CITY OF WEST LINN, OREGON

CALAROGA SANITARY SEWER PUMP STATION REPLACEMENT

TECHNICAL SPECIFICATIONS

100% SUBMITTAL

VOLUME 1 OF 3

MARCH 2024

Digitally signed by Matthew Sprick
Contact Info: Carollo Engineers, Inc
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JUNE 10, 2014
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CITY OF WEST LINN, OREGON

CALAROGA SANITARY SEWER PUMP STATION REPLACEMENT

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DIVISION 00 - BIDDING REQUIREMENTS, CONTRACT FORMS, AND CONDITIONS OF THE CONTRACT

DIVISION 01 - GENERAL REQUIREMENTS

DOCUMENT 00451A

CONSTRUCTION CONTRACTOR QUALIFICATIONS FORM

ARTICLE 1 — QUALIFICATION DETERMINATION

1.01 Engineer has sole discretion in the determination of qualified businesses.

ARTICLE 2 — CONTACT AND OWNERSHIP INFORMATION

2.01 Provide contact information for the business:

Legal Name of Business:			
Corporate Office			
Name:		Phone number:	
Title:		Email address:	
Business address of corporate office:			
Local Office			
Name:		Phone number:	
Title:		Email address:	
Business address of local office:			

2.02 Provide information on the business's organizational structure:

Form of Business:	☐ Sole Proprietorship ☐ Partnership ☐ Corporation		
☐ Limited Liability Company ☐ Joint Venture comprised of the following companies:			
	1.		
	2.		
	3.		
Provide a separate Qualification Statement for each Joint Venturer.			
Date Business was formed:		State in which business was formed:	
Is this business authorized to operate in the Project location?		☐ Yes ☐ No ☐ Pending	

2.03 Identify all businesses that own Business in whole or in part (25 percent or greater), or that are wholly or partly (25 percent or greater) owned by Business:

Name of business:		Affiliation:	
Address:			
Name of business:		Affiliation:	
Address:			
Name of business:		Affiliation:	
Address:			

2.04 Provide information regarding the business's officers, partners, and limits of authority.

Name:		Title:	
Authorized to sign contracts: ☐ Yes ☐ No		Limit of Authority:	$
Name:		Title:	
Authorized to sign contracts: ☐ Yes ☐ No		Limit of Authority:	$
Name:		Title:	
Authorized to sign contracts: ☐ Yes ☐ No		Limit of Authority:	$
Name:		Title:	

2.05 License requirements

A. Owner will only receive or consider Bids from Bidders that are licensed by the Oregon Construction Contractors Board or Oregon State Landscape Contractors Board, as appropriate.

B. In accordance with Oregon ORS, Section 468A.720, the Bidder must be licensed for performing the asbestos abatement Work, as applicable.

C. Provide information regarding licensure for Business:

1. Licensed in the state where the project is to be constructed continuously for minimum period of 5 years.

Name of License:			
Licensing			
License No:		Expiration Date:	
Name of License:			
Licensing			
License No:		Expiration Date:	

ARTICLE 3 — FINANCIAL

3.01 Financial requirements:

A. The financial condition of the business cannot be such that its financial ability to complete the Project is in doubt, in the opinion of the Owner.

3.02 Provide the most recent audited financial statement, and if such audited financial statement is not current, also provide the most current financial statement.

3.03 Provide information regarding the business's financial stability.

Financial Institution:		
Business address:		
Date of business's most recent financial statement:		☐ Attached
Date of business's most recent audited financial statement:		☐ Attached
Financial indicators from the most recent financial statement		
Contractor's Current Ratio (Current Assets ÷ Current Liabilities)		
Contractor's Quick Ratio ((Cash and Cash Equivalents + Accounts Receivable + Short Term Investments) ÷ Current Liabilities)		
Is the business in bankruptcy?		

ARTICLE 4 — SAFETY PROGRAM

4.01 Must have a designated Safety Manager.

4.02 Submit a copy of the company's Safety Program.

4.03 Submit the company protocol for call-in of emergency work.

A. Must have a 24-hour 7 day a week emergency on call service that is answered by a person and not a recording.

4.04 Submit a statement that all employees that perform work:

A. Have completed the company safety training.

4.05 Provide information regarding Business's safety organization and safety performance.

Name of Business's Safety		
Safety Certifications		
Certification Name	Issuing Agency	Expiration

4.06 Provide 3 years of data in the format below that includes Contractor's Worker's Compensation Insurance Experience Modification Rate (EMR), Total Recordable Injury Rate (TRIR) for incidents, and Total Number of Recorded Man Hours (MH) based on 29 CFR 1904 OSHA Recording and Reporting Occupational Injuries and Illness requirements. Bidder shall submit Worker's Compensation Insurance Experience Modification Rate (EMR) letter from insurance broker with signed Agreement.

Year									
Company	EMR	TRIR	MH	EMR	TRIR	MH	EMR	TRIR	MH

ARTICLE 5 — SURETY INFORMATION

5.01 Provide information regarding the surety company that will issue required bonds on behalf of the Business, including but not limited to performance and payment bonds.

Surety Name:			
Surety is a corporation organized and existing under the laws of the state of:			
Is surety authorized to provide surety bonds in the Project location?	☐ Yes ☐ No		
Is surety listed in "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" published in Department Circular 570 (as amended) by the Bureau of the Fiscal Service, U.S. Department of the Treasury? ☐ Yes ☐ No			
Mailing Address (principal place of business):			
Physical Address (principal place of business):			
Phone (main):		Phone (claims):	

ARTICLE 6 — INSURANCE

6.01 Provide information regarding business's insurance company(s), including but not limited to its Commercial General Liability carrier. Provide information for each provider.

Name of insurance provider, and type of policy (CLE, auto, etc.):	
Insurance Provider	Type of Policy (Coverage Provided)

Are providers licensed or authorized to issue policies in the Project location?			☐ Yes ☐ No
Does provider have an A.M. Best Rating of A-VII or better?			☐ Yes ☐ No
Mailing Address (principal place of business):			
Physical Address (principal place of business):			
Phone (main):		Phone (claims):	

ARTICLE 7 — FACILITIES

7.01 Provide information regarding the facilities:

REQUIREMENT	YES OR NO
Does the business have a permanent service facility?	

ARTICLE 8 — EXPERIENCE AND RESOURCES

8.01 Provide information regarding the business:

REQUIREMENT	YES OR NO
Has the business been operating at least 5 years?	
Has the business had at least $3.0 million, annual gross revenue?	
Does the business or any of its officers have adverse criminal or legal records, such as criminal convictions, defaults, loss of licenses, etc.?	
Does the business have a poor project performance record, such as repeated claims, litigation, defaults, etc.?	
Does the business have a training program staffed by qualified instructors, to provide proper training in the operation and maintenance of equipment as specified in the Contract Documents?	

8.02 Provide information that will identify the overall size and capacity of the business.

Average number of full-time employees:	
Estimate of gross revenue for the current year:	
Estimate of gross revenue for the previous year:	

8.03 Provide information regarding the business's current workload.

A. Submit all projects currently under contract using the form provided in the Invitation to Bid.

8.04 Provide information regarding the business's previous contracting experience.

Years of experience with projects similar to the proposed project:				
As a general contractor:		As a joint venturer:		
Has business, or a predecessor in interest, or an affiliate identified in Paragraph 1.03:				
Been disqualified as a bidder by any local, state, or federal agency within the last 5 years? ☐ Yes ☐ No				
Been barred from contracting by any local, state, or federal agency within the last 5 years? ☐ Yes ☐ No				
Been released from a bid in the past 5 years? ☐ Yes ☐ No				
Defaulted on a project or failed to complete any contract awarded to it? ☐ Yes ☐ No				
Refused to construct or refused to provide materials defined in the contract documents or in a change order? ☐ Yes ☐ No				
Been a party to any currently pending litigation or arbitration? ☐ Yes ☐ No				
Provide full details in a separate attachment if the response to any of these questions is Yes.				

A. Submit completed projects in the last 3 years using the form provided in the Invitation to Bid.
   1. Minimum of 3 projects.
   2. Maximum of 6 projects.
   3. "Completion" means the similar project has been installed and is substantially complete.

B. Minimum experience requirements:
   1. At least 3 projects for a water and/or wastewater system of similar scope and complexity to this Project.
      a. At least 1 project with a dollar value of at least 80 percent of estimated cost for this Project.

ARTICLE 9 — PROJECT STAFFING

9.01 Provide resumes on key individuals whom Business intends to assign to the Project.

A. Key individuals must be permanent employees of the Business.

B. Key individuals include the following:
   1. Project Manager.
   2. Project Superintendent.
   3. Quality Manager.
   4. Safety Manager.

C. Resumes may be provided for Business's key leaders as well.

D. Minimum qualifications:
   1. Each of the key individuals each must have minimum of 10 years of experience in similar construction projects.
   2. Project Manager and Project Superintendent have served in similar roles on at least 2 comparable project(s) in the past 5 years.
   3. Safety Manager must have appropriate certification or license.

ARTICLE 10 — REQUIRED ATTACHMENTS

10.01 Provide the following information with the Statement of Qualifications:

A. If business is a joint venture, provide separate Qualifications Statements for each joint venturer as specified in this Document.

B. Provide this Document with information filled out.

C. Financial statements as specified in this Document.

D. Current projects as specified in this Document.

E. Previous experience with similar projects as specified in this Document.

F. Resumes for the key individuals listed as specified in this Document.

G. Attachments providing additional information as specified in this Document.

END OF DOCUMENT

DOCUMENT 00453

BID PREFERENCES

1.01 Do you claim a bid preference in accordance with Oregon ORS 279a.120 – Preference for Oregon Goods and Services; Non-Resident Bidders?

[ ] Yes [ ] No

A. If so, are you submitting proof of qualification for bid preference?

[ ] Yes [ ] No

1.02 Do you claim a bid preference for use of recycled materials in accordance with Oregon ORS 279a.125- Preference for Recycled Materials?

[ ] Yes [ ] No

A. If so, are you submitting proof of qualification for bid preference?

[ ] Yes [ ] No

END OF DOCUMENT

DOCUMENT 00612

WARRANTY BOND

Contractor Name: Address (principal place of business):	**Surety** Name: Address (principal place of business):
Owner Name: Address (principal place of business):	**Construction Contract** Description (name and location): Contract Price: Effective Date of Contract: Contract's Date of Substantial Completion:

Bond

Bond Amount: _____

Date of Bond: _____

Bond Period: Commencing 364 days after Substantial Completion of the Work under the Construction Contract, and continuing until 18 months after such Substantial Completion.

Modifications to this Bond form:

☐ None ☐ See Paragraph 9

Surety and Contractor, intending to be legally bound hereby, subject to the terms set forth in this Document, do each cause this Warranty Bond to be duly executed by an authorized officer, agent, or representative.

Contractor as Principal	Surety
_____ *(Full formal name of Contractor)*	_____ *(Full formal name of Surety) (corporate seal)*
By: _____ *(Signature)*	By: _____ *(Signature) (Attach Power of Attorney)*
Name: _____ *(Printed or typed)*	Name: _____ *(Printed or typed)*
Title: _____	Title: _____
Attest: _____ *(Signature)*	Attest: _____ *(Signature)*
Name: _____ *(Printed or typed)*	Name: _____ *(Printed or typed)*
Title:	Title:

Notes: (1) Provide supplemental execution by any additional parties, such as joint venturers. (2) Any singular reference to Contractor, Surety, Owner, or other party is considered plural where applicable.

1. The Contractor and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors, and assigns to the Owner for the performance of the Construction Contract's Correction Period Obligations. The Construction Contract is incorporated in this Document by reference.
2. If the Contractor performs the Correction Period Obligations, the Surety and the Contractor shall have no obligation under this Warranty Bond.
3. If Owner gives written notice to Contractor and Surety during the Bond Period of Contractor's obligation under the Correction Period Obligations, and Contractor does not fulfill such obligation, then Surety shall be responsible for fulfillment of such Correction Period Obligations. Surety shall either fulfill the Correction Period Obligations itself, through its agents or contractors, or, in the alternative, Surety may waive the right to fulfill the Correction Period Obligations itself, and reimburse the Owner for all resulting costs incurred by Owner in performing Contractor's Correction Period Obligations, including but not limited to correction, removal, replacement, and repair costs.
4. The Surety's liability is limited to the amount of this Warranty Bond. Renewal or continuation of the Warranty Bond will not modify such amount, unless expressly agreed to by Surety in writing.
5. The Surety shall have no liability under this Warranty Bond for obligations of the Contractor that are unrelated to the Construction Contract. No right of action will accrue on this Warranty Bond to any person or entity other than the Owner or its heirs, executors, administrators, successors, and assigns.
6. Any proceeding, legal or equitable, under this Warranty Bond may be instituted in any court of competent jurisdiction in the location in which the Work or part of the Work is located and must be instituted within 2 years after the Surety refuses or fails to perform its obligations under this Warranty Bond.
7. Written notice to the Surety, the Owner, or the Contractor must be mailed or delivered to the address shown in this Warranty Bond.
8. Definitions:
    8.1. Construction Contract—The agreement between the Owner and Contractor identified on the cover page of this Warranty Bond, including all Contract Documents and changes made to the agreement and the Contract Documents.
    8.2. Contract Documents—All the documents that comprise the agreement between the Owner and Contractor.
    8.3. Correction Period Obligations—The duties, responsibilities, commitments, and obligations of the Contractor with respect to correction or replacement of defective Work, as referenced in Invitation to Bid.
    8.4. Substantial Completion—As defined in the Construction Contract.
    8.5. Work—As defined in the Construction Contract.
9. Modifications to this Bond are as follows: None.

END OF DOCUMENT

SECTION 01110

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Detailed description of the Work.

1.02 THE WORK

A. The Work consists of:
   1. Construction of Calaroga Sanitary Sewer Pump Station, including installation of new wet well, valve vault, gabion retaining wall, control and electrical panels, instrumentation, piping and valves, modifications of the existing wet well to repurpose as a sanitary sewer manhole, site paving, landscape mitigation, repair and reconstruction of existing improvements affected by the Work, and incidentals for complete and usable facility.
   2. Commissioning of the Work.

1.03 LOCATION OF PROJECT

A. The Work is located at 3821 Calaroga Drive West Linn, Oregon 97068.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01116

CONTRACT DOCUMENT LANGUAGE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Explanation of arrangement, language, reference standards, and format.

1.02 REFERENCES

A. Construction Specifications Institute (CSI):
   1. MasterFormat™.
   2. SectionFormat™.
   3. PageFormat™.

1.03 PROJECT MANUAL ARRANGEMENT

A. Document and Section numbers used in Project Manual, and Project Manual arrangement are in accordance with CSI MasterFormat™, except where departures have been deemed necessary.

B. Sections are written in CSI SectionFormat™, Three-Part Section Format, except where departures have been deemed necessary.

C. Page format for Sections in the Project Manual is in PageFormat™, except where departures have been deemed necessary.

1.04 CONTRACT DOCUMENT LANGUAGE

A. Specification Section Paragraphs entitled "Section Includes" summarize briefly what is generally included in the section.
   1. Requirements of Contract Documents are not limited by "Section Includes" paragraphs.

B. Specifications have been partially streamlined by intentionally omitting words and phrases, such as "the Contractor shall," "in conformity therewith," "shall be" following "as indicated," "a," "an," "the" and "all."
   1. Assume missing portions by inference.

C. Phrase "by Engineer" modifies words such as "accepted," "directed," "selected," "inspected," and "permitted," when they are unmodified.

D. Phrase "to Engineer" modifies words such as "submit," "report," and "satisfactory," when they are unmodified.

E. Colons (:) are used to introduce a list of particulars, an appositive, an amplification, or an illustrative quotation:
   1. When used as an appositive after designation of product, colons are used in place of words "shall be."

F. Word "provide" means to manufacture, fabricate, deliver, furnish, install, complete, assemble, erect in place, test, or render ready for use or operation, including necessary related material, labor, appurtenances, services, and incidentals.

G. Term "products" includes materials and equipment as specified in Section 01601 - Product Requirements.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01140

WORK RESTRICTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for sequencing and scheduling the Work affected by existing site and facility, work restrictions, and coordination between construction operations and plant operations.

1.02 SUBMITTALS

A. Baseline Schedule with Method of Procedure (MOP) tasks.

B. Method of Procedure (MOP) Form.

C. Method of Procedure (MOP) Log.

D. Progress Schedule with MOP tasks.

1.03 METHOD OF PROCEDURE (MOP)

A. Comply with MOP Instructions as specified in Attachment A - Method of Procedure (MOP).

B. Prepare MOP for the following conditions:
   1. Shutdowns, diversions, and tie-ins to the existing facility.
   2. Process start-up activities.
   3. Power interruption and tie-ins.
   4. Switch over between temporary and permanent facilities, equipment, piping, and electrical and instrumentation systems.
   5. Process constraints requiring interruption of operating processes or utilities.

C. Other Work not specifically listed may require MOPs as determined necessary by the Contractor, Owner, or Engineer.

D. Submit Baseline Schedule, as specified in Section 01321 - Schedules and Reports with proposed MOPs.

E. Submit MOP Log at construction progress meetings.

F. No consideration will be given to claims of additional time and cost associated to preparing MOPs required by the Owner and Engineer to complete this work in a manner that facilitates proper operation of the facility and compliance with effluent discharge criteria.

G. Where required to minimize process interruptions while complying with specified constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.

1.04 GENERAL CONSTRAINTS ON WORK AND SCHEDULING OF WORK

A. Perform abandoned pipe Work as specified in Section 01738 - Selective Alterations and Demolition.

B. Pump station project:
   1. The Calaroga Sanitary Sewer Pump Station is the City of West Linn's only means of conveying domestic wastewater from this neighboring service area. Impairing the operational capabilities of this pump station will result in serious environmental damage and monetary fines.
   2. Conduct Work in a manner that will not impair the operational capabilities of essential elements of the pumping process or reduce the capacity of the pump station below levels sufficient to convey the wastewater received on site.
   3. Conduct commissioning activities as specified in Section 01756 - Commissioning in a manner that will not impair the operational capabilities of essential elements of the pumping process or reduce the capacity of the entire pump station below levels sufficient to convey the wastewater received on site.
      a. Conduct PCIS Optimization and Fine-Tuning as specified in Section 01756 - Commissioning.
   4. The status of the pump station shall be defined as "operational" when it is capable of conveying the entire quantity of wastewater received to the sanitary sewer system indicated on the Drawings.

1.05 UTILITIES

A. Provide advance notice to and utilize services of Underground Services Alert (U.S.A.) for location and marking of underground utilities operated by utility agencies other than the Owner.

B. Maintain electrical, telephone, water, gas, sanitary facilities, and other utilities within existing facilities in service and in neighborhood. Provide temporary utilities when necessary.

C. New yard utilities were designed using existing facility drawings and survey information.
   1. Field verification of utilities locations was not performed during design.
   2. Services crossed or located nearby by new yard utilities may require relocation and possible shutdowns.
   3. Pipe alignments as indicated on the Drawings.

1.06 WORK BY OTHERS

A. Where proper execution of the Work depends upon work by others, inspect and promptly report discrepancies and defects.

