of 4 consecutive hours under the design operating conditions. The Manufacturer's representative shall adjust each belt filter press system at the start of each run and may make further adjustments hourly during each test run. Samples shall be collected at least every 30 minutes to determine sludge feed consistency, solids capture efficiency, and sludge cake moisture content. Consistent compliance with design conditions shall be defined as the average of sample values meeting or exceeding the specified design conditions during the

testing period.

Samples will be collected by Design-Builder, and analyses shall be performed by a certified independent testing laboratory. On-site solids analysis may be used for guidance before and during the test; however, only certified lab analyses will be considered for compliance with the specified performance.

3-4. TEST REPORTS. The equipment manufacturer shall prepare a test report, including all installation check and performance tests and other recorded data and observations. A PDF copy of the report shall be submitted to Design-Builder after completion of the specified tests.

3-4.01. Field Evaluation Report. The Design-Builder shall submit a written report after completion of the tests presenting the results of the field evaluation tests. The report shall include all data collected during field testing, including, but not limited to, the following:

- Results of preliminary test runs to select belt speed, pressure, and polymer dosage.

- Data from extended duration testing to demonstrate consistent achievement of design conditions for each belt filter press, including at least hourly data for:

    Sludge feed rate
    Feed total solids concentration
    Feed sludge volatile solids (VS)
    Belt wash flow rate
    Active polymer dose
    Filtrate suspended solids concentration
    Thickened cake sludge solids concentration (when operating in thickening mode)
    Sludge cake total solids concentration

- Conclusions from extended duration field testing using the data collected, including:

    Hydraulic throughput, gpm
    Solids throughput, lb dry solids/hr
    Thickened sludge solids concentration, percent dry solids (when operating in thickening mode)
    Sludge cake consistency, percent dry
    Solids capture efficiency, percent
    Polymer type
    Polymer use, active pounds/ton dry solids

3-5. MODIFICATIONS. If the system equipment fails to satisfy the performance requirements, the equipment shall be modified. Modifications shall be made, or additional equipment shall be furnished and installed, as necessary to produce an installation satisfying the performance requirements. The equipment shall be completely retested after modification. Modifications and additional equipment shall be provided, and retesting shall be performed at the expense of the equipment manufacturer. All structural, piping, or electrical modifications necessary to accommodate the modified equipment shall be made at equipment manufacturer's expense.

3-6. TRAINING. The equipment manufacturer shall furnish the services of a competent and experienced operator of the equipment who is directly employed by the manufacturer to instruct Owner's operating personnel in the proper operation and maintenance of the equipment. Training shall be in accordance with the Demonstration and Training section. All costs for these services shall be included in the Contract Price.

3-6.01. Operations Training. Classroom instruction covering the theory of operation, site specific operation of the equipment and optimization of the submersible propeller mixer operation.

3-6.02. Maintenance Training. Hands-on training in separate sessions for: (1) mechanical maintenance and (2) electrical and instrumentation maintenance. Sessions shall run concurrently following the operations training.

End of Section