1.07 SHUTDOWN CONSTRAINTS

A. General shutdown constraints:
   1. Execute the Work while the existing facility is in operation.
   2. Some activities may be accomplished without a shutdown.
   3. Apply to activities of construction regardless of process or work area.
   4. Activities that disrupt pump station or utilities operations must comply with these shutdown constraints.
   5. Organize work to be completed in a minimum number of shutdowns.
   6. Provide thorough advanced planning, including having required equipment, materials, and labor on hand at time of shutdown.
   7. Shutdown MOPs:
      a. Advise the Engineer a minimum of 3 weeks prior to need for any complete or partial plant shutdown for tie-ins.
      b. Prepare and submit MOP to Engineer for any complete or partial plant shutdown required a minimum of 2 weeks prior to the shutdown.
      c. Owner's written approval of MOP is required prior to beginning Work.
   8. Where required to minimize process interruptions while complying with specified constraints, provide temporary pumping, power, lighting, controls, instrumentation, and safety devices.
   9. Final determination of the permitting of shutdowns will be the sole judgment of the Owner.
   10. Owner maintains the ability to abort on the day of the scheduled shutdown.
   11. Unplanned shutdowns due to emergencies are not specified in this Section.

B. Unit process availability work limitations:
   1. Shutdowns and tie-ins or other activities that disrupt pump station operations are prohibited unless the following unit process availability conditions exist and unless otherwise approved in writing by the Owner and Engineer:
      a. Temporary bypass pump and piping system is operational.

C. Process, electrical and instrumentation - tie-in shutdowns:
   1. Schedule no more than 1 tie-in shutdown per day, unless otherwise approved in writing by the Owner and Engineer.

1.08 WORK RESTRICTIONS

A. Provide safe, continuous access to control equipment for operations and maintenance personnel.

B. Work must abide by City of West Linn light and noise ordinances (West Linn Municipal Code Sections 5.426, 5.487, and 5.260.

C. Piping:
   1. Provide temporary piping during construction for existing and new equipment to maintain pump station operation in service during construction.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

ATTACHMENT A - METHOD OF PROCEDURE (MOP)

“METHOD OF PROCEDURE” (MOP)
Instructions and Forms

Definition and Purpose

“Method of Procedure” (MOP) is a detailed document submitted by the Contractor to request process shutdown(s), utility tie-in(s), work in areas that may risk unanticipated outages, or flow diversions to accommodate site construction activities during a project. Such activities may include (but are not limited to) new tie-ins to utilities or structures, mechanical modifications to process piping or equipment, demolition, bulkhead installation, and cleaning processes.

The MOP provides a detailed plan to the Owner and Engineer that describes specific aspects of the work including purpose, time of execution, and anticipated impacts on treatment processes. The MOP also includes contingency measures and provisions for rapid closure in the event that shutdown or work progress difficulties are encountered. Information from relevant trades associated with the requested shutdown, diversion, or tie-in is also included.

The Owner should use the information within the MOP to define operational procedures and methods to safely and successfully assist the Contractor.

MOP Process Summary

WHO	STEP	TIMING
Contractor	1. Identify MOPs needed on MOP Log and Baseline Schedule.	No later than 7 days prior to Preconstruction Scheduling Meeting
Contractor, Owner, Engineer	2. Pre-MOP Meeting.	More than 28 days prior to work
Contractor	3. Submits MOP.	No later than 28 days prior to work
Owner	4. Reviews MOP.	
Owner	5. MOP finalized.	No later than 7 days prior to work
Contractor	6. Complete Readiness Checklist.	No later than 5 days prior to work
Contractor	7. Complete Safety Checklist.	Immediately prior to commencing work
Contractor	8. Complete Work.	
Contractor	9. Update MOP Log and Progress Schedules.	Monthly

MOP Process Detail

STEP 1. Identifies MOPs needed on MOP Log and Baseline Schedule.

Contractor submits a preliminary list of anticipated project MOPs on MOP Log. MOPs identified but not limited to those shutdowns, diversions, or tie-ins described in the Contract Documents. Incorporate MOPs as tasks in Baseline Schedule. Date scheduled MOPs to coincide with the appropriate construction activities.

STEP 2. Pre-MOP Meeting.

Contractor requests a Pre-MOP Meeting with the Owner and Engineer to discuss the nature of the shutdown, diversion, or tie-in, and to gather the information necessary to complete the MOP Form. The pre-MOP meeting may be waived by the Owner or Engineer if the work is deemed to be minor.

STEP 3. Submits MOP.

Contractor completes the MOP Form and submit 3 copies for approval to the Owner's Project Manager (OPM).

STEP 4. Reviews MOP.

OPM distributes MOP Form for review by the Owner's Construction Coordinator, O&M Representative, and Engineer's Project Representative. Review MOP Form for completeness, accuracy, compliance with both the construction schedule, constraints defined in contract documents, and to ensure that the requested work does not negatively impact plant operations or other concurrent project activities. Additional information may be requested to better understand the nature of and method for completing the Work.

STEP 5. MOP finalized.

Once the MOP is agreed to by all parties, the MOP will be finalized by signature. Copies are distributed to the Owner, Engineer, and Contractor.

STEP 6. Complete Readiness Checklist.

Contractor verifies everything is ready for the work.

STEP 7. Complete Safety Checklist.

Contractor ensures safety.

STEP 8. Complete work.

Contractor complete work.

STEP 9. Update MOP Log and Progress Schedules.

Contractor updates MOP Log weekly and distributes at the regularly scheduled construction progress meetings.

ATTACHMENT B - METHOD OF PROCEDURE (MOP) FORM

METHOD OF PROCEDURE (MOP) FORM

Owner:		**Date:**	
Contractor:		**Carollo Project No.:**	
Project Name:		**Submittal No.:**	
Submittal Title:		**Spec/Dwg. Reference:**	

MOP #	Task Title *(Provide <10 word title)*:	Submittal Date: *(No later than 28 days prior to work)*

SCHEDULE OF WORK ACTIVITY START: *(Date/Time)* END: (Date/Time)

REQUESTOR:

PRIMARY POINT OF CONTACT:	PHONE/PAGER:
SECONDARY POINT OF CONTACT:	PHONE/PAGER:

NOTIFY	☐	Control Room, Phone	☐	Security, Phone

BUILDING:	LOCATION OF WORK FLOOR/LEVEL:

DESCRIPTION OF WORK: *(Provide sufficient details on process isolation, work sequencing, and safety (i.e., control of significant hazards unique to the work) to demonstrate an understanding of the work and how it will be completed within the constraints, and its impact on the processes and facility.)*

Task Summary:

Processes Affected:

Trades Affected:

WORK PLAN:

Work Sequencing:

Process Isolation:

Spill Prevention Plan:

Contingency Plans:

CRITICAL EQUIPMENT/TOOLS: *(pumps and discharge hoses with correct fittings, blind flanges and pipe plugs, no-hub fittings, properly sized electrical service components, generators, portable lighting, chlorine for potable water pipe breaks, etc.)*

☐	Acoustic Ceiling/or Walls Access	☐	Excavation Permit	☐	Lock Out/Tag Out
☐	Chemical Use Approval	☐	Fire Sprinkler Impairment	☐	Life Safety Systems
☐	Confined Space Permit	☐	Flammable Materials	☐	Roof Protocol
☐	Critical Lift Plan	☐	Flush / Discharge	☐	Work After Dark
☐	Energized Electrical Work	☐	High Pressure Test	☐	
☐	Elect. Panel Schedules	☐	Hot Work/Open Flame	☐	

EXISTING SERVICE(S) AT RISK:							
☐	Breathing Air	☐	Elect Normal	☐	Process Access	☐	Telephones
☐	Chemical Distribution	☐	Fire Protection	☐	Safety Showers	☐	UPS
☐	City Water	☐	HVAC	☐	SCADA	☐	VAX/DATA
☐	Communication	☐	Inert Gas	☐	Security	☐	
☐	Domestic Drain	☐	Instrument - Air	☐	Solvent Drain	☐	
☐	Elect-Bus Duct	☐	Life Safety System	☐	Specialty Gases	☐	
☐	Elect Emergency	☐	Natural Gas	☐	Storm Drain	☐	

REVIEWER'S
INSTRUCTIONS / COMMENTS: _____

☐ PREJOB BRIEFING MUST BE COMPLETED PRIOR TO COMMENCING WORK:

	Full Name (printed)	**Signature**	**Phone**	**Date**
Submitted By				
System Owner				
Reviewer (if needed)				
Reviewer (if needed)				
Reviewer (if needed)				
Reviewer (if needed)				

ATTACHMENT C - READINESS CHECKLIST

READINESS CHECKLIST
(5 days prior to work)

Checklist provided as a guide but is not all inclusive.

1. Confirm all parts and materials are on site: _____
2. Review work plan: _____
3. Review contingency plan: _____

ATTACHMENT D - SAFETY CHECKLIST

SAFETY CHECKLIST
(Just prior to commencing work)

Checklist provided as a guide but is not all inclusive.

1. Location awareness:
   a. Emergency exits: _____
   b. Emergency shower and eyewash: _____
   c. Telephones and phone numbers: _____
   d. Shut-off valve: _____
   e. Electrical disconnects: _____
2. Inspect work area:
   a. Take time to survey the area you are working in. Ensure that what you want to do will work. Do you have enough clearance? Is your footing secure? Do you have adequate lighting and ventilation? Are surrounding utilities out of the way for you to perform your work?
3. SDS (Safety Data Sheets):
   a. Understand the chemicals and substances in the area you are working in by reading the SDS.
4. Lockout/Tagout Procedure:
   a. Lockout/tagout energy sources before beginning work.
   b. Make sure all valves associated with the work are locked out and tagged out on each side of the penetration.
   c. Make sure the lines are depressurized.
5. Overhead work:
   a. Use appropriate personal protective equipment; i.e., safety harness, lifeline, etc.
   b. Select appropriate tie-off points; i.e., structurally adequate, not a pipe or conduit, etc.
   c. Spotter assigned and in position.
   d. Pipe rack access; i.e., check design capacity, protective decking or scaffolding in place, exposed valves or electrical switches identified and protected.
6. Safety equipment:
   a. Shepherd's hook.
   b. ARC flash protection.
   c. Fire extinguisher.
   d. Other: _____.
7. Accidents:
   a. Should accidents occur, do not shut off and do not attempt to correct the situation, unless you are absolutely positive that your action will correct the problem and not adversely affect other people or equipment.
8. Review process start-up documents:
   a. In the event the system is shutdown, the Control Center should have a working knowledge of the process start-up procedures in order to deal effectively with unforeseen events.
9. Evacuation procedures:
   a. Do not obstruct evacuation routes.
   b. Take time to survey the area for evacuation routes.

ATTACHMENT E - METHOD OF PROCEDURE (MOP) LOG

METHOD OF PROCEDURE (MOP) LOG
Sample

MOP Number	Task Title	Date Requested	Date Approved	Date Work Planned	Work Completed (yes/no)
001					
002					
003					

SECTION 01220

MEASUREMENT AND PAYMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Procedures for measurement and payment of Work under this Contract for lump sum items and unit prices.

1.02 LUMP SUM ITEMS

A. Item 1L: Mobilization:
   1. Measurement:
      a. Includes all work required to mobilize to the site. Does not include mobilization for excavation and temporary excavation support equipment.
      b. Measurement for payment shall be Lump Sum.
   2. Payment:
      a. Lump sum.

B. Item 2L: Demobilization:
   1. Measurement:
      a. Includes all work required to demobilize from the site.
      b. Measurement for payment shall be Lump Sum.
   2. Payment:
      a. Lump sum.

C. Item 3L: Project Management
   1. Measurement:
      a. Includes costs including Contractor's fee for overhead and profit for continuous, full-time management of the Contract as described in the Contract Documents, covering a period of time not less than from the Notice to Proceed through the entire length of the allowable Contract Times specified in the Contract Documents.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

D. Item 4L: Excavation:
   1. Measurement:
      a. Includes all costs related to the excavation and removal of earth and rock from the site to perform the Work. This item also includes costs for mobilization and demobilization of excavation equipment.
      b. Measurement for payment will be Lump sum.
   2. Payment:
      a. Lump sum.

E. Item 5L: Temporary Excavation Support:
   1. Measurement:
      a. Requirements as specified in Section 02260 - Excavation Support and Protection.
      b. Measurement for payment will be Lump sum.
   2. Payment:
      a. Lump sum.

F. Item 6L: Guard Rail and Bollards:
   1. Measurement:
      a. Includes work required for installation of guard rail, guard rail concrete curb/pad, and bollards with chain for the project.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

G. Item 7L: Retrofit Existing Wet Well:
   1. Measurement:
      a. Includes all costs related to demolition, removal, and disposal of the existing pump station wet well and pump station equipment as well as installation of new improvements to retrofit the wet well.
      b. Includes installation of new sanitary sewer pipeline to new wet well.
      c. Measurement for payment will be Lump sum.
   2. Payment:
      a. Lump sum.

H. Item 8L: Construct New Pump Station, Valve Vault, and Utility Vaults:
   1. Measurement:
      a. Includes all work required for installation of pump station wet well, valve vault, PGE vault, Comcast vault, and Lumen vault including pumps, piping, valves, instrumentation, and conduits/conductors.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

I. Item 9L: Electrical, Instrumentation and Controls:
   1. Measurement:
      a. Includes work required for installation of new electrical panels, instrumentation, conduits, wiring/conductors, and associated equipment pads.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

J. Item 10L: Storm Water Infrastructure:
   1. Measurement:
      a. Includes all work required for installation of stormwater drain and piping.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

K. Item 11L: Final Construction Survey:
   1. Measurement:
      a. Includes all work required for final survey of the completed construction site for determination of net cut/fill.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

L. Item 12L: Commissioning:
   1. Measurement:
      a. Includes all work required for commissioning all pump station equipment, instrumentation and controls. This item also includes all submittal and meetings required for start up and commissioning work including development of contractor operation and maintenance manuals.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

M. Item 13L: Traffic Control:
   1. Measurement:
      a. Includes work required for management, including, but not limited to, temporary striping, signage, delineators, K-rails, cones, labor, flagmen, temporary fence, and equipment necessary for traffic control during the course of the work.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

N. Item 14L: Dust Control and Storm Water Pollution Prevention:
   1. Measurement:
      a. Includes work required for dust control and storm water pollution prevention including all erosion and sediment control measures.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

O. Item 15L: Demolition Work:
   1. Measurement:
      a. Includes work required demolition, removal, and disposal of vegetation (including trees) as well as conduits, piping (not included Asbestos Cement Pipe), pavement, and other items marked for demolition and removal.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

P. Item 16L: Closeout:
   1. Measurement:
      a. Includes work required for close-out of project as described in Specification Section 01770 – Close Out Procedures.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

Q. Item 17L: Plantings:
   1. Measurement:
      a. Includes work required for supplying and establishing plantings and installation of topsoil as defined in the landscaping drawings.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

R. Item 18L: Temporary Bypass Pumping:
   1. Measurement:
      a. Includes work required to provide bypass pumping to maintain continuous service for the Calaroga Sanitary Sewer Pump Station. See Specification Section 02552 – Temporary Bypass Pumping for requirements.
      b. Measurement for payment shall be by week.
   2. Payment:
      a. Lump sum.

S. Item 19L: All other costs required to complete all Work in the Contract Documents not covered by the other Line Items:
   1. Measurement:
      a. All other costs required to complete all Work in the Contract Documents not covered by the other Line Items.
      b. Measurement for payment shall be by percent complete.
   2. Payment:
      a. Lump sum.

1.03 UNIT PRICE ITEMS

A. Measurement of quantities:
   1. Work paid at a unit price times number of units measured will be measured by Engineer in accordance with United States Standard Measures:
      a. 1 ton shall consist of 2,000 pounds avoirdupois.
   2. Provide and pay for accurate scales:
      a. Use platform scales of sufficient size and capacity to permit the entire vehicle or combination of vehicles to rest on the scale platform while being weighed.
      b. Combination vehicles may be weighed as separate units provided they are disconnected while being weighed.
      c. Have scales inspected and certified as often as necessary to ascertain accuracy.
      d. Furnish weigh slips and daily summary weigh sheets to Engineer.

e. When material is shipped by rail, certified car weights will be acceptable, provided that not more than the actual weight of material will be paid, without consideration of minimum car weight used for assessing freight tariff:
    1) Car weight will not be acceptable for materials passing through mixing plants.
f. Daily, or at shorter intervals when necessary to ensure accuracy, weigh empty trucks used to haul material paid by weight:
    1) Provide such trucks with plain, unique, permanent, legible identification marks.

3. Reinforcing steel, steel shapes, castings, and similar items paid by weight will be measured by handbook weights for the type and quantity indicated for the Work.

B. Item 1U: Gabion Retaining Wall:
1. Measurement:
    a. Includes work for constructing new gabion basket retaining wall as indicated on the Drawings and as required per Specification Section 02337 – Gabion Basket Retaining Walls.
    b. Also included is preparation of wall foundation and installation of appurtenances (drain rock, drain piping and filter fabric) and associated design by supplier.
    c. Measurement for payment shall be based on square foot of wall facing as measured on backside (pump station) facing.
2. Payment:
    a. Square feet.

C. Item 2U: Temporary Dewatering:
1. Measurement:
    a. Requirements as specified in Section 02241 - Dewatering.
    b. Measurement for payment will be weekly.
2. Payment:
    a. Week.

D. Item 3U: Existing Forcemain Demolition and Disposal:
1. Measurement:
    a. Includes all work required for removal, handling, and disposal of existing 4-inch in asbestos cement pipe.
    b. Disposal and handling shall meet requirements of Specification Section 01354 – Hazardous Material Procedures.
    c. Measurement for payment shall be by linear foot as measure horizontally.
2. Payment:
    a. Linear feet.

E. Item 4U: Subgrade Probing and Grouting
1. Measurement:
    a. Includes work required for the management of probing and grouting activities including, but not limited to, mobilization of equipment, developing suitable drilling methods, grouting procedures, grout mixing parameters, furnishing, handling, transporting, storing, mixing and injecting of grouting materials, handling and disposal of drill cuttings,

wastewater, and waste grout, cleanup of the areas upon completion of work, and all equipment materials, and other incidentals to complete the work as specified in Specification Section 02256 – Subgrade Probing and Grouting. Collection of the grout samples shall be included in these costs.

b. Measurement for payment will be by probe hole.

2. Payment:
   a. Number of probe holes.

F. Item 5U: New Paving:
   1. Measurement:
      a. Includes all work required for installation of paving for the project as indicated on the Drawings and described in Specification Section 02742 – Asphaltic Concrete Paving.
      b. Measurement for payment shall be by square feet of paved area.
   2. Payment:
      a. Square foot.

G. Item 6U: Aggregate Base Course:
   1. Measurement:
      a. Includes all work required for transporting, installing, and compacting of aggregate base course as described in Specification Section 02300 – Earthwork.
      b. Includes all costs related to importing and backfilling site to approximate elevations and rough and final grading of the site. This item also includes costs for mobilization and demobilization of grading and backfill equipment.
      c. Measurement for payment shall be by ton of aggregate base course.
   2. Payment:
      a. Ton.

H. Item 7U: New Forcemain:
   1. Measurement:
      a. Includes all work required for installation of new 4-inch raw sewage force main from Valve Vault to connection to existing force main in the street. Includes also all pavement and ground restoration required in and adjacent to street to restore ground to existing conditions.
      b. Measurement for payment shall be by linear foot as measure horizontally.
   2. Payment:
      a. Linear feet.

I. Item 8U: Interlocking Block Retaining Wall:
   1. Measurement:
      a. Includes all work required for installation of the interlocking block retaining wall described in the Contract Documents. See Specification Section 02836 – Interlocking Block Retaining Wall for additional requirements.
      b. Measurement for payment shall be by square foot as measure on block face.
   2. Payment:
      a. Square Feet.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01260

CONTRACT MODIFICATION PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Administrative and procedural requirements for executing a change in the Work.

1.02 PRELIMINARY REQUIREMENTS

A. Change Order Cost Basis Summary Form:
   1. Submit a sample to Engineer for review within 15 calendar days following Notice to Proceed.
      a. Items will be reviewed and their value, percentage, or calculation method mutually agreed to by the Contractor and Owner prior to executing a Change Order on the Project.
   2. Used by the Contractor for pricing each Change Order required for additions, deletions, or revisions in the Work.
   3. Include the following information:
      a. Agreed upon markups, percentages, and procedures for calculating all surcharges, etc. associated with the Cost of the Change Order Work.
      b. References for unit price information and special unit price information.
      c. Attachments with the following information:
         1) Certified labor rates breakdown.
         2) Equipment rates.
         3) Bond and insurance rates (PI&I).

1.03 REQUEST FOR INFORMATION OR INTERPRETATION (RFI)

A. Contractor may issue RFIs to request interpretation of the documents or to request for information that may be missing.

B. General Instructions:
   1. Number RFIs consecutively.
      a. Add a consecutive letter to the RFI number on modified submittals of the same RFI (i.e., RFI 4B).
   2. Provide RFI for 1 item.
      a. There may be exceptions when multiple items are so functionally related that expediency indicates review of the group of items as a whole.
      b. RFIs with multiple items will be rejected without review.
   3. Contractor sign and date RFIs indicating review and approval.
      a. Contractor’s signature indicates that they have satisfied RFI review responsibilities and constitutes Contractor's written approval of RFI.
      b. RFIs without Contractor's signature will be returned to the Contractor unreviewed. Subsequent submittal of this information will be counted as the first resubmittal.

C. Engineer will render a written clarification, interpretation, or decision on the issue submitted or initiate an amendment or supplement to the Contract within 21 days.
    1. In the event the Contractor identifies an RFI as critical to the progress of the project, Engineer will make every effort to reduce the RFI response time.

1.04 PRELIMINARY PROCEDURES

A. Owner or Engineer may initiate changes by submitting a Request for Proposal (RFP) to Contractor including the following information:
    1. Detailed description of the Change, Products, and location of the change in the Project.
    2. Supplementary or revised drawings or specifications.
    3. Projected time span for making the change, and a specific statement if overtime work is authorized.
    4. A specific period of time during which the requested price will be considered valid.
    5. Such request is for information only, and is not an instruction to execute the changes, or to stop work in progress.

B. Contractor may initiate changes by submitting a Change Proposal to Engineer containing the following:
    1. Description of proposed changes.
    2. Reason for making changes.
    3. Specific period of time during which requested price will be considered valid.
    4. Effect on Total Contract Cost and/or Contract Time.
    5. Documentation supporting any change in Total Contract Cost and/or Contract Time, as appropriate.

1.05 WORK CHANGE DIRECTIVE AUTHORIZATION

A. In lieu of a Request for Proposal (RFP), Engineer may issue a Work Change Directive Authorization for Contractor to proceed with a change for subsequent inclusion in a Change Order.

B. Authorization will describe changes in the Work, both additions and deletions, with attachments of revised Contract Documents to define details of the change and will designate method of determining any change in the Contract Sum and/or the Contract Time, as appropriate.

C. Owner and Engineer will sign and date the Work Change Directive Authorization as authorization for the Contractor to proceed with the changes.

D. Contractor may sign and date the Work Change Directive Authorization to indicate agreement with the terms.

1.06 DOCUMENTATION OF CHANGE PROPOSALS

A. Change proposal:
    1. Support with sufficient substantiating data to allow Engineer to evaluate the quotation.
        a. Lump sum.

b. Unit prices: Use previously established unit prices.
c. Time-and-material/force account basis:
    1) Name of the Owner's authorized agent who ordered the work, and date of the order.
    2) Dates and times work was performed, and by whom.
    3) Time record, summary of hours worked, and hourly rates paid.
    4) Receipts and invoices for:
        a) Equipment used, listing dates and times of use.
        b) Products used, listing of quantities.
        c) Subcontracts.

2. Provide additional data to support time and cost computations:
    a. Labor required.
    b. Equipment required.
    c. Products required:
        1) Recommended source of purchase and unit cost.
        2) Quantities required.
    d. Taxes, insurance, and bonds.
    e. Credit for work deleted from Contract, similarly documented.
    f. Overhead and profit.
    g. Justification for change to Contract Time.

1.07 PREPARATION OF CHANGE ORDERS AND FIELD ORDERS

A. Engineer will prepare each Change Order and Field Order.

B. Change Orders:
    1. Will describe changes in the Work, both additions and deletions, with attachments of revised Contract Documents to define details of the change.
    2. Will provide an accounting of the adjustment in the Contract Sum and in the Contract Time.
    3. Recommendation of Change Proposal is indicated by Engineer's signature.
    4. Upon signature and execution by Owner, the Change Proposal becomes a Change Order altering the Contract Time and Total Contract Cost, as indicated.
        a. Owner's Representative will transmit one signed copy each to Contractor and Engineer.
    5. Contractor may only request payment for changes in the Work against an approved Change Order.
    6. If either Engineer or Owner's Representative disapproves the Change Proposal, the reason for disapproval will be stated.
        a. A request for a revised proposal or cancellation of the proposal will be shown.

C. Field Orders:
    1. Order minor changes in the Work without changes in Contract Price or Contract Times.

1.08 LUMP-SUM/FIXED PRICE CHANGE ORDER

A. Content of Change Orders will be based on, either:
   1. Engineer's Proposal Request and Contractor's responsive Change Proposal as mutually agreed between Owner and Contractor.
   2. Contractor's Change Proposal for a change, as recommended by Engineer.

B. Owner and Engineer will sign and date the Change Order to establish the change in Contract Sum and in Contract Time and serve as authorization for the Contractor to proceed with the changes.

C. Contractor will sign and date the Change Order to indicate agreement with the terms.

1.09 UNIT PRICE CHANGE ORDER

A. Content of Change Orders will be based on, either:
   1. Engineer's definition of the scope of the required changes.
   2. Contractor's Change Proposal for a change, recommended by Engineer.
   3. Survey of completed work.

B. The amounts of the unit prices to be:
   1. Those stated in the Contract.
   2. Those mutually agreed upon between Owner and Contractor.

C. When quantities of each of the items affected by the Change Order can be determined prior to start of the work:
   1. Owner and Engineer will sign and date the Change Order as authorization for Contractor to proceed with the changes.
   2. Contractor will sign and date the Change Order to indicate agreement with the terms.

D. When quantities of the items cannot be determined prior to start of the work:
   1. Engineer or Owner will issue a Work Change Directive authorization directing Contractor to proceed with the change on the basis of unit prices, and will cite the applicable unit prices.
   2. At completion of the change, Engineer will determine the cost of such work based on the unit prices and quantities used.
   3. Contractor shall submit documentation to establish the number of units of each item and any claims for a change in Contract Time.

E. Owner and Engineer will sign and date the Change Order to establish the change in Contract Sum and in Contract Time and serve as authorization for the Contractor to proceed with the changes.

F. Contractor will sign and date the Change Order to indicate their agreement with the terms.

1.10 TIME AND MATERIAL/FORCE ACCOUNT CHANGE ORDER/WORK CHANGE DIRECTIVE AUTHORIZATION

A. Engineer will issue a Work Change Directive for the Owner's signature authorizing Contractor to proceed with the changes.

B. At completion of the change, Contractor shall submit itemized accounting and supporting data as specified in this Section.

C. Engineer will determine the allowable cost of such work, as provided in the Contract Documents.

D. Owner and Engineer will sign and date the Change Order to establish the change in Contract Sum and in Contract Time and serve as authorization for the Contractor to proceed with the changes.

E. Contractor will sign and date the Change Order to indicate their agreement.

1.11 CORRELATION WITH CONTRACTOR'S SUBMITTALS

A. Periodically revise Schedule of Values and Applications for Payment forms to record each Change Order as a separate item of Work, and to record the adjusted Contract Sum.

B. Periodically revise the Construction Schedule to reflect each change in Contract Time. Revise subschedules to show changes for other items of work affected by the changes.

C. Upon completion of work under a Change Order, enter pertinent changes in Record Documents.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01292

SCHEDULE OF VALUES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for preparation, format, and submittal of Schedule of Values.

1.02 PREPARATION

A. Schedule of Values shall be a listing of all cost loaded, on-site construction activities from the progress schedule, listed in numerical order, showing that the sum total of all cost-loaded activities equal the Contract value.

B. When the schedule is changed or revised to include added or deleted work, the Schedule of Values shall also be revised such that the sum total of all cost-loaded activities continuously equal the current Contract value.
   1. Equate the aggregate of these costs to the Lump Sum Contract Price.

C. Prepare Schedule of Values identifying costs of Major Items of Work.

1.03 SUBMITTALS

A. Submit Schedule of Values for the Preliminary Schedule as specified in, Section 01321 - Schedules and Reports.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01294

APPLICATIONS FOR PAYMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Procedures for preparation and submittal of Applications for Payment.

1.02 FORMAT

A. Develop satisfactory spreadsheet-type form generated by downloading cost data from the Progress Schedule.
   1. Submit payment requests and attach spreadsheet with cost data related to Progress Schedule.

B. Fill in information required on form.

C. When Change Orders are executed, add Change Orders at end of listing of scheduled activities:
   1. Identify change order by number and description.
   2. Provide cost of change order in appropriate column.

D. After completing, submit Application for Payment.

E. Engineer will review application for accuracy. When accurate, Engineer will transmit application to Owner for processing of payment.

F. Execute application with signature of responsible officer of Contractor.

1.03 SUBSTANTIATING DATA

A. Provide Substantiating Data identifying:
   1. Project.
   2. Application number and date.
   3. Cost flow summary.
   4. Updated schedule of values.
   5. Progress schedule.
   6. Detailed list of enclosures.
   7. Stored products log.
   8. Equipment log.
   9. Submit “certified” payroll, if applicable.
   10. Record (as-built) documents.
   11. Photos and videos from current pay period.
   12. Applicable unconditional waiver and release on progress payment for previous payment made by Owner.

1.04 SUBMITTALS

A. Submit Application for Payment and Substantiating Data with cover letter.

1.05 PAYMENT REQUESTS

A. Prepare progress payment requests on a monthly basis. Base requests on the breakdowns of costs for each scheduled activity and the percentage of completion for each activity.

B. Indicate total dollar amount of work planned for every month of the project. Equate sum of monthly amounts to Lump Sum Contract Price.

C. Generate Progress Payment request forms by downloading cost data from the schedule information to a spreadsheet type format.

D. Identify each activity on the Progress Schedule that has a cost associated with it, the cost for each activity, the estimated percent complete for each activity, and the value of work completed for both the payment period and job to date.

E. Prepare summary of cost information for each Major Item of Work listed in the Schedule of Values. Identify the value of work completed for both the payment period and job to date.

F. Payment period:
   1. Monthly Application for Payment period shall begin on the 1st day of each month, and end on the last day of each month.
   2. Submit Application for Payment to Engineer no later than the 5th day of each month for work completed the previous month.
   3. Engineer will finalize and submit recommendation for Application for Payment to Owner by the 15th day of each month to allow time for processing and approval.

1.06 COST SUMMARIES

A. Prepare Summary of Cost Information for each Major Item of Work listed in the Schedule of Values. Identify the Value of Work Completed for both the payment period and job to date.

B. Cash flow summary: Prepare cash flow summary, indicating total dollar amount of work planned for each month of the project. Equate sum of monthly amounts to Lump Sum contract price.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01312

PROJECT MEETINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for conducting conferences and meetings for the purposes of addressing issues related to the Work, reviewing and coordinating progress of the Work and other matters of common interest, and includes the following:
   1. Qualifications of Meeting Participants.
   2. Basic Meeting Requirements
   3. Pre-construction Conference.
   4. Pre-submittal Conference.
   5. Web Based Construction Document Management Software Training.
   6. Progress Meetings.
   7. Pre-Installation Meetings.
   8. Commissioning Coordination Meetings.
   9. Instrumentation and Control Coordination Meetings.
   10. Close-out Meeting.
   11. Post Construction Meeting.

1.02 QUALIFICATIONS OF MEETING PARTICIPANTS

A. Representatives of entities participating in meetings shall be qualified and authorized to act on behalf of entity each represents.

1.03 BASIC MEETING REQUIREMENTS

A. Attendees:
   1. Meeting leader shall require attendance of parties directly affecting, or affected by, Work being discussed at the meeting.

B. Location:
   1. In location convenient for most invitees.

C. Notification:
   1. Meeting leader shall notify attendees of meeting, including an agenda, a minimum of 7 days prior to meeting.

D. Agenda:
   1. Meeting leader shall prepare copies of agenda for participants and distribute at the meeting.
   2. Minimum requirements:
      a. Meeting purpose:
      b. Review minutes of previous meeting.
      c. Safety and security.

d. Discuss issues.
e. Action items.
f. Next meeting.

E. Meeting minutes:
1. Meeting leader shall provide draft minutes within 7 days of meeting and send to all attendees for comment within 7 days.
2. Meeting leader shall incorporate comments from attendees and submit final meeting minutes to attendees within 7 days of receipt of comments.

1.04 PRE-CONSTRUCTION CONFERENCE

A. Owner leads the meeting.

B. Timing:
1. Upon issuance of Notice to Proceed, or earlier when mutually agreeable.

C. Required attendees:
1. Contractor's project manager and superintendent, Owner, Engineer, representatives of utilities, major subcontractors and others involved in performance of the Work, and others necessary to agenda.

D. Agenda minimum requirements:
1. Meeting purpose:
a. To establish working understanding between parties and to discuss Construction Schedule, shop drawing and other submittals, cost breakdown of major lump sum items, processing of submittals and applications for payment, and other subjects pertinent to execution of the Work.
2. Adequacy of distribution of Contract Documents.
3. Distribution and discussion of list of major subcontractors and suppliers.
4. Proposed progress schedules and critical construction sequencing.
5. Major equipment deliveries and priorities.
6. Project coordination.
7. Designation of responsible personnel.
8. Procedures and processing of:
a. Field decisions.
b. Proposal requests.
c. Submittals - separate, meeting.
d. Change Orders.
e. Request for Information/Interpretations.
f. Applications for Payment.
g. Record Documents.
9. Use of premises:
a. Office, construction, and storage areas.
b. Owner's requirements.
10. Construction facilities, controls, and construction aids.
11. Temporary utilities.
12. Safety and first aid procedures.
13. Security procedures.
14. Housekeeping procedures.

15. Safety and security.
16. Review proposed photographer submittal.
17. Action items.
18. Next meeting.

1.05 PRE-CONSTRUCTION SCHEDULING MEETING

A. Engineer leads the meeting.

B. Timing:
   1. Within 7 days of Notice to Proceed, or earlier when mutually agreeable.

C. Required attendees:
   1. Contractor's project manager, superintendent, scheduler, Owner, Engineer, and others necessary to agenda.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. To establish the format and features of the Construction Schedule.
   2. Schedule preparation.
   3. Reporting requirements
   4. Updates and revision procedures.
   5. Schedule delay analysis procedures.
   6. Schedule methodology.
   7. Planned sequence of operations.
   8. Cost and labor loading methodology.
   9. Proposed activity coding structure as specified in Section 01321 - Schedules and Reports.
   10. Naming convention: Name schedule files with the year, month and day of the data date, revision identifier, and a description of the schedule.
      a. Example 1: 2014_07_30 rev 1 draft baseline schedule.xer.
      b. Example 2: 2014_09_30 rev 2 sep final update.xer.
   11. Action items.
   12. Next meeting.

1.06 PRE-SUBMITTAL CONFERENCE

A. Engineer leads the meeting.

B. Timing:
   1. Prior to producing any submittals.

C. Required attendees:
   1. Contractor's project manager and superintendent, Owner, Engineer, representatives of utilities, major subcontractors, individual equipment manufacturers furnishing major pieces of equipment, and others involved in performance of the Work, and others necessary to agenda.

D. Agenda minimum requirements:
    1. Meeting purpose:
        a. Reviewing the entire Project, equipment, schedules, and submittal requirements.
        b. Review the entire Project, equipment, control philosophy, schedules, and submittal requirements.
        c. Awareness of requirements by major subcontractors, major suppliers, and major equipment manufacturers.
        d. Format and procedures for submittals
        e. Review of the master submittal schedule.
    2. Review equipment list.
    3. Review submittal schedule.
    4. Format of submittals.
    5. Procedures and processing of submittals.
        a. Review turn-around time.
    6. Discuss specific electrical and instrumentation and controls submittal requirements.
    7. Safety and security.
    8. Action items.
    9. Next meeting.

1.07 WEB BASED CONSTRUCTION DOCUMENT MANAGEMENT SOFTWARE TRAINING

A. Contractor can submit a written request to the Engineer to waive the training based on staff having sufficient familiarity with the software and its complete usage. Engineer will lead the meeting.

B. Timing:
    1. Upon issuance of Notice to Proceed, or earlier when mutually agreeable,
    2. Duration minimum: 2 hours.

C. Required attendees:
    1. Mandatory attendance.
        a. Contractor’s project manager.
        b. Contractor’s field superintendent.
        c. Contractor’s project engineer.
    2. Other attendees:
        a. Owner, Engineer, Contractor’s quality control manager, Contractor’s project scheduler and any other persons involved with preparing and transmitting documents.

D. Agenda minimum requirements:
    1. Meeting purpose:
        a. Train construction team on the use of the web based document management system software.
    2. Safety.
    3. General Items.
    4. Contractor functions.
    5. Owner functions.
    6. Engineer functions.
    7. Action items.

1.08 PROGRESS MEETINGS

A. Owner will lead the meeting.

B. Timing:
   1. Hold meetings throughout progress of the Work at the following intervals:
      a. While contractor is on site, progress meetings must be held weekly.
      b. During post-substantial completion period and pre-mobilization on site: maximum bi-weekly intervals.
      c. Agenda must be updated weekly and sent to all regular attendees regardless if a meeting occurs.

C. Required attendees:
   1. Owner, Engineer, Contractor, Contractor's Project Manager, superintendent, quality control manager, project scheduler, major subcontractors and suppliers as appropriate to agenda topics for each meeting.
   2. Additional invitees:
      a. Owner utility companies when the Work affects their interests, and others necessary to agenda.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. Provide the status of the Work.
   2. Review minutes of previous meeting.
   3. Safety and security.
   4. Quality control:
      a. Review of out-of-compliance inspection or test results.
      b. Field observations, problems, and decisions.
      c. Review of offsite fabrication and delivery schedules.
      d. Planned progress during succeeding work period.
      e. Coordination of required inspections and tests.
      f. Maintenance of quality and work standards.
   5. Construction schedule summary.
      a. Provide a monthly update to the overall project schedule and identify critical path equipment/submittals/etc.
   6. Review of 6 weeks schedule.
      a. Contractor shall provide printed hard copies for each attendee.
      b. Schedule to include upcoming inspections and special tests in addition to project construction activities.
   7. Review of off-site fabrication and delivery schedules.
   8. Review of submittals schedule and status of submittals.
   9. Request for information (RFI's) status.
   10. MOP's/shutdown coordination.
   11. Change order management status.
   12. Maintenance of quality standards (QA/QC).
   13. Field observations, problems, and conflicts.
   14. Commissioning.
   15. Partnering recognition status (optional).
   16. General Items.
   17. Action items.
   18. Next meeting.

1.09 PRE-INSTALLATION MEETINGS

A. Contractor leads the meeting.

B. Timing:
   1. When specified in Technical Sections or requested by Engineer, before commencing Work of specific section.

C. Required attendees:
   1. Owner, Engineer, Contractor, Contractor's Project Manager, General Superintendent, project scheduler, major subcontractors including electrical instrumentation, and suppliers as appropriate to agenda topics for each meeting.
   2. Additional invitees:
      a. Owner utility companies when the Work affects their interests and others necessary to the agenda.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. Review conditions of installation, preparation and installation procedures.
      b. Review coordination with related work.
   2. Review minutes of previous meeting.
   3. Safety and security.
   4. Action items.
   5. Next meeting.

1.10 PRE-SHUTDOWN MEETINGS

A. Contractor leads the meeting.

B. Timing:
   1. Short-term and longer-term shutdowns and other tie-ins that require an Owner approved MOP require a pre-shutdown meeting at Project site at least 3 working days prior to commencing shutdown for tie-in or modification of specific plant systems.

C. Required attendees:
   1. Require attendance of parties directly affecting, or affected by shutdown, including Engineer, specific work crews, Owner's construction, operations, and maintenance staff.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. Review conditions of installation, preparation, and installation procedures.
      b. Review coordination with related work.
   2. Review minutes of previous meeting.
   3. Review accepted Construction Method of Procedure (MOP), as specified in Attachment A of Section 01140 - Work Restrictions, including conditions of shutdown, preparation, and installation procedures.
   4. Review timelines and sequences.
   5. Review responsibilities.

6. Review dry run plan and schedule, as necessary.
7. Review coordination with related work.
8. Safety and security.
9. Action items.
10. Next meeting.

1.11 COMMISSIONING COORDINATION MEETINGS

A. Contractor leads the meeting.

B. Timing:
   1. Separate commissioning coordination meetings will be scheduled as required by Engineer.

C. Required attendees:
   1. Require attendance of parties directly affecting, or affected by process start-up and testing, including Engineer, Commissioning Coordinator, specific work crews, Owner's operations, and maintenance staff.

D. Agenda minimum requirements:
   1. Meeting purpose:
      a. Coordinate commissioning activities.
   2. Review minutes of previous meeting.
   3. Review Commissioning Schedule.
   4. Review Owner Training Schedule.
   5. Review test plans.
   6. Review accepted Construction Method of Procedure (MOP), as specified in Attachment A of Section 01140 - Work Restrictions.
   7. Owner makes final decision for commissioning GO or NO GO.
   8. Safety and security.
   9. Action items.
   10. Next meeting.

1.12 INSTRUMENTATION AND CONTROL COORDINATION MEETINGS

A. Meetings and conferences as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.13 CLOSE-OUT MEETING

A. Owner leads the meeting.

B. Timing:
   1. After punch list items are completed.

C. Required attendees:
   1. Owner, Engineer, Contractor, Contractor's Project Manager, and Superintendent.

D. Agenda minimum requirements:
    1. Meeting purpose:
        a. Coordinate close-out activities.
    2. Review minutes of previous meeting.
    3. Review punch list completion.
    4. Transfer of record documents.
    5. Finalize payment.
    6. Safety and security.
    7. Action items.
    8. Next meeting.

1.14 POST CONSTRUCTION MEETING

A. Owner leads the meeting.

B. Required attendees:
    1. Engineer, Contractor, appropriate manufacturers, and installers of major units of constructions, affected subcontractors, and Owner's operations and maintenance staff.

C. Timing:
    1. About 11 months after date of Substantial Completion.

D. Location:
    1. Meet in Owner's office or other mutually agreed upon place.

E. Agenda minimum requirements:
    1. Meeting purpose:
        a. Review project for compliance with Contract Documents.
    2. Inspect the Work and draft list of items to be completed or corrected.
    3. Review service and maintenance contracts and take appropriate corrective action when necessary.
    4. Complete or correct defective work and may extend correction period .
    5. Safety and security.
    6. Action items.
    7. Next meeting.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01321

SCHEDULES AND REPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Schedules and reports.

1.02 SUBMITTAL REQUIREMENTS

A. Submit preliminary and baseline schedule.

B. Submit preliminary and baseline schedule of values.

C. Submit preliminary and baseline schedule of submittals.

D. Submit, on a monthly basis, updated schedules as specified.

E. Submit final schedule update as specified.

F. Submit revised schedules and time impact analyses as specified.

G. Submit schedules in the media and number of copies as follows:
   1. Provide each submittal in PDF format and in other formats specified in this Section.
   2. 3 sets of the critical path method (CPM) network and/or bar chart (as specified by the Owner) on 22-inch by 34-inch sheets.
      a. Color-coding to be specified by the Owner.
   3. 3 sets of tabular reports listing all activities sorted numerically identifying duration, early start, late start, early finish, late finish, total float, and all predecessor/successor information.
   4. 2 sets of CPM Schedule data electronic files in a native backed-up file (.xer).

1.03 SCHEDULER

A. Designate, in writing and within 5 calendar days after Notice of Award, the person responsible for preparation, maintenance, updating, and revision of all schedules.

B. Scheduler shall have the authority to act on behalf of Contractor.
   1. A minimum of 5 years verifiable experience in preparation of construction schedules for projects of similar value, size, and complexity.
   2. Knowledge of critical path method (CPM) scheduling utilizing Primavera P6 Professional or Asta Powerproject software.

1.04 SCHEDULING FORMAT

A. Utilize CPM format.

B. Provide a cost and labor loaded schedule.

C. Engineer approval of the format is required.

1.05 SCHEDULING HARDWARE AND SOFTWARE

A. All scheduling software and hardware located on-site.

B. Prepare computerized schedule utilizing the most current version of Oracle Primavera P6 or Asta Powerproject.
   1. Provide 1 licensed copy of the scheduling software to the Engineer, registered in the Engineer's name, for the duration of the Project.
   2. The provided copy of the software shall be a standalone version for installation on a standalone computer.

C. Contractor and Engineer must agree on the format.

1.06 PRE-CONSTRUCTION SCHEDULING MEETING

A. As specified in Section 01312 - Project Meetings.

1.07 REVIEW AND ACCEPTANCE OF SCHEDULES

A. Engineer will review Baseline Schedule, Schedule Updates, Schedule Revisions and Time Impact Analyses to ascertain compliance with specified project constraints, compliance with milestone dates, durations and sequence, accurate inter-relationships, and completeness.

B. Engineer and Owner will issue written comments following completion of review of Baseline Schedule within 21 calendar days after receipt.

C. Written comments on review of Schedule Updates and Schedule Revisions and Time Impact Analyses will be returned to Contractor within 14 calendar days after receipt by Engineer.

D. Revise and resubmit schedule in accordance with Engineer's comments within 7 calendar days after receipt of such comments or request joint meeting to resolve objections.

E. If Engineer requests a meeting, the Contractor and all major subcontractors must participate in the meeting with Engineer.
   1. Revise and resubmit schedule within 7 calendar days after meeting.

F. Use accepted schedule for planning, organizing, and directing the work and for reporting progress.

G. Engineer's submittal review response:
   1. When schedule reflects Owner's and Contractor's agreement of project approach and sequence, schedule will be accepted by Owner.
   2. Engineer's submittal review response for schedule submittal will be "Receipt Acknowledged - Filed for Record" including applicable comments.

3. Acceptance of the schedules by the Owner is for general conformance with the Contract Documents and for Owner's planning information and does not relieve the Contractor of sole responsibility for planning, coordinating, and executing the Work within the contract completion dates.
    a. Omissions and errors in the accepted schedules shall not excuse performance less than that required by the Contract Documents.
    b. Acceptance by the Owner in no way constitutes an evaluation or validation of the Contractor's plan, sequence or means, methods, and techniques of construction.

1.08 SCHEDULE UPDATES

A. Any update:
    1. Prepare update using most recent accepted version of schedule including:
        a. Actual start dates of activities that have been started.
        b. Actual finish dates of activities that have been completed.
        c. Percentage of completion of activities that have been started but not finished.
        d. Actual dates on which milestones were achieved.
        e. Update activities by inputting percent complete figures with actual dates.
        f. Use retained logic in preparing Schedule Updates.
        g. When necessary, input remaining durations for activities whose finish dates cannot be calculated accurately with a percent complete figure only.
        h. Revisions to the schedule may be included that have been previously approved as specified in this Section under Revisions to Schedule.

B. Monthly updates:
    1. Submit written narrative report in conjunction with each Schedule Update including descriptions of the following:
        a. Activities added to or deleted from the schedule are to adhere to cost and other resource loading requirements.
            1) Identify added activities in manner distinctly different from original activity designations.
        b. Changes in sequence or estimated duration of activities.
        c. Current or anticipated problems and delays affecting progress, impact of these problems and delays and measures taken to mitigate impact.
        d. Assumptions made and activities affected by incorporating change order work into the schedule.
    2. Submit updated schedule and materials specified under Submittal of Progress Schedules, 5 calendar days before the monthly schedule update meeting.
    3. Since Monthly Schedule Update is the application for progress payment required as specified in Section 01294 - Applications for Payment, submittal and acceptance of the monthly Schedule Update is a condition precedent to the making of any progress payments.

C. Weekly progress meeting:
    1. Update the schedule prior to weekly progress meeting.
        a. Identify overall progress of each Major Item of Work in the Summary Schedule.
        b. If there are significant changes to the schedule, submit a written report at the weekly progress meeting.

2. Should monthly Schedule Update show project completion earlier than current Contract completion date, show early completion time as schedule activity, identified as “Project Float”.
3. Should monthly Schedule Update show project completion later than current Contract completion date, prepare and submit a Schedule Revision in accordance with the Revisions to Schedule.

1.09 REVISIONS TO SCHEDULE

A. Submit Revised Schedule within 5 days:
   1. When delay in completion of any activity or group of activities indicates an overrun of the Contract Time or milestone dates by 20 working days or 5 percent of the remaining duration, whichever is less.
   2. When delays in submittals, deliveries, or work stoppages are encountered making necessary the replanning or rescheduling of activities.
   3. When the schedule does not represent the actual progress of activities.
   4. When any change to the sequence of activities, the completion date for major portions of the Work, or when changes occur which affect the critical path.
   5. When Contract modification necessitates schedule revision, submit schedule analysis of change order work with cost proposal.

B. Create a separate submittal for Schedule Revisions.
   1. Comply with schedule updates as specified in this Section.
   2. Do not submit with Schedule Updates.

C. Schedule Revisions will not be reflected in the schedule until after the revision is accepted by the Owner.
   1. This includes Schedule Revisions submitted for the purpose of mitigating a Contractor-caused project delay (Recovery Schedule).

1.10 ADJUSTMENT OF CONTRACT TIME OR PRICE

A. Contract Time will be adjusted only for causes specified in Contract Documents.
   1. Non-excusable delay:
      a. Non-excusable delays include actions or inactions of the Contractor, or events for which the Contractor has assumed contractual responsibility (including actions or inactions of subcontractors, suppliers, or material manufacturers at any tier) that would independently delay the completion of the Work beyond the current Contract completion date).
      b. No time extensions will be granted for non-excusable delays.
   2. Excusable delay:
      a. Events which are unforeseeable, outside the control of, and without the fault or negligence of either the Owner or the Contractor (or any party for whom either is responsible), which would independently delay the completion of the Work beyond the current Contract completion date.
      b. The Contractor may be entitled to a time extension only.
      c. No other damages will be approved.

3. Compensable delay:
    a. Actions or inactions of the Owner, or events for which the Owner has assumed contractual responsibility, which would independently delay the completion of the Work beyond the current Contract completion date.
    b. The Contractor may be entitled to a time extension and delay damages.
4. Concurrent delay:
    a. Concurrent delay is any combination of the above 3 types of delay occurring on the same calendar date.
    b. Exception to concurrent delay:
        1) Cases where the combination consists of 2 or more instances of the same type of delay occurring on the same calendar date.
        2) When one cause of delay is Owner-caused or caused by an event which is beyond the control and without the fault or negligence of either the Owner or the Contractor and the other Contractor-caused, the Contractor may be entitled only to a time extension and no delay damages.

CONTRACTOR'S ELIGIBILITY FOR TIME AND/OR EXTENDED OVERHEAD				
DELAY TYPE	**NONCONCURRENT DELAY**	**DELAY CONCURRENT WITH**		
Nonexcusable	X	X	T	T
Compensable	TEO	T	TEO	T
Noncompensable	T	T	T	T
Notes: Eligibility: X - No Time and No Extended Overhead; T: Time; EO: Extended Overhead				

B. If the Contractor believes that the Owner has impacted its work, such that the project completion date will be delayed, the Contractor must submit proof demonstrating the delay to the critical path.
    1. This proof, in the form of a Time Impact Analysis, may entitle the Contractor to an adjustment of Contract Time or Contract Price.

C. Time Impact Analysis:
    1. Use the accepted schedule update that is current relative to the time frame of the delay event (change order, third party delay, or other Owner-caused delay). Represent the delay event in the schedule by:
        a. Inserting new activities associated with the delay event into the schedule.
        b. Revising activity logic.
        c. Revising activity durations.
    2. If the project schedule's critical path and completion date are impacted as a result of adding this delay event to the schedule, a time extension equal to the magnitude of the impact may be warranted.
    3. The Time Impact Analysis submittal must include the following information:
        a. A fragment of the portion of the schedule affected by the delay event.
        b. A narrative explanation of the delay issue and how it impacted the schedule.
        c. A schedule file used to perform the Time Impact Analysis.

D. When a delay to the project as a whole can be avoided by revising preferential sequencing or logic, and the Contractor chooses not to implement the revisions, the Contractor will be entitled to a time extension and no compensation for extended overhead.

E. Indicate clearly that the Contractor has used, in full, all project float available for the Work involved in the request, including any float that may exist between the Contractor's planned completion date and the Contract completion date.
   1. Utilize the latest version of the Schedule Update accepted at the time of the alleged delay, and all other relevant information, to determine the adjustment of the Contract Time.

F. Adjustment of the Contract Times will be granted only when the Contract Float has been fully utilized and only when the revised date of completion of the Work has been pushed beyond the Contract completion date.
   1. Adjustment of the Contract Times will be made only for the number of days that the planned completion of the work has been extended.

G. Actual delays in activities which do not affect the critical path Work or which do not move the Contractor's planned completion date beyond the Contract completion date will not be the basis for an adjustment to the Contract Time.

H. If completion of the project occurs within the specified Contract Time, the Contractor is not entitled to job-site or home office overhead beyond the Contractor's originally planned occupancy of the site.

I. Notify Engineer of a request for Contract Time adjustment.
   1. Submit request as specified in the Contract Documents.
   2. In cases where the Contractor does not submit a request for Contract Time adjustment for a specific change order, delay, or Contractor request within the specified period of time, then it is mutually agreed that the particular change order, delay, or Contractor request has no time impact on the Contract completion date and no time extension is required.

J. The Engineer will, within 30 calendar days after receipt of a Contract Time adjustment, request any supporting evidence, review the facts, and advise the Contractor in writing.
   1. Include the new Progress Schedule data, if accepted by the Owner, in the next monthly Schedule Update.
   2. When the Owner has not yet made a final determination as to the adjustment of the Contract Time, and the parties are unable to agree as to the amount of the adjustment to be reflected in the Progress Schedule, reflect that amount of time adjustment in the Progress Schedule as the Engineer may accept as appropriate for such interim purpose.
   3. It is understood and agreed that any such interim acceptance by the Engineer shall not be binding and shall be made only for the purpose of continuing to schedule the Work, until such time as a final determination as to any adjustment of the Contract Time acceptable to the Engineer has been made.
   4. Revise the Progress Schedule prepared thereafter in accordance with the final decision.

1.11 SCHEDULE PREPARATION

A. Preparation and submittal of Progress Schedule represents Contractor's intention to execute the Work within specified time and constraints.

B. All costs associated with schedule requirements are included in the Contract Price.

C. During preparation of the preliminary Progress Schedule, Engineer will facilitate Contractor's efforts by answer questions regarding sequencing issues, scheduling constraints, interface points, and dependency relationships.

D. Prepare schedule utilizing Precedence Diagramming Method (PDM).

E. Prepare schedule utilizing activity durations in terms of working days.
   1. Do not exceed 15 working day duration on activities except concrete curing, submittal review, and equipment fabrication and deliveries.
   2. Where duration of continuous work exceeds 15 working days, subdivide activities by location, stationing, or other sub-element of the Work.
   3. Coordinate holidays to be observed with the Owner and incorporate them into the schedule as non-working days.

F. Failure to include an activity required for execution of the Work does not excuse Contractor from completing the Work and portions thereof within specified times and at price specified in Contract.
   1. Contract requirements are not waived by failure of Contractor to include required schedule constraints, sequences, or milestones in schedule.
   2. Contract requirements are not waived by Owner’s acceptance of the schedule. In event of conflict between accepted schedule and Contract requirements, terms of Contract govern at all times, unless requirements are waived in writing by the Owner.

G. Reference schedule to working days with beginning of Contract Time as Day "1".

H. Baseline Schedule and Project Completion:
   1. Should Contractor submit a Baseline Schedule showing project completion more than 20 working days prior to Contract completion date, Owner may issue Change Order, at no cost to Owner, revising time of performance of Work and Contract completion date to match Contractor’s schedule completion date.
   2. Adjust accordingly any Contract milestone dates.

I. Imposed dates and hidden logic are prohibited.

J. Interim milestone dates, operational constraints:
   1. In event there are interim milestone dates and/or operational constraints set forth in Contract, show them on schedule.
   2. Do not use Zero Total Float constraint or Mandatory Finish Date on such Contract requirements.

K. Contract float is for the mutual benefit of both Owner and Contractor.
   1. Changes to the project that can be accomplished within this available period of float may be made by Owner without extending the Contract Time, by utilizing float.
   2. Time extensions will not be granted nor delay damages owed until Work extends beyond currently accepted Contract completion date.
   3. Likewise, Contractor may utilize float to offset delays other than delays caused by Owner.
   4. Mutual use of float can continue until all available float shown by schedule has been utilized by either Owner or Contractor, or both. At that time, extensions of the Contract Time will be granted by Owner for valid Owner-caused or third party-caused delays which affect the planned completion date and which have been properly documented and demonstrated by Contractor.
   5. Non-sequestering of float: Pursuant to float sharing requirements of Contract, schedule submittals can be rejected for, use of float suppression techniques such as preferential sequencing or logic, special lead or lag logic restraints, extended activity durations or imposed dates.

L. Resource loading and leveling:
   1. Input labor data on each schedule activity.
   2. Manpower data consists of the man-hours estimated to perform each task, categorized by trade.
   3. Provide leveled manpower requirements.
      a. Availability of the resources drive activity duration.

M. Cost loading: All schedules:
   1. Only on-site construction activities.
   2. The sum total of all cost loaded activities equal to the current value of the Contract, including change orders, at all times.
   3. Owner acceptance of the Baseline Schedule creates the Schedule of Values required as specified in Section 01292 - Schedule of Values
   4. Provide updated Schedule of Values as the monthly Payment Application as specified in Section 01294 - Applications for Payment.
   5. Payments will not be made until updated Schedule of Values is accepted.

N. Schedule logic:
   1. Assembled to show order in which Contractor proposes to carry out Work, indicate restrictions of access, availability of Work areas, and availability and use of manpower, materials, and equipment.
   2. Form basis for assembly of schedule logic on the following criteria:
      a. Which activities must be completed before subsequent activities can be started?
      b. Which activities can be performed concurrently?
      c. Which activities must be started immediately following completed activities?
      d. What major facility, equipment, or manpower restrictions are required for sequencing these activities?

O. Commissioning schedule:
   1. Commissioning activities and milestones (As specified in Section 01756 - Commissioning) shall be an integral part of the overall project schedule.
   2. Commissioning activities and milestones shall be extracted from the main project schedule to provide a separate commissioning schedule that is submitted each time the project schedule is submitted.

1.12 NETWORK DETAILS AND GRAPHICAL OUTPUT

A. Produce a clear, legible, and accurate calendar based, time scaled, and graphical network diagram.
   1. Group activities related to the same physical areas of the Work. Produce the network diagram based upon the early start of all activities.

B. Include for each activity, the description, activity number, estimated duration in working days, total float, and all activity relationship lines.

C. Illustrate order and interdependence of activities and sequence in which Work is planned to be accomplished.
   1. Incorporate the basic concept of the precedence diagram network method to show how the start of 1 activity is dependent upon the start or completion of preceding activities and its completion restricts the start of following activities.

D. Provide schedule showing the critical path for the project.
   1. Critical Path is defined as a sequence of activities that has zero total float.

E. Provide report of Near Critical Path activities for the project, when required by Engineer.
   1. Near Critical Path activities are those with 15 working days or less of float.

F. Delineate the specified contract duration and identify the planned completion of the Work as a milestone.
   1. Show the time period between the planned and Contract completion dates, if any, as an activity identified as project float.

G. Identify system shutdown dates, system tie-in dates, specified interim completion or milestone dates and contract completion date as milestones.

H. Include, in addition to construction activities:
   1. Submission dates and review periods for major equipment submittals, shoring submittals, and indicator pile program:
      a. Shoring reviews: Allow 4-week review period for each shoring submittal.
      b. Pile indicator program: Allow 3-week review period for analysis of program.
   2. Any activity by the Owner or the Engineer that may affect progress or required completion dates.
   3. Equipment and long-lead material deliveries over 8 weeks.
   4. Approvals required by regulatory agencies or other third parties.

I. Produce network diagram on 22-inch by 34-inch sheets with grid coordinate system on the border of all sheets utilizing alpha and numeric designations.

J. Identify the execution of the following:
   1. Mobilization.
   2. All required submittals and submittal review times showing 30 calendar day duration for such activities and equal amount of time for re-submittal reviews.
   3. Equipment and materials procurement/fabrication/delivery.
   4. Excavation.
   5. Shoring design and submission of detailed shoring submittals. Identify submission as a milestone.
   6. Shoring review, shoring materials procurement, shoring installation, and shoring removal.
   7. Backfill and compaction.
   8. Dewatering.
   9. Grading, subbase, base, paving, and curb and gutters.
   10. Fencing and landscaping.
   11. Concrete, including installation of forms and reinforcement, placement of concrete, curing, stripping, finishing, and patching.
   12. Tests for leakage of concrete structures intended to hold water.
   13. Metal fastenings, framing, structures, and fabrications.
   14. Waterproofing and dampproofing, insulation, roofing and flashing, and sealants.
   15. Doors and windows, including hardware and glazing.
   16. Finishes including coating and painting, flooring, ceiling, and wall covering.
   17. Pumps and drives, including identification of ordering lead time, factory testing, and installation.
   18. Retaining wall.
   19. Trenching, pipe laying, and trench backfill and compaction.
   20. Piping, fittings, and appurtenances, including identification of ordering and fabrication lead time, layout, installation and testing.
   21. Valves, gates, and operators, including identification of order lead-time, installation, and testing.
   22. Plumbing specialties.
   23. Electric transmission, service, and distribution equipment, including identification of ordering lead-time, and factory testing.
   24. Other electrical work including lighting, heating and cooling, and special systems, including identification of ordering lead-time.
   25. Instrumentation and controls, including identification of ordering lead-time.
   26. Preliminary testing of equipment, instrumentation, and controls.
   27. Commissioning Phase:
      a. Source Testing.
      b. Owner Training.
      c. Installation Testing.
      d. Functional Testing.
      e. Clean Water Facility Testing.
   28. Process Start-up Phase:
      a. Process Start-up.
      b. Process Operational Period.
      c. Instrumentation and Controls Performance Testing.
   29. Substantial completion.

30. Punch list work.
31. Demobilization.

1.13 WEATHER DAY ALLOWANCE

A. Definition:
   1. Weather conditions that prevent or inhibit the Contractor's performance of the Work and affect the Critical Path indicated on the Schedule shall be referred to as a Weather Day.
   2. A Weather Day is defined as the Contractor being unable to perform at least 4 hours of work on the Critical Path.

B. Allowance:
   1. Include as a separate identifiable activity on the critical path, an activity labeled "Weather Days Allowance".

C. Actual weather day:
   1. Insert a weather delay activity in critical path to reflect actual weather day occurrences when weather days are experienced and accepted by Engineer.
   2. Reduce duration of Weather Days Allowance activity as weather delays are experienced and inserted into the Schedule. Remaining weather days in Weather Day Allowance at completion of project is considered float.
   3. The Contractor shall provide a written notice to the Engineer of the occurrence of a weather day within 2 days after the onset of such weather and shall describe in reasonable detail the type of weather encountered and the Work interfered with or interrupted.
      a. A schedule update will not suffice as a written notice.
      b. The Engineer will determine if the weather day constitutes a use of a portion of the Weather Day Allowance.
      c. After use of all the Weather Day Allowance, the Engineer will determine if the Contractor is entitled to an extension of the Contract Time due to weather conditions.
      d. Weather days are considered excusable delay as defined in this Section.

1.14 PRELIMINARY SCHEDULE

A. Procedure:
   1. Submit proposed Preliminary Schedule within 14 calendar days after Notice to Proceed.
   2. Meet with Engineer within 7 calendar days after receipt of Preliminary Schedule to review and make necessary adjustments.
   3. Submit revised Preliminary Schedule within 5 calendar days after meeting.
   4. Update Preliminary Schedule monthly until the Baseline Schedule is accepted.

B. Format:
   1. Simplified Gannt chart.

C. Activities:
   1. Define activities to be completed in the first 90 calendar days of Work.
   2. Actualize activities performed during the first 90 days into the first monthly schedule update.

1.15 PRELIMINARY SCHEDULE OF VALUES

A. Preliminary Schedule of Values as specified in in Section 01292 - Schedule of Values.

B. Procedure:
   1. Submit proposed Preliminary Schedule of Values within 14 calendar days after Notice to Proceed.
   2. Meet with Engineer within 7 calendar days after receipt of Preliminary Schedule of Values to review and make necessary adjustments.
   3. Submit revised Preliminary Schedule of Values within 5 calendar days after meeting.

1.16 WORK WITHIN THE FIRST 90 DAYS

A. Proceed with Work after Preliminary Schedule and Preliminary Schedule of Values have been accepted by Owner.

B. Submittal and acceptance of Preliminary Schedule and Preliminary Schedule of Values is condition precedent to making of progress payments as specified in Section 01294 - Applications for Payment and payments for mobilization costs otherwise provided for in the Contract.

1.17 SCHEDULE OF SUBMITTALS

A. Schedule of Submittals shall include submittals required in the Contract Documents but not limited to test plans, training plans, test procedures, operation and maintenance manuals, shop drawings, samples, record documents, and specifically required certificates, warranties, and service agreements.
   1. Data for “Or Equals” or substitutions shall be submitted with the Schedule of Submittals.

B. Preliminary Schedule of Submittals:
   1. Due date: After Preliminary Schedule has been submitted and accepted by Owner.
   2. Format:
      a. Include submittals anticipated in the first 90 calendar days after award of contract using early start dates.
      b. Indicate week and month anticipated for submittal to Engineer.
      c. Indicate “Priority” submittals where review time can impact Contractor’s schedule.
         1) “Priority” indication will not alter review times specified in Section 01330 - Submittal Procedures.
         2) Engineer will endeavor to provide early review of “Priority” submittals where possible.
      d. List of “Or Equals” or substitutions.
   3. Submittal of Preliminary Schedule of Submittals shall be a condition precedent to Owner making progress payments during the first 90 calendar days after award of contract.

C. Final Schedule of Submittals:
   1. Due date: 30 days after Baseline Schedule has been submitted and accepted by Owner.
   2. Format:
      a. Include submittals using early start dates.
      b. Include all submittals, including those required in the Preliminary Schedule of Submittals.
      c. Indicate week and month anticipated for submittal to Engineer.
      d. Indicate “Priority” submittals where review time can impact Contractor’s schedule.
         1) “Priority” indication will not alter review times specified in Section 01330 - Submittal Procedures.
      e. Data for “Or Equals” or substitutions.
   3. Submittal of Final Schedule of Submittals shall be a condition precedent to Owner making progress payments after the first 90 calendar days after Notice to Proceed.

D. Provide updated Schedule of Submittals with updated schedules if schedule revisions change listing and timing of submittals.

1.18 BASELINE SCHEDULE AND BASELINE SCHEDULE OF VALUES

A. Due date: No more than 45 calendar days after Notice to Proceed.

B. Format:
   1. Schedule: Show sequence and interdependence of all activities required for complete performance of all Work, beginning with date of Notice to Proceed and concluding with date of final completion of Contract.
   2. Schedule of Values: As specified in Section 01292 - Schedule of Values.

C. Acceptance of the Baseline Schedule and Baseline Schedule of Values by the Owner is a condition precedent to making payments as specified in Section 01294 - Applications for Payment after the first 90 calendar days after Notice to Proceed.

1.19 SUMMARY SCHEDULE

A. Due date: At weekly progress meetings and after each Schedule Update or Schedule Revision.

B. Format:
   1. Consolidate groups of activities associated with Major Items of Work shown on Baseline Schedule.
   2. intended to give an overall indication of the project schedule without a large amount of detail.

1.20 COST FLOW SUMMARY

A. Due date: After Baseline Schedule has been submitted and accepted by the Owner, submit on a monthly basis as specified in Section 01294 - Applications for Payment.

B. Format:
   1. Tabular and graphic report showing anticipated earnings each month of the Contract period.
   2. Base tabulation on the summation of the cost-loaded activities each month.
   3. Show planned amounts.
   4. Show actual earned amounts and anticipated remaining earnings.
   5. Spreadsheet format of all schedule activities showing cost and percentage completion during the current month for which payment is sought.

1.21 PROGRESS SCHEDULE AND UPDATED SCHEDULE OF VALUES

A. Due date: Submit on a monthly basis as specified in Section 01294 - Applications for Payment.

B. Format: Schedule of Values: As specified in Section 01292 - Schedule of Values.

1.22 WEEKLY SCHEDULE

A. Due date: At every weekly progress meeting.

B. Format:
   1. Contractor and Engineer must agree on the format.
   2. 6-Week Schedule showing the activities completed during the previous week and the Contractor's schedule of activities for following 5 weeks.
   3. Use the logic and conform to the status of the current progress schedule when producing a Weekly Schedule in CPM schedule or a bar chart format.
      a. In the event that the Weekly Schedule no longer conforms to the current schedule, Contractor may be required to revise the schedule as specified in this Section.
   4. The activity designations used in the Weekly Schedule must be consistent with those used in the Baseline Schedule and the monthly Schedule Updates.

1.23 LABOR HISTOGRAM

A. Due date:
   1. With progress payments after Baseline Schedule has been submitted and accepted by Owner.

B. Format:
   1. Labor histogram depicting total craft manpower and craft manpower for Contractor's own labor forces and those of each subcontractor.
   2. Submit in electronic format.

1.24 COMMISSIONING SCHEDULE

A. Proposed Commissioning Schedule:
   1. Schedule requirements: As specified in Section 01756 - Commissioning.
   2. Submittal due date: Within 90 days after Notice to Proceed.
   3. Engineer response due within 20 calendar days of receipt.
   4. Contractor responsible for updating schedule and resubmitting within 10 calendar days of receipt of Engineer and Owner comments.

B. Construction Schedule can include the Commissioning Schedule after Engineer acceptance of the Proposed Commissioning Schedule.
   1. Capable of extracting a stand-alone Commissioning Schedule.
   2. Capable of extracting a stand-alone Owner Training Schedule.

C. Monthly update requirements:
   1. Highlight percentages of completion, actual start and finish dates, and remaining durations, as applicable.
   2. Include activities not previously included in the previously accepted detail work plan Commissioning Schedule.
   3. Change Order required for any change to contractual dates.
   4. Reviews of these submittals by Engineer will not be construed to constitute acceptance within the time frames, durations, or sequence of work for each added activity.

1.25 FINAL SCHEDULE

A. The final Schedule Update becomes the As-Built Schedule.
   1. The As-Built Schedule reflects the exact manner in which the project was constructed by reflecting actual start and completion dates for all activities accomplished on the project.
   2. Contractor's Project Manager and scheduler sign and certify the As-Built Schedule as being an accurate record of the way the project was actually constructed.

B. Retainage will not be released until final Schedule Update is provided.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01322

WEB BASED CONSTRUCTION DOCUMENT MANAGEMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for web-based construction document management.

1.02 REQUIREMENTS

A. Owner, Engineer, Construction Manager, and Contractor shall utilize the specified EADOC, web-based construction management software, for submission of data and documents.
   1. Web based construction management software is available to all Contractor's personnel, subcontractor personnel, suppliers, consultants, Owner, Construction Manager**,** and Engineer at no cost.
   2. The joint use of this system is to facilitate electronic exchange of information, automation of key processes, and overall management of Contract Documentation.
   3. Web based construction management software shall be the primary means of project information submission and management.

1.03 USER ACCESS LIMITATIONS

A. Provide a list of Contractor's key web based construction management software personnel for the Engineer's acceptance.

B. The Engineer reserves the right to perform a security check on all potential users.
   1. The Contractor will be allowed to add additional personnel and subcontractors to the web-based construction management software.
   2. Subcontractors and suppliers will be given access to web-based construction management software by and through the Contractor.
   3. Contractor is responsible for adding and removing users from the system after the initial setup by the Engineer.

C. The Engineer will grant initial access to the web-based construction management software by creating user profiles to accepted Contractor personnel.
   1. User profiles will define levels of access into the system; determine assigned function based authorizations and user privileges.

1.04 JOINT OWNERSHIP OF DATA

A. Data entered in a collaborative mode (entered with the intent to share as determined by permissions and workflows within the web-based construction management software system) by Engineer and Contractor will be jointly owned.

1.05 AUTOMATED SYSTEM NOTIFICATION AND AUDIT LOG TRACKING

A. Review comments made (or lack thereof) by Owner on Contractor submitted documentation shall not relieve Contractor from compliance with requirements of the Contract Documents.

B. Contractor is responsible for managing, tracking, and documenting the Work to comply with the requirements of the Contract Documents.

C. Owner’s acceptance via automated system notifications or audit logs extends only to the face value of the submitted documentation and does not constitute validation of the Contractor's submitted information.

1.06 COMPUTER REQUIREMENTS

A. Contractor shall use computer hardware and software that meets the requirements of the web-based construction management software system as recommended by the web-based construction management software to access and utilize the web-based construction management software.

B. As recommendations are modified by the web-based construction management software , Contractor will upgrade their system(s) to meet or exceed the recommendations.
   1. Upgrading of Contractor's computer systems will not be justification for a cost or time modification to the Contract.

C. Contractor shall ensure that connectivity to the web-based construction management software system is accomplished through DSL, cable, T-1 or wireless communications systems.
   1. The minimum bandwidth requirements for using the system is 128 kb/s. It is recommended a faster connection be used when uploading pictures and files into the system.

D. Web-based construction management software supports the current and prior 2 major versions of Chrome, Mozilla's Firefox, Microsoft’s Internet Explorer and Apple’s Safari on a rolling basis.
   1. Each time a new version of one of these browsers is released the web-based construction management software will begin supporting the update and stop supporting the fourth-oldest version.

1.07 CONTRACTOR RESPONSIBILITY

A. Contractor shall be responsible for the validity of their information placed in the web-based construction management software and for the abilities of their personnel.

B. Entry of information exchanged and transferred between the Contractor and its subcontractors and suppliers on the web-based construction management software shall be the responsibility of the Contractor.

C. Accepted users shall be knowledgeable in the use of computers, including Internet Browsers, email programs, cad drawing applications, and Adobe Portable Document Format (PDF) document distribution program.

D. Contractor shall utilize the existing forms in the web-based construction management software to the maximum extent possible. If a form does not exist in the web-based construction management software the Contractor must include a form of their own or provided by Engineer as an attachment to a submittal.

E. Adobe PDF documents will be created through electronic conversion rather than optically scanned whenever possible. Contractor is responsible for the training of their personnel in the use of the web-based construction management software (outside what is provided by Owner) and the other programs indicated above as needed.

1.08 TRAINING

A. The Owner has arranged and paid for web-based training on using web-based construction management software for the Contractor.

B. Contractor shall arrange and pay for the facilities and hardware/software required to facilitate Contractor's training.

PART 2 PRODUCTS

2.01 DESCRIPTION

A. Web-based construction management software provided by EADOC.

PART 3 EXECUTION

3.01 WEB-BASED CONSTRUCTION MANAGEMENT SOFTWARE UTILIZATION

A. Web-based construction management software shall be utilized in connection with all document and information management required by these Contract Documents.

3.02 SUBMITTALS

A. Use the web-based construction management software feature for Master Submittals List.
   1. Contractor shall select from the predefined submittals list.

B. Content: As specified in Section 01330 - Submittal Procedures.

C. Format: As specified in Section 01330 - Submittal Procedures.

D. Submit Portable Document Format (PDF) documents to the web-based construction management software submittal workflow process and forms.
   1. Consolidate electronic format submittals with multiples pages into a single file.

E. Hardcopy submittals:
   1. Contractor shall provide 3 hard copies of submittals within 14 days of the Submittal being closed.
   2. Hardcopy requirements as specified in Section 01330 - Submittal Procedures.

F. Samples:
   1. Contractor shall enter submittal data information into the web-based construction management software.
   2. Attach a copy of the submittal form(s) to the sample.

G. Record And Closeout Submittals:
   1. Operation and maintenance data as specified in Section 01782 - Operation and Maintenance Manuals.
   2. Extra materials, spare parts, etc.

3.03 REQUESTS FOR INFORMATION/INTERPRETATION (RFI)

A. Use web-based construction management software for RFIs as specified in Section 01260 - Contract Modification Procedures.

3.04 OFFICIAL CORRESPONDENCE

A. Use web-based construction management software for memos, notices, change proposals, or any official correspondence.

3.05 INSPECTION REQUESTS

A. Use web-based construction management software to request inspection for a portion of Work that is ready for inspection and prior to covering up the Work.

3.06 FINANCIAL SUBMITTALS

A. Use web-based construction management software for financial submittals as specified in Section 01330 - Submittal Procedures.

3.07 OTHER

A. Use web-based construction management software for daily reports, meeting agendas and minutes, and other construction documents.

END OF SECTION

SECTION 01330

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements and procedures for submittals to confirm compliance with Contract Documents.

1.02 GENERAL INSTRUCTIONS

A. Contractor is responsible to determine and verify field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and check and coordinate each item with other applicable approved shop drawings and Contract Document requirements.

B. Provide submittals:
   1. That are specified or reasonably required for construction, operation, and maintenance of the Work.
   2. That demonstrate compliance with the Contract Documents.

C. Where multiple submittals are required, provide a separate submittal for each specification section.
   1. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
      a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section.
      b. For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.

D. Prepare submittals in the English language. Do not include information in other languages.

E. Present measurements in customary American units (feet, inches, pounds, etc.).

F. Must be clear and legible, and of sufficient size for presentation of information.

G. Page size other than drawings:
   1. Minimum page size will be 8 1/2-inch by 11-inch.
   2. Maximum page size will be 11-inch by 17-inch.

H. Drawing sheet size:
   1. Maximum sheets size: 22-inch by 34-inch.
      a. Minimum plan scale: 1/8-inch equals 1 foot-0 inches.
      b. Minimum font size: 1/8-inch minimum.
   2. 11-inch by 17-inch sheet:
      a. Minimum plan scale: 1/8-inch equals 1 foot-0 inches.
      b. Minimum font size: 1/8-inch minimum.

I. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.

J. Provide submittal information from only 1 manufacturer for a specified product. Submittals with multiple manufacturers for 1 product will be rejected without review.

1.03 SUBMITTAL ORGANIZATION

A. Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.

B. For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is used.

C. Bookmarks:
   1. Bookmarks shall match the table of contents.
   2. Bookmark each section (tab) and heading.
   3. Drawings: Bookmark at a minimum, each discipline, area designation, or appropriate division.
   4. At file opening, display all levels of bookmarks as expanded.

D. Where applicable (i.e., except for drawings, figures, etc.) submittal content shall be electronically searchable utilizing the PDF file as submitted.

E. Thumbnails optimized for fast web viewing.

F. Sequentially number pages within the tabbed sections:
   1. Submittals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.

G. Attachments:
   1. Specification section: Include with each submittal a copy of the relevant specification section.
      a. Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
      b. Provide a list of all numbered deviations with a clear explanation and reason for the deviation.

2. Drawings: Include with each submittal a copy of the relevant Drawing, including relevant addendum updates.
    a. Indicate either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
    b. Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
    c. Provide field dimensions and relationship to adjacent or critical features of the Work or materials.

H. Contractor: Prepare submittal information in sufficient detail to show compliance with specified requirements.
    1. Determine and verify quantities, field dimensions, product dimensions, specified design and performance criteria, materials, catalog numbers, and similar data.
    2. Coordinate submittal with other submittals and with the requirements of the Contract Documents.

I. Contractor: Prepare "Or Equal" submittal information.
    1. Provide standard submittal requirements.
        a. In addition, provide in sufficient detail to show reason for variance from specified product and impacts.
    2. Provide reason the specified product is not being provided.
    3. Explain the benefits to the Owner for accepting the "Or Equal".
    4. Itemized comparison of the proposed "Or Equal" with product specified including a list of significant variations:
        a. Design features.
        b. Design dimensions.
        c. Installation requirements.
        d. Operations and maintenance requirements.
        e. Availability of maintenance services and sources of replacement materials.
    5. Reference projects where the product has been successfully used:
        a. Name and address of project.
        b. Year of installation.
        c. Year placed in operation.
        d. Name of product installed.
        e. Point of contact: Name and phone number.
    6. Define impacts:
        a. Impacts to other contracts.
        b. Impacts to other work or products.
    7. Contractor represents the following:
        a. Contractor bears the burden of proof of the equivalency of the proposed "Or Equal".
        b. Proposed "Or Equal" is equal or superior to the specified product.
        c. Contractor will provide the warranties or bonds that would be provided on the specified product on the proposed "Or Equal" unless Owner requires a Special Warranty.

d. Contractor will coordinate installation of accepted "Or Equal" into the Work and will be responsible for the costs to make changes as required to the Work.
e. Contractor waives rights to claim additional costs caused by proposed "Or Equal" which may subsequently become apparent.

J. Contractor: Prepare substitution submittal information.
1. Provide standard submittal requirements.
a. In addition, provide in sufficient detail to show reason for variance from specified product and impacts.
2. Provide reason the specified product is not being provided.
3. Explain the benefits to the Owner for accepting the substitution.
4. Itemized comparison of the proposed substitution with product specified including a list of significant variations:
a. Design features.
b. Design dimensions.
c. Installation requirements.
d. Operations and maintenance requirements.
e. Availability of maintenance services and sources of replacement materials.
5. Reference projects where the product has been successfully used:
a. Name and address of project.
b. Year of installation.
c. Year placed in operation.
d. Name of product installed.
e. Point of contact: Name and phone number.
6. Define impacts:
a. Impacts to Contract Price.
1) Required license fees or royalties.
2) Do not include costs under separate contracts.
3) Do not include Engineer’s costs for redesign or revision of Contract Documents.
b. Impacts to Contract Time.
c. Impacts to Contract Scope.
d. Impacts to other contracts.
e. Impacts to other work or products.
7. Contractor represents the following:
a. Contractor shall pay associated costs for Engineer to evaluate the substitution.
b. Contractor bears the burden of proof of the equivalency of the proposed substitution.
c. Proposed substitution does not change the design intent and will have equal performance to the specified product.
d. Proposed substitution is equal or superior to the specified product.
e. Contractor will provide the warranties or bonds that would be provided on the specified product on the proposed substitution unless Owner requires a Special Warranty.

f. Contractor will coordinate installation of accepted substitution into the Work and will be responsible for the costs to make changes as required to the Work.
g. Contractor waives rights to claim additional costs caused by proposed substitution which may subsequently become apparent.

1.04 SUBMITTAL IDENTIFICATION NUMBERING

A. Number each submittal using the format defined below:

1.05 SUBMITTALS IN ELECTRONIC MEDIA FORMAT

A. General: Provide all information in PC-compatible format using Windows® operating system as utilized by the Owner and Engineer.

B. Text: Provide text documents and manufacturer's literature in Portable Document Format (PDF).

C. Graphics: Provide graphic submittals (drawings, diagrams, figures, etc.) utilizing Portable Document Format (PDF).

1.06 SUBMITTAL PROCEDURE

A. Engineer: Review submittal and provide response:
   1. Review description:
      a. Engineer will be entitled to rely upon the accuracy or completeness of designs, calculations, or certifications made by licensed professionals accompanying a particular submittal whether or not a stamp or seal is required by Contract Documents or Laws and Regulations.
      b. Engineer's review of submittals shall not release Contractor from Contractor's responsibility for performance of requirements of Contract Documents. Neither shall Engineer's review release Contractor from fulfilling purpose of installation nor from Contractor's liability to replace defective work.
      c. Engineer's review of shop drawings, samples, or test procedures will be only for conformance with design concepts and for compliance with information given in Contract Documents.
      d. Engineer's review does not extend to:
         1) Accuracy of dimensions, quantities, or performance of equipment and systems designed by Contractor.
         2) Contractor's means, methods, techniques, sequences, or procedures except when specified, indicated on the Drawings, or required by Contract Documents.
         3) Safety precautions or programs related to safety which shall remain the sole responsibility of the Contractor.
      e. Engineer can Approve or Not Approve any exception at their sole discretion.
   2. Review timeframe:
      a. Except as may be provided in technical specifications, a submittal will be returned within 30 days.

b. When a submittal cannot be returned within the specified period, Engineer will, within a reasonable time after receipt of the submittal, give notice of the date by which that submittal will be returned.
c. Engineer's acceptance of progress schedule containing submittal review times less than those specified or agreed to in writing by Engineer will not constitute Engineer's acceptance of review times.
d. Critical submittals:
    1) Contractor will notify Engineer in writing that timely review of a submittal is critical to the progress of Work.

3. Schedule delays:
    a. No adjustment of Contract Times or Contract Price will be allowed due to Engineer's review of submittals, unless all of the following criteria are met:
        1) Engineer has failed to review and return first submission within the agreed upon time frame.
        2) Contractor demonstrates that delay in progress of Work is directly attributable to Engineer's failure to return submittal within time indicated and accepted by Engineer.
4. Review response will be returned to Contractor with one of the following dispositions:
    a. Approved:
        1) No Exceptions:
            a) There are no notations or comments on the submittal and the Contractor may release the equipment for production.
        2) Make Corrections Noted - See Comments:
            a) The Contractor may proceed with the Work, however, all notations and comments must be incorporated into the final product.
            b) Resubmittal not required.
        3) Make Corrections Noted - Confirm:
            a) The Contractor may proceed with the Work, however, all notations and comments must be incorporated into the final product.
            b) Submit confirmation specifically addressing each notation or comment to the Engineer within 15 calendar days of the date of the Engineer's transmittal requiring the confirmation.
    b. Not approved:
        1) Correct and resubmit:
            a) Contractor may not proceed with the Work described in the submittal.
            b) Contractor assumes responsibility for proceeding without approval.
            c) Resubmittal of complete submittal package is required within 30 calendar days of the date of the Engineer's submittal review response.
        2) Rejected - See Remarks:
            a) Contractor may not proceed with the Work described in the submittal.
            b) The submittal does not meet the intent of the Contract Documents. Resubmittal of complete submittal package is required with materials, equipment, methods, etc. that meet the requirements of the Contract Documents.

c. Receipt acknowledged - Filed for record:
    1) This is used in acknowledging receipt of informational submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc.
d. Receipt acknowledged with comments - Resubmit:
    1) This is used in acknowledging receipt of informational submittals that address means and methods of construction such as schedules and work plans, conformance test reports, health and safety plans, etc. Feedback regarding missing information, conflicting information, or other information that makes it incomplete can be made with comments.

B. Contractor: Prepare resubmittal, if applicable:
    1. Clearly identify each correction or change made.
    2. Include a response in writing to each of the Engineer's comments or questions for submittal packages that are resubmitted in the order that the comments or questions were presented from the first and subsequent submittals and numbered consistent with the Engineer's numbering.
        a. Acceptable responses to Engineer's comments are listed below:
            1) "Incorporated" Engineer's comment or change is accepted and appropriate changes are made.
            2) "Response" Engineer's comment not incorporated. Explain why comment is not accepted or requested change is not made. Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
        b. Reviews and resubmittals:
            1) Contractor shall provide resubmittals which include responses to all submittal review comments separately and at a level of detail commensurate with each comment.
            2) Contractor responses shall indicate how the Contractor resolved the issue pertaining to each review comment.
                a) Responses such as "acknowledged" or "noted" are not acceptable.
            3) Resubmittals which do not comply with this requirement may be rejected and returned without review.
            4) Contractor shall be allowed no extensions of any kind to any part of their contract due to the rejection of non-compliant submittals.
            5) Submittal review comments not addressed by the Contractor in resubmittals shall continue to apply whether restated or not in subsequent reviews until adequately addressed by the Contractor to the satisfaction of the reviewing and approving authority.
        c. Any resubmittal that does not contain responses to the Engineer's previous comments shall be returned for Revision and Resubmittal. No further review by the Engineer will be performed until a response for previous comments has been received.
    3. Resubmittal timeframe:
        a. Contractor shall provide resubmittal within 15 days.
        b. When a resubmittal cannot be returned within the specified period, Contractor shall notify Engineer in writing.

4. Review costs:
    a. Costs incurred by Owner as a result of additional reviews of a particular submittal after the second time it has been reviewed shall be borne by Contractor.
    b. Reimbursement to Owner will be made by deducting such costs from Contractor's subsequent progress payments.

1.07 PRODUCT DATA

A. Edit submittals so that the submittal specifically applies to only the product furnished.

B. Neatly cross out all extraneous text, options, models, etc. that do not apply to the product being furnished, so that the information remaining is only applicable to the product being furnished.

1.08 SHOP DRAWINGS

A. Contractor to field verify elevation, coordinates, and pipe material for pipe tie-in to pipeline or structure prior to the preparation of shop drawings.

B. Indicate project designated equipment tag numbers for submittal of devices, equipment, and assemblies.

1.09 SAMPLES

A. Details:
    1. Submit labeled samples.
    2. Samples will not be returned.
    3. Provide number of sample submittals as below:
        a. Total: 3 minimum.
            1) Owner: 1.
            2) Engineer: 2.
            3) Contractor: None.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

ATTACHMENT A - CONTRACTOR SUBMITTAL TRANSMITTAL FORM

CONTRACTOR SUBMITTAL TRANSMITTAL FORM

Owner:	Click here to enter text.	**Date:**	MM/DD/YYYY
Contractor:	Click here to enter text.	**Project No.:**	XXXXX.XX
Project Name:	Click here to enter text.	**Submittal Number:**	000
Submittal Title:	Click here to enter text.		
To:	Click here to enter text.		
From:	Click here to enter text.	Click here to enter text.	
	Click here to enter text.	Click here to enter text.	

Specification No. and Subject of Submittal / Equipment Supplier			
Spec ##:	Spec ##.	**Subject:**	Click here to enter text.
Authored By:	Click here to enter text.	**Date Submitted:**	XX/XX/XXXX

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

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

SECTION 01340

PHOTOGRAPHIC AND VIDEOGRAPHIC DOCUMENTATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for photographs and videos.

B. The purpose of the photographs and videos is to document the condition of the facilities prior to the Contractor beginning work at the Project site, the progress of the Work, and the Project site after Substantial Completion of the Work.

C. The scope of the photographic and videographic documentation shall be the sole responsibility of the Contractor but shall be acceptable to the Engineer.

1.02 SUBMITTALS

A. Photographer qualifications.

B. Pre-construction photographs and videos: Submit prior to beginning work at the Project site or prior to the Preconstruction Conference specified in Section 01312 - Project Meetings, whichever occurs earlier.

C. Construction photographs and videos: Submit with each application for payment.

D. Post-construction photographs and videos: Submit with project closeout documents as specified in Section 01770 - Closeout Procedures.

1.03 PHOTOGRAPHER

A. Photographer qualified and equipped to photograph either interior or exterior exposures, with lenses ranging from wide angle to telephoto.

B. Submit example work of previous photographs and video recording meeting the requirements of this Section.
   1. Provide to Engineer no later than the pre-construction conference.
   2. Provide photographs used for site examination.
   3. Provide video of site examination.
   4. Provide samples that used same camera and lighting equipment proposed for the Work.
   5. Engineer will review work examples to determine if the quality of the images is acceptable.
   6. Contractor is responsible for modifications to equipment and/or inspection procedures to achieve report material of acceptable quality.
   7. Do not commence Work prior to approval of the material by the Engineer.
   8. Once accepted, the standard report material shall serve as a standard for the remaining work.

1.04 KEY PLAN

A. Submit key plan of Project site with notation of vantage points marked for location and direction of each photograph.

B. Include the same label information as the corresponding set of photographs.

1.05 PHOTOGRAPHS

A. Provide prints of each photograph for each area of Work.

B. Provide a digital copy of each photograph for each area of Work.
   1. Monthly: Indexed digital flash drive.
   2. Project record documents:
      a. Catalog and index prints in chronological sequence.
      b. Include typed table of contents.

1.06 PRE-CONSTRUCTION PHOTOGRAPHS AND VIDEOS

A. Provide photographs and video of the condition entire site including each area of Work prior to the start of Work.
   1. Areas to be photographed and videoed shall include the site of the Work and all existing facilities, either on or adjoining the Project site, including the interior of existing structures that could be damaged as a result of the Contractor's Work.
   2. Include general condition, structures, vegetation, staging, storing, working, parking areas and excavation areas.

1.07 CONSTRUCTION PHOTOGRAPHS AND VIDEOS

A. Time-Lapse Video:
   1. Identification: For each recording, provide the following information in file metadata tag or on web-based project software site:
      a. Name of Project.
      b. Owner: City of West Linn.
      c. Name of Engineer.
      d. Name of Contractor.
      e. Name and contact information for photographer.
      f. Date(s) and time(s) video recording was recorded.
      g. Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
   2. Frequency of time-lapse photos: 1 each workday at 9 am and 3 pm.
   3. Duration of time-lapse photos: 20 seconds.
   4. Access to video:
      a. Submit to web-based construction project management system monthly.
      b. Web-based access: Secure access limited to City and Contractor.

B. Provide photographs and videos of construction in each area of Work throughout progress of Work including a key plan designating where each photograph was taken.

C. Take site and interior photographs and videos from differing directions of building demolition, pre-excavation, footing excavation, soil testing, utility crossings, installation of bypass piping, excavation of access pits, installation of lining system in pipes, rehabilitation of manholes, building modifications, utilities, electrical and instrumentation modifications, and other applicable activities indicating relative progress of the work.

D. Take photos a maximum of 7 calendar days prior to Submittal.

1.08 POST-CONSTRUCTION PHOTOGRAPHS AND VIDEOS

A. Provide photographs of the entire site including each area of Work at the completion of Work.
   1. Include general condition, structures, vegetation, staging, storing, working, parking areas and excavation areas.
   2. Take photos and video from same points in same direction as pre-construction examination.

B. Submittal of photos and videos is a condition of final payment.

PART 2 PRODUCTS

2.01 MEDIA

A. Paper media:
   1. Commercial grade, glossy surface, acid-free photographic paper.
   2. Submit 3 prints of each photographic view within 7 days of taking photographs.
   3. Format:
      a. Ground photos: Color, matte finish, 8-1/2-inch by 11-inch size, mounted on soft card stock.
      b. Aerial photos: Color, matte finish, 11-inch by 17-inch size, mounted on soft card stock.
      c. Mount each print in a separate, archival type, non-glare, 3-hole punched protector.
   4. Identification: On photograph, provide the following information:
      a. Name of project.
      b. Date stamp: Unless otherwise indicated, date and time stamp each photograph as it is being taken so stamp is integral to photograph.
      c. Description of vantage point, indicating location and direction by compass point.
   5. Provide a suitably sized 3-ring binder for each set of prints.
      a. Furnish binders in sufficient quantities to hold entire set of prints taken for the duration of the Contract.
      b. Label binder spine and front with project name.

B. Digital media:
   1. Flash drive compatible with current Microsoft Windows.
   2. Provide photos as individual, indexed JPG files with the following characteristics:
      a. Compression shall be set to preserve quality over file size.

b. Highest resolution JPG images shall be submitted. Resizing to a smaller size when high resolution JPGs are available shall not be permitted.
c. JPG image resolution shall be 5 megapixels at 2,400 by 1,800 or higher.
d. Images shall have rectangular, clean images. Artistic borders, beveling, drop shadows, etc., are not permitted.

3. Identification: On photograph, provide the following information:
   a. Name of project.
   b. Date stamp: Unless otherwise indicated, date and time stamp each photograph as it is being taken so stamp is integral to photograph.
   c. Description of vantage point, indicating location and direction by compass point.

C. Videos:
1. Video quality shall be 720p HD or greater in MPG, AVCHD, AVI, or MP4 format.
2. Digital color video format.
3. Provide audio portion of the composite video sufficiently free from electrical interference and background noise to provide complete intelligibility of oral report.
4. Identification: On each copy provide a label with the following information:
   a. Name of project.
   b. Date video was recorded.
5. Submit 1 copy of each video within 7 days of recording.
6. Display continuous running time.
7. At start of each video recording, record weather conditions from local newspaper or television and the actual temperature reading at Project site.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01354

HAZARDOUS MATERIAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Procedures required when encountering hazardous materials at the Work site.

1.02 REFERENCES

A. Oregon Administrative Rules (OAR).

B. Occupational Safety and Health Administration (OSHA).

C. United States Code of Federal Regulation (CFR):
   1. Title 29 - Labor:
      a. 1926.62 - Lead.
   2. Title 40 - Protection of Environment:
      a. 261 - Identification and Listing of Hazardous Waste.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Adequately wet: Penetration of the pipe wall with liquid to prevent release of particulates.
   2. Asbestos cement pipe: Also commonly referred to as AC transite pipe, AC pipe or ACP. Pipe that is generally composed of cement and asbestos fibers.
   3. Competent person: A trained worker who is capable of identifying existing and predictable asbestos hazards, perform exposure assessment and monitoring, is qualified to train other workers, and has the authority to take immediate corrective action to eliminate a hazardous exposure.
   4. Non-friable asbestos-containing material (NACM): Material containing more than 1 percent asbestos, that when dry, cannot be crumbled, pulverized, or reduced to powder by hand pressure.
   5. Regulated asbestos-containing material (RACM): Category II non-friable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder in the course of work.

1.04 SUBMITTALS

A. Submit laboratory reports, hazardous material removal plans, and certifications.

B. Submit the following work plan:
   1. Removal and Legal Disposal of Asbestos Cement Pipe Plan.
      a. Work plan shall include, but not be limited, to the following:
         1) Schedule of work.
         2) Security measures for work and disposal area.
         3) Staff training: Provide at least one competent person who is capable of identifying asbestos hazards at the job site for the entire duration of the AC pipe removal and disposal operation.
         4) Trenching and removal of pipe procedure.

1.05 OPERATING DIGESTERS

A. Observe safety precautions in vicinity of operating digesters which contain digester gases, including methane, hydrogen sulfide, and carbon dioxide.

1.06 HAZARDOUS MATERIALS PROCEDURES

A. Hazardous materials are those defined by 40 CFR and State specific codes.

B. When hazardous materials have been found that were indicated in the Contract Documents:
   1. Prepare and initiate implementation of plan of action.
   2. Notify such agencies as are required to be notified by laws and regulations within the times stipulated by such laws and regulations.
   3. Designate a Certified Industrial Hygienist to issue pertinent instructions and recommendations for protection of workers and other affected persons' health and safety.
   4. Identify and contact Subcontractors and licensed personnel qualified to undertake storage, removal, transportation, disposal, and other remedial work required by, and in accordance with, laws and regulations.

C. Forward to Engineer, copies of reports, permits, receipts, and other documentation related to remedial work.

D. Assume responsibility for worker health and safety, including health and safety of Subcontractors and their workers.
   1. Instruct workers on recognition and reporting of materials that may be hazardous.

E. File requests for adjustments to Contract Times and Contract Price due to the finding of Hazardous Materials in the Work site in accordance with Contract Documents.
   1. Minimize delays by continuing performance of the Work in areas not affected by hazardous materials operations.

F. When hazardous materials have been found:
   1. Prepare and initiate implementation of plan of action.
   2. Notify immediately Owner, Engineer, and other affected persons.
   3. Notify such agencies as are required to be notified by laws and regulations with the times stipulated by such laws and regulations.
   4. Designate a Certified Industrial Hygienist to issue pertinent instructions and recommendations for protection of workers and other affected persons' health and safety.
   5. Identify and contact Subcontractors and licensed personnel qualified to undertake storage, removal, transportation, disposal, and other remedial work required by, and in accordance with, laws and regulations.

1.07 LEAD PAINT REMOVAL AND DISPOSAL

A. No lead observed.

1.08 ASBESTOS MATERIALS

A. It is the specific intent of these Contract Documents to exclude from the Work any and all products or materials containing asbestos. No products containing asbestos shall be incorporated in the Work.

B. Removal of existing ACM shall be performed by a firm that is registered by OSHA and certified by the State Contractors Licensing Board and shall be a licensed abatement contractor in the state where the Project is located.

C. Submit 3 copies of plan for the removal, containment, and disposal of ACM.

D. Submit 3 copies of abatement license of ACM removal contractor.

PART 2 PRODUCTS

2.01 ASBESTOS CEMENT PIPE (ACP)

A. Pipe to be removed from the ground has been in service for approximately 60 years.
   1. Manufacturer and exact composition of the pipe to be removed is unknown.
   2. ACP is generally manufactured using Portland cement or pozzolan cement and asbestos fiber.
   3. Common pipe lengths: 3 feet 3 inches, 6 feet 6 inches, 9 feet 9 inches, and 13 feet 0 inches.

B. Pipe fittings. Separate from pipe brass, galvanized pipe, copper, cast iron, galvanized pipe or steel fittings and dispose of separately.

PART 3 EXECUTION

3.01 ASBESTOS MATERIALS

A. Notifications:
   1. Notify OSHA 24 hours prior to performing asbestos material removal operations.
   2. Notify Owner 3 working days in advance of commencing asbestos material removal operations.

B. Work area:
   1. Establish a regulated work area, using at a minimum, construction warning tape to establish limits of work area for the asbestos material removal.
   2. On site stockpiling or storage of asbestos material designated for disposal shall not be allowed.

C. Safety:
   1. Conduct an Initial Exposure Assessment (IEA).
   2. Provide a hand/face wash station.

D. Worker qualifications:
   1. Asbestos removal shall be performed by employees trained in wet methods, vacuum cleaners with HEPA filters to collect debris and prompt cleanup in accordance with OAR 437, Division 2, Subdivision Z – Toxic and Hazardous Substances, § 1910.1001 – Asbestos.

E. Legal disposal:
   1. Legal disposal of asbestos material is the Contractor's responsibility.
   2. Contractor shall transport the asbestos material to a landfill suitable for the purpose as determined by the Contractor.

3.02 EXCAVATION OF AC PIPE

A. Machine excavates to expose asbestos cement pipe.

B. Hand excavates areas under pipe where breaks are planned.

C. Pipe shall be pre-wetted prior to any breaks being made.

D. Pipe shall be snapped using mechanical snapping methods.

3.03 AC PIPE REMOVAL

A. All required pipe breaking operations shall require adequate pre-wetting with potable water.

B. Make every effort to minimize the number of pipe breaks. Wherever possible, the pipe should be removed by pulling the pipe out of the pipe joint collars.

C. Remove sections of AC pipe intact at joint collars by mechanical snapping methods between collars.

D. Wet and containerize waste materials as removed from the trench. Use lifting straps and methods that do not further damage the pipe.

E. Sections of AC pipe that become cut, have broken edges or have any friable surface shall be wet at exposed fractures and immediately wrapped.
   1. Pipe ends shall be sealed completely using a minimum 6-mil poly film wrap, which is securely fastened, taped to completely enclose the pipe and ACP appurtenances and shall have conspicuous, legible labeling that has the following or equivalent labeling: CAUTION: CONTAINS ASBESTOS FIBERS. BREATHING ASBESTOS DUST MAY CAUSE SERIOUS BODILY HARM.

F. AC pipe sections shall not be left exposed in public view, either in trench or in disposal area.

G. All connecting parts of pipe, rubber gaskets, and pipe couplings shall be discarded with pipe.

H. AC pipe from this project only shall be placed in the bin designated.

END OF SECTION

SECTION 01357

DELEGATED DESIGN PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Delegated Design procedures.

1.02 GENERAL

A. Delegated Design - Professional design services assigned to the Contractor by express delegation in the Contract Documents. Work is “Delegated Design” where the Technical Sections require the Contractor to provide professional design services and to submit signed and sealed documents from a registered Professional Engineer.

B. Contractor’s Professional Engineer - The design professional retained by the Contractor to perform Delegated Design.

C. Owner may require Contractor to provide professional design services for a portion of the Work by express delegation in the Contract Documents.
   1. Requirements of Delegated Design component as specified in the Technical Section and as indicated on the Drawings.
   2. Such delegation will specify the performance and design criteria that such services must satisfy, and the Submittals that the Contractor must furnish to the Engineer with respect to the Delegated Design.

D. Contractor shall cause such Delegated Design services to be provided pursuant to the professional standard of care by a properly licensed design professional, whose signature and seal shall appear on Drawings, calculations, Specifications, certifications, and Submittals prepared by such design professional.
   1. Contractor shall not be responsible for the adequacy of performance or design criteria specified by the Owner or Engineer.
   2. Contractor is not required to provide professional services in violation of applicable Laws and Regulations.
   3. Such design professional shall issue certifications of design required by Laws and Regulations.
   4. If a Shop Drawing or other Submittal related to the Owner-delegated design is prepared by the Contractor, a Subcontractor, or others for submittal to the Engineer, then such Shop Drawing or other Submittal shall bear the written approval of Contractor’s design professional when submitted by the Contractor to the Engineer.

E. Owner and Engineer shall be entitled to rely upon the adequacy, accuracy, and completeness of the services, certifications, and approvals performed or provided by the design professionals retained or employed by Contractor under Delegated Design, subject to the professional standard of care and the performance and design criteria stated in the Contract Documents.

F. Engineer's review, approval, and other determinations regarding design drawings, calculations, Specifications, certifications, and other Submittals furnished by Contractor pursuant to a Delegated Design will be only for the following limited purposes:
   1. Confirming that Submittal is in conformance with the performance and design criteria specified in the Contract Documents.

1.03 CONTRACTOR'S PROFESSIONAL ENGINEER

A. Contractor or Subcontractor shall retain a licensed Professional Engineer to perform Delegated Design.

B. Qualifications:
   1. Holding a current license to perform the specified design in the same jurisdiction as the Project site.
   2. Experienced in designing similar systems of similar complexity.

C. Insurance:
   1. Provide Contractor's Professional Engineer's Professional Liability Insurance as specified in Invitation to Bid.

D. Responsibilities:
   1. Review and design in accordance with system performance and design criteria stated in the Contract Documents.
      a. Prepare written requests for clarifications or interpretations of performance or design criteria for submittal to the Engineer by the Contractor.
   2. Sign and seal design reports, calculations, design drawings and specifications, and other design Submittals for the Delegated Design Work.
   3. Review and submit written approval of Submittals related to the Delegated Design Work.
   4. Design modifications to the Delegated Design Work as required.
   5. Visit the Site, as required, to verify that installation of the Delegated Design Work is in conformance with the Delegated Design Drawings and Specifications.
   6. Submit through Contractor to Engineer written, signed, and sealed certification that the installed Delegated Design Work complies with Contractor's Professional Engineer's design.

1.04 SUBMITTALS

A. Prior to the start of Delegated Design:
   1. Contractor's Professional Engineer's qualifications:
      a. Experience for the Delegated Design.
      b. Evidence of Professional Engineering license.
   2. Contractor's Professional Engineer Professional Liability Insurance certificate.

B. Delegated Design:
   1. Product data:
      a. Details related to the Delegated Design as specified in Technical Sections to completely describe the system.
   2. Design documents with signature and seal from the Contractor's Professional Engineer.
      a. Design documents include but are not limited to Drawings, calculations, Specifications, inspection reports, and certifications.
   3. Lists and schedules:
      a. Prepare and submit lists or schedules of items where Delegated Design is required by the Contract Documents.
      b. Group items by location in the Work.
         1) When "Area Numbers" are indicated on the Contract Drawings, group lists in accordance with those "areas."
         2) For work without area numbers, group using logical divisions acceptable to the Engineer.
         3) Group items within each "area" as follows:
            a) Systems.
            b) Components.
            c) Supports.
            d) Anchorage.
            e) Bracing.

C. Construction services:
   1. Contractor's Professional Engineer's comments on Submittals.
   2. Other construction documents, as required.

1.05 ENGINEER RESPONSE TO DELEGATED DESIGN SUBMITTALS

A. Engineer response will be either of the following:
   1. Approved. Make Corrections Noted - See Comments:
      a. Contractor may proceed with the Work; however, all notations and comments must be incorporated into the final product.
      b. Review was for the limited purpose of determining that the document was stamped by a Professional Engineer and that such design is generally consistent with and will not negatively affect the design concept presented in the Contract Documents.
   2. Rejected - See Remarks:
      a. Contractor may not proceed with the Work described in the Submittal.
      b. Submittal does not meet the intent of the Contract Documents.
      c. Resubmittal of complete Submittal package is required with materials, equipment, methods, etc., that meet the requirements of the Contract Documents.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01410

REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Regulatory authorities and codes.

1.02 AUTHORITIES HAVING JURISDICTION

A. Also referred to as the permitting agency.

B. Building Department: City of West Linn Building Department.

C. Fire Department: Tualatin Valley Fire and Rescue.

1.03 APPLICABLE CODES

A. International Code Council (ICC).
   1. Building code:
      a. International Building Code (IBC), 2021.
         1) State and City Local amendments.
      b. International Existing Building Code (IEBC), 2021.
         1) State and City Local amendments.
   2. Electrical code:
      a. National Fire Protection Association (NFPA), NFPA 70: National Electrical Code (NEC), 2020.
         1) State and City Local amendments.
   3. Energy code:
      a. International Energy Conservation Code (IECC), 2021.
         1) State and City Local amendments.
   4. Fire code:
      a. International Fire Code (IFC), 2021.
         1) State and City Local amendments.
   5. Fuel gas code:
      a. International Fuel Gas Code (IFGC), 2021.
         1) State and City Local amendments.
   6. Mechanical code:
      a. International Mechanical Code (IMC), 2021.
         1) State and City Local amendments.
   7. Plumbing code:
      a. International Plumbing Code (IPC), 2021.
         1) State and City Local amendments.

B. Oregon Department of Consumer and Business Services, Building Codes Division (BCD):
   1. Building code:
      a. Oregon Structural Specialty Code (OSSC), 2019.
   2. Electrical code:
      a. Oregon Electrical Specialty Code (OESC), 2014.
   3. Energy codes:
      a. Oregon Energy Efficiency Specialty Code (OEESC), 2014.
   4. Fire code:
      a. Oregon Fire Code (OFC), 2019.
   5. Mechanical code:
      a. Oregon Mechanical Specialty Code (OMSC), 2019.
   6. Plumbing code:
      a. Oregon Plumbing Specialty Code (OPSC), 2014.

1.04 CONSTRUCTION MANAGEMENT PLAN

A. Prior to site disturbance or the issues of building permits, the applicant shall submit a construction management plan in compliance with Community Development Code (CDC) 32.050.G for review and approval by the City of West Linn Engineer and Planning Director or designees. Per this code, the construction management plan shall include:
   1. The location of proposed temporarily disturbed areas (site ingress/egress for construction equipment, areas for storage of material, construction activity areas, grading and trenching, etc.) that will subsequently be restored to original grade and replanted with native vegetation, shall be identified, mapped and enclosed with fencing per subsection (3) of this section.
   2. Appropriate erosion control measures consistent with Clackamas County Erosion Prevention and Sediment Control Planning and Design Manual, rev. 2008, and a tentative schedule of work.
   3. The water resource area shall be protected, prior to construction, with an anchored chain link fence (or equivalent approved by the City) at its perimeter that shall remain undisturbed, except as specifically authorized by the approval authority. Additional fencing to delineate approved temporarily disturbed areas may be required. Fencing shall be mapped and identified in the construction management plan and maintained until construction is complete.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01450

QUALITY CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Quality control and control of installation.
   2. Tolerances.
   3. References.
   4. Mock-up requirements.
   5. Authority and duties of Owner's representative or inspector.
   6. Sampling and testing.
   7. Testing and inspection services.
   8. Contractor's responsibilities.

1.02 QUALITY CONTROL AND CONTROL OF INSTALLATION

A. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.

B. Comply with manufacturers' instructions, including each step in sequence.

C. When manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

E. Perform Work by persons qualified to produce required and specified quality.

F. Verify field measurements are as indicated on Shop Drawings or as instructed by manufacturer.

G. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

H. When specified, products will be tested and inspected either at point of origin or at Work site:
   1. Notify Engineer in writing well in advance of when products will be ready for testing and inspection at point of origin.
   2. Do not construe that satisfactory tests and inspections at point of origin is final acceptance of products. Satisfactory tests or inspections at point of origin do not preclude retesting or re-inspection at Work site.

I. Do not ship products which require testing and inspection at point of origin prior to testing and inspection.

1.03 TOLERANCES

A. Monitor fabrication and installation tolerance control of products to produce acceptable Work. Do not permit tolerances to accumulate.

B. Comply with manufacturers' tolerances. When Manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding.

C. Adjust products to appropriate dimensions; position before securing products in place.

1.04 REFERENCES

A. ASTM International (ASTM):
   1. E329 - Standard for Agencies Engaged in Construction Inspection, Testing or Special Inspection.

B. National Institute of Standards and Technology (NIST).

1.05 PRODUCT REQUIREMENTS

A. For products or workmanship specified by association, trade, or other consensus standards, comply with requirements of standard, except when more rigid requirements are specified or are required by applicable codes.

B. Conform to reference standard by date of issue current on date of Contract Documents, except where specific date is established by code.

C. Obtain copies of standards where required by product specification sections.

D. When specified reference standards conflict with Contract Documents, request clarification from Engineer before proceeding.

1.06 MOCK-UP REQUIREMENTS

A. Tests will be performed under provisions identified in this Section and identified in respective product specification sections.

B. Assemble and erect specified items with specified attachment and anchorage devices, flashings, seals, and finishes.

C. Accepted mock-ups shall be comparison standard for remaining Work.

D. Where mock-up has been accepted by Engineer and is specified in product specification sections to be removed; remove mock-up and clear area when directed to do so by Engineer.

1.07 AUTHORITY AND DUTIES OF OWNER'S REPRESENTATIVE OR INSPECTOR

A. Owner’s Project Representative employed or retained by Owner is authorized to inspect the Work.

B. Inspections may extend to entire or part of the Work and to preparation, fabrication, and manufacture of products for the Work.

C. Deficiencies or defects in the Work which have been observed will be called to Contractor's attention.

D. Inspector will not:
   1. Alter or waive provisions of Contract Documents.
   2. Inspect Contractor's means, methods, techniques, sequences, or procedures for construction.
   3. Accept portions of the Work, issue instructions contrary to intent of Contract Documents, or act as foreman for Contractor. Supervise, control, or direct Contractor's safety precautions or programs; or inspect for safety conditions on Work site, or of persons thereon, whether Contractor's employees or others.

E. Inspector will:
   1. Conduct on-site observations of the Work in progress to assist Engineer in determining when the Work is, in general, proceeding in accordance with Contract Documents.
   2. Report to Engineer whenever Inspector believes that Work is faulty, defective, does not conform to Contract Documents, or has been damaged; or whenever there is defective material or equipment; or whenever Inspector believes the Work should be uncovered for observation or requires special procedures.

1.08 SAMPLING AND TESTING

A. General:
   1. Prior to delivery and incorporation in the Work, submit listing of sources of materials, when specified in sections where materials are specified.
   2. When specified in sections where products are specified:
      a. Submit sufficient quantities of representative samples of character and quality required of materials to be used in the Work for testing or examination.
      b. Test materials in accordance with standards of national technical organizations.

B. Sampling:
   1. Furnish specimens of materials when requested.
   2. Do not use materials which are required to be tested until testing indicates satisfactory compliance with specified requirements.
   3. Specimens of materials will be taken for testing whenever necessary to determine quality of material.
   4. Assist Engineer in preparation of test specimens at site of work, such as soil samples and concrete test cylinders.

1.09 TESTING AND INSPECTION SERVICES

A. Contractor will employ and pay for specified services of an independent firm to perform Contractor quality control testing as required in the technical specifications for various work and materials.

B. Owner will employ and pay for specified services of an “Owner’s independent testing firm” certified to perform testing and inspection as required in the technical specifications for various work and materials or stipulated in Section 01455 - Regulatory Quality Assurance to confirm Contractor’s compliance with Contract Documents.

C. The Owner’s independent testing firm will perform tests, inspections and other services specified in individual specification sections and as required by Owner and requested by the Engineer.

D. The qualifications of laboratory that will perform the testing, contracted by the Owner or by the Contractor, shall be as follows:
   1. Has authorization to operate in the state where the project is located.
   2. Meets “Recommended Requirements for Independent Laboratory Qualification,” published by American Council of Independent Laboratories.
   3. Meets requirements of ASTM E329.
   4. Laboratory Staff: Maintain full time specialist on staff to review services.
   5. Testing Equipment: Calibrated at reasonable intervals with devices of accuracy traceable to NIST or accepted values of natural physical constants.
   6. Will submit copy of report of inspection of facilities made by Materials Reference Laboratory of NIST during most recent tour of inspection, with memorandum of remedies of deficiencies reported by inspection.

E. Testing, inspections, and source quality control may occur on or off project site. Perform off-site testing inspections and source quality control as required by Engineer or Owner.

F. Contractor shall cooperate with Owner’s independent testing firm, furnish samples of materials, design mix, equipment, tools, storage, safe access, and assistance by incidental labor as requested.
   1. Notify Engineer and Owner’s independent testing firm 48 hours prior to expected time for operations requiring testing.
   2. Make arrangements with Owner’s independent testing firm and pay for additional samples and tests required for Contractor’s use.

G. Limitations of authority of testing Laboratory: Owner’s independent testing firm or Laboratory is not authorized to:
   1. Agency or laboratory may not release, revoke, alter, or enlarge on requirements of Contract Documents.
   2. Agency or laboratory may not approve or accept any portion of the Work.
   3. Agency or laboratory may not assume duties of Contractor.
   4. Agency or laboratory has no authority to stop the Work.

H. Testing and employment of an Owner’s independent testing firm or laboratory shall not relieve Contractor of obligation to perform Work in accordance with requirements of Contract Documents.

I. Re-testing or re-inspection required because of non-conformance to specified requirements shall be performed by same Owner’s independent testing firm on instructions by Engineer. Payment for re-testing or re-inspection will be charged to Contractor by deducting testing charges from Contract Sum/Price.

J. The Owner’s independent testing firm responsibilities will include:
   1. Test samples of mixes submitted by Contractor.
   2. Provide qualified personnel at site. Cooperate with Engineer and Contractor in performance of services.
   3. Perform specified sampling and testing of products in accordance with specified standards.
   4. Ascertain compliance of materials and mixes with requirements of Contract Documents.
   5. Promptly notify Engineer and Contractor of observed irregularities or non-conformance of Work or products.
   6. Perform additional tests required by Engineer.
   7. Attend preconstruction meetings and progress meetings when requested.

K. Owner’s independent testing firm individual test reports:
   1. After each test, Owner’s independent testing firm will promptly submit electronically report to Engineer and to Contractor.
   2. Test reports shall include at least the following information:
      a. Date issued.
      b. Project title and number.
      c. Name of inspector.
      d. Date and time of sampling or inspection.
      e. Identification of product and specifications section.
      f. Location in Project.
      g. Type of inspection or test.
      h. Date of test.
      i. Certified test results stamped and signed by a registered Engineer in the state where the project is located.
      j. Summary of conformance with Contract Documents.
      k. When requested by Engineer, the Owner’s independent testing firm will provide interpretation of test results.

1.10 CONTRACTOR'S RESPONSIBILITIES

A. Cooperate with Owner’s independent testing firm or laboratory personnel and provide access to construction and manufacturing operations.

B. Secure and deliver to Owner’s independent testing firm or laboratory adequate quantities of representative samples of materials proposed to be used and which require testing.

C. Provide to Owner’s independent testing firm or laboratory and Engineer preliminary mix design proposed to be used for concrete, and other materials mixes which require control by testing laboratory.

D. Submit product test reports electronically.

E. Furnish incidental labor and facilities:
   1. To provide access to construction to be tested.
   2. To obtain and handle samples at Work site or at source of product to be tested.

3. To facilitate inspections and tests.
4. For storage and curing of test samples.

F. Notify Owner's independent testing firm or laboratory 48 hours in advance of when observations, inspections and testing is needed for laboratory to schedule and perform in accordance with their notice of response time.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01455

REGULATORY QUALITY ASSURANCE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Project regulatory requirements for quality assurance that includes Special Inspections, Special Certification, and Structural Observation.

B. Special Certification and Special Inspections in this Section are in addition to the requirements specified in Section 01450 - Quality Control, and in the individual Sections.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete.
   2. 530 - Building Code Requirements for Masonry Structures.
   3. 530.1 - Specification for Masonry Structures.

B. American Institute of Steel Construction (AISC):
   1. 360 - Specification for Structural Steel Buildings.

C. American Society of Civil Engineers (ASCE):
   1. 7 - Minimum Design Loads for Buildings and Other Structures.

D. American Welding Society (AWS):
   1. D1.3 - Structural Welding Code - Sheet Steel.
   2. D1.4 - Structural Welding Code - Reinforcing Steel.

E. ASTM International (ASTM):
   1. A706 - Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   4. C1611 - Standard Test Method for Slump Flow of Self-Consolidating Concrete.

F. Building Code:
   1. As specified in Section 01410 - Regulatory Requirements.

G. The Masonry Society (TMS):
   1. 402 - Building Code for Masonry Structures.
   2. 602 - Specifications for Masonry Structures.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Special Certification: Certification for designated seismic systems that demonstrates compliance with performance requirements.
   2. Special Inspection: Inspection 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.
   3. Special Inspection, Continuous: The full-time observation of work requiring Special Inspection by an approved special inspector who is present in the area where the work is being performed.
   4. Special Inspection, Periodic: The part-time, or intermittent observation of work requiring Special Inspection by an approved special inspector who is present in the area where the work is being performed and at the completion of the work.
   5. Structural Observation: The visual observation of the structural system by a registered design professional for general conformance to the approved construction documents at significant construction stages and at completion of the structural system.

1.04 SUBMITTALS

A. Submit Special Certifications for designated seismic systems.

B. Schedule and coordinate the submittal of Special Inspection reports and test results prepared by others.

1.05 SPECIAL INSPECTION

A. Owner will employ 1 or more special inspectors who will provide Special Inspections during construction.

B. Special inspector(s) shall be qualified for inspection of the particular type of materials or operations requiring Special Inspection.

C. Testing laboratory: Testing that is required to satisfy the requirements of Special Inspection will be performed by the Owner's testing laboratory as specified in Section 01450 - Quality Control.

D. Duties of special inspector:
   1. General: Required duties of the special inspector(s) shall be as described in the Building Code.
   2. Reporting: Special inspector(s) shall provide reports of each inspection to the Owner and shall distribute copies of inspection reports to the Engineer and Contractor as required.
      a. Reports shall, at a minimum, include the following items:
         1) Date and time of inspection, and name(s) of individual(s) performing the inspection.
         2) Structures and areas of the structure where work or testing was observed.

3) Discrepancies between the requirements of the Contract Documents and the work or testing observed.
4) Other areas of deficiency in the Work.

E. Special Inspections shall not be construed as fulfilling the requirements for Structural Observation.

F. Owner or special inspector are responsible to select materials for Special Inspection.
1. Contractor shall not select materials for Special Inspection.

1.06 SPECIAL CERTIFICATION

A. Provide equipment that meets the special certification requirements of the Building Code.

B. Designated seismic systems shall be subject to the testing and qualification requirements of the regulatory Building Code, and shall require Special Certification as set forth in ASCE 7:
1. Mechanical equipment that is assigned an importance factor of 1.50 as specified in Section 01850 - Design Criteria.
2. All electrical equipment.

C. Special certification requirements for designated seismic systems:
1. Submittals shall include certification that the equipment is seismically qualified. Certifications are subject to review and acceptance by Owner.
2. Certifications may be at least one of the following in accordance with ASCE 7:
a. Analysis.
b. Testing.
c. Experience data.

1.07 STRUCTURAL OBSERVATION

A. Owner will employ 1 or more registered design professionals to provide Structural Observation(s) during construction.
1. Registered design professional will be a civil or structural engineer currently licensed as such in the state where the project is located and regularly engaged in structural design equivalent to or similar to that indicated on the Drawings.

B. Structural Observations shall not be construed as fulfilling the requirements for Special Inspections.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SPECIAL INSPECTIONS

A. Owner will provide Special Inspection of the following types of work as described in the Building Code wherever such work occurs, unless otherwise specified.
   1. Attachment A - Concrete - Special Inspection Schedule.
   2. Attachment B - Architectural, Mechanical, and Electrical Components - Special Inspection Schedule.
   3. Attachment D - Soils - Special Inspection Schedule.

3.02 SPECIAL CERTIFICATION

A. Special inspector shall examine the designated seismic system(s) and determine whether the designated system components, including anchorage, are consistent with the evidence of compliance submitted for Special Certification.

3.03 STRUCTURAL OBSERVATION

A. The following work requires Structural Observation in accordance with the Building Code.
   1. All structures in all areas:
      a. Foundations.
      b. Elevated slabs.

3.04 SCHEDULE

A. Allow time necessary for Special Inspections and Structural Observation specified in this Section.

B. Sufficient notice shall be given so that the Special Inspections and Structural Observations can be performed. Allow time for individuals performing to travel to the site.

3.05 PROCEDURE

A. Special inspector will immediately notify the Engineer of any corrections required and follow notification with appropriate documentation.

B. Contractor shall not proceed until the work is satisfactory to the Engineer.

END OF SECTION

ATTACHMENT A - CONCRETE - SPECIAL INSPECTION SCHEDULE

CONCRETE - SPECIAL INSPECTION SCHEDULE
(Includes: Cast-in-place, precast, prestressed, precast-prestressed, and shotcrete.)

Verification and Inspection	Reference Standard	Frequency of Inspection[1] (During Task Listed)	
		Continuous	Periodic
1. Inspect reinforcement, including prestressing tendons, and verify placement.	ACI 318 Building Code		●
2. Reinforcing bar welding:			
a. Verify weldability of reinforcing bars other than ASTM A706;	AWS D1.4 ACI 318		●
b. Inspect single-pass fillet welds, maximum 5/16 inch; and	AWS D1.4 ACI 318		●
c. Inspect all other welds.	AWS D1.4 ACI 318	●	
3. Inspect anchors cast in concrete.	ACI 318		●
4. Inspect anchors post-installed in hardened concrete members:			
a. Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads.	ACI 318	●	
b. Mechanical anchors and adhesive anchors not defined in 4.a.	ACI 318		●
5. Verify use of required design mix.	ACI 318 Building Code		●
6. Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.	ASTM C172 ASTM C31 ACI 318 Building Code	●	
7. Inspect concrete and shotcrete placement for proper application techniques.	ACI 318 Building Code	●	
8. Verify maintenance of specified curing temperature and techniques.	ACI 318 Building Code		●
9. Inspect prestressed concrete for:			
a. Application of prestressing forces; and	ACI 318	●	
b. Grouting of bonded prestressing tendons.	ACI 318	●	
10. Inspect erection of precast concrete members.	ACI 318		●
11. Verify in-situ concrete strength, prior to stressing of tendons in post-tensioned concrete and prior to removal of shores and forms from beams and structural slabs.	ACI 318		●
12. Inspect formwork for shape, location and dimensions of the concrete member being formed.	ACI 318		●

Notes:

(1) "●" represents a required inspection activity for the project where it occurs.

ATTACHMENT B - ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS - SPECIAL INSPECTION SCHEDULE

ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS - SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection(1) (During Task Listed)	
		Continuous	Periodic
1. Plumbing, mechanical, and electrical components:			
a. Anchorage of electrical equipment for emergency and standby power systems.	Building Code		●
b. Anchorage of other electrical and mechanical equipment over 400 lb. on floors or roofs.	Building Code		●

Notes:

(1) "●" represents a required inspection activity for the project where it occurs.

ATTACHMENT C - SOILS - SPECIAL INSPECTION SCHEDULE

SOILS - SPECIAL INSPECTION SCHEDULE

Verification and Inspection	Reference Standard	Frequency of Inspection[1] (During Task Listed)	
		Continuous	Periodic
1. Verify materials below shallow foundations are adequate to achieve the design bearing capacity.	Building Code		●
2. Verify excavations are extended to proper depth and have reached proper material.	Building Code		●
3. Perform classification and testing of fill and backfill materials.	Building Code		●
4. Verify use of proper materials, densities, and lift thicknesses during placement and compaction of fill and backfill.	Building Code	●	
5. Prior to placement of fill, observe subgrade and verify that site has been prepared properly.	Building Code		●

Notes:

(1) "●" represents a required inspection activity for the project where it occurs.

SECTION 01460

CONTRACTOR QUALITY CONTROL PLAN

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Contractor Quality Control Plan.

1.02 SUBMITTALS

A. Qualifications of the Contractor's Quality Control (CQC) Plan Manager.

B. Contractor's Daily Quality Control Report:
   1. Submit to Engineer within 1 day of completion of each inspection using the approved form.

C. Daily Inspection Report:
   1. Submit to Engineer at the end of each working day or no later than prior to the beginning of the next working day using the approved form.

1.03 CONTRACTOR'S INSPECTION OF THE WORK

A. Work performed by Contractor shall be inspected by the Contractor's CQC Plan Manager. Non-conforming Work and any safety hazards in the Work area shall be noted and promptly corrected.

B. No materials or equipment shall be used in Work without inspection and acceptance by Contractor's CQC Plan Manager.

1.04 QUALIFICATIONS

A. Contractor's CQC Plan Manager: Demonstrate having performed similar CQC functions on similar type projects. Submit records of personnel experience, training, and qualifying registrations.

B. Minimum qualifications: Candidate must have a minimum of 10 years of experience on projects of similar type and size.

1.05 COVERING WORK

A. Whenever Contractor intends to backfill, bury, cast in concrete, or otherwise cover any Work, notify Engineer not less than 24 hours in advance to request inspection before beginning any such Work of covering. Failure of Contractor to notify Engineer in accordance with this requirement shall be resolved according to Article 14 of the General Conditions.

1.06 CONTRACTOR'S QUALITY CONTROL PROGRAM

A. General: Establish and execute a Quality Control (CQC) Plan for Work. The plan shall establish adequate measures for verification and conformance to defined requirements by Contractor personnel and lower-tier Subcontractors (including Fabricators, Suppliers, and Subcontractors). This program shall be described in a Plan responsive to this Section.

B. CQC personnel:
   1. Contractor's CQC Plan Manager shall report to a Senior Project Manager of the Contractor and shall have no supervisory or managerial responsibility over the workforce.
   2. The Contractor CQC Plan Manager shall be on-site as often as necessary, but not less than the daily working hours specified in the Contract Documents to remedy and demonstrate that Work is being performed properly and to make multiple observations of Work in progress.
   3. The Contractor is to furnish personnel with assigned CQC functions reporting to the CQC Manager. Persons performing CQC functions shall have sufficient qualifications, authority, and organizational freedom to identify quality problems and to initiate and recommend solutions.

C. CQC Plan:
   1. Contractor's CQC Plan shall include a statement by the Senior Project Manager designating the CQC Plan Manager and specifying the authority delegated to the CQC Plan Manager to direct cessation or removal and replacement of defective Work.
   2. Describe the CQC program and include procedures, work instructions, and records. Describe methods relating to areas that require special testing and procedures as required by the specifications.
   3. Include specific instructions defining procedures for observing Work in process and comparing this Work with the Contract requirements (organized by specifications section).
   4. Describe procedures to ensure that equipment or materials that have been accepted at the Site are properly stored, identified, installed and tested.
   5. Include procedures to verify that procured products and services conform to the requirements of the Specifications. Requirements of these procedures shall be applied, as appropriate, to lower-tier Suppliers and/or Subcontractors.
   6. Commissioning quality control: Include procedures to verify that the commissioning requirements of the Contract Documents are integrated into the Contractor's CQC Plan and conform to the requirements of the Specifications. Requirements of these procedures shall be applied, as appropriate, to the Contractor and the lower-tier Suppliers and/or Subcontractors.
   7. Include instructions for recording inspections and requirements for demonstrating through the Daily Inspection Reports that Work inspected was in compliance or a deficiency was noted and action to be taken.
   8. Procedures to preclude the covering of deficient or rejected Work.

9. Procedures for halting or rejecting Work.
10. Procedures for resolution of differences between the CQC Plan Manager and the production personnel.
11. Identify contractual hold/inspection points as well as any Contractor-imposed hold/inspection points.

D. Daily Inspection Report: Include, at a minimum:
1. Inspection of specific work.
2. Quality characteristics in compliance.
3. Quality characteristics not in compliance.
4. Corrective/remedial actions taken.
5. Statement of certification.
6. CQC Manager's signature, electronic signature is acceptable.
7. Information provided on the daily report shall not constitute notice of delay or any other notice required by the Contract Documents.

E. Deficient and Non-conforming Work and Corrective Action: Include procedures for handling deficiencies and non-conforming Work. Deficiencies and non-conforming Work are defined as documentation, drawings, material, equipment, or Work not conforming to the indicated requirements or procedures. The procedure shall prevent non-conformances by identification, documentation, evaluation, separation, disposition, and corrective action to prevent reoccurrence. Conditions having adverse effects on quality shall be promptly identified and reported to the senior level management. The cause of conditions adverse to quality shall be determined and documents and measures implemented to prevent recurrence. In addition, at a minimum, this procedure shall address:
1. Personnel responsible for identifying deficient and non-complying items within Work.
2. How and by whom deficient and non-compliant items are documented "in the field."
3. The personnel and process utilized for logging deficient and non-compliant Work at the end of each day onto a deficiency log.
4. Tracking processes and tracking documentation for deficient and non-conforming Work.
5. Personnel responsible for achieving resolution of outstanding deficiencies.
6. Include detailed procedures for the performance and control of special process (e.g., welding, soldering, heat treating, cleaning, plating, nondestructive examination, etc.).

F. Audits: The CQC program shall provide for regularly scheduled documented audits to verify that CQC procedures are being fully implemented by Contractor and its Subcontractors. Audit records shall be made available to Engineer upon request.

G. Documented control/quality records:
1. Establish methods for control of Contract Documents that describe how Drawings and Specifications are received and distributed to ensure the correct issue of the document being used. Describe how record document/drawing data are documented and furnished to Engineer.
2. Maintain evidence of activities affecting quality. Including operating logs, records of inspection, audit reports, personnel qualification and certification records, procedures, and document review records.

3. Maintain quality records in a manner that provides for timely retrieval and traceability. Protect quality records from deterioration, damage and destruction.
4. Develop a list of specific records as required by the Contract Documents that will be furnished to Engineer at the completion of activities.

H. Acceptance of CQC Plan: Engineer's acceptance of the CQC Plan shall not relieve Contractor from any of its obligations for performance of Work. Contractor's CQC staffing is subject to Engineer's review and continued acceptance. Owner, at its sole discretion, and without cause, may direct Contractor to remove and replace the CQC Plan Manager.
1. Acceptance of the CQC Plan by the Engineer is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction.
2. After acceptance of the CQC Plan, notify the Engineer in writing of any proposed change. Proposed changes are subject to acceptance by the Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01500

TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Furnishing, maintaining, and removing construction facilities and temporary controls, including temporary utilities, construction aids, barriers and enclosures, security, access roads, temporary controls, project sign, field offices and sheds, and removal after construction.

1.02 REFERENCE

A. American National Standards Institute (ANSI).

B. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

1.04 TEMPORARY UTILITIES

A. Temporary electrical power:
   1. Arrange with local utility to provide adequate temporary electrical service.
   2. Provide and maintain adequate jobsite power distribution facilities conforming to applicable Laws and Regulations.
   3. Provide, maintain, and pay for electric power for performance of the Work except for power required for the final start up test.

B. Temporary electrical lighting:
   1. In work areas, provide temporary lighting sufficient to maintain lighting levels during working hours not less than lighting levels required by OSHA and state agency which administers OSHA regulations where Project is located.
   2. When available, permanent lighting facilities may be used in lieu of temporary facilities:
      a. Prior to final completion of the Work, replace bulbs, lamps, or tubes used by Contractor for lighting.

C. Temporary heating, cooling, and ventilating:
   1. Heat and ventilate work areas to protect the Work from damage by freezing, high temperatures, weather, and to provide safe environment for workers.
   2. Permanent heating system may be utilized when sufficiently completed to allow safe operation.

D. Temporary water:
   1. Pay for and construct facilities necessary to furnish potable water for human consumption and non-potable water for use during construction.
   2. Remove temporary piping and connections and restore affected portions of the facility to original condition before final Completion.
   3. Pay for water used for construction prior to final Completion.
   4. Development of potable water supply:
      a. Potable water is not available at construction site.
      b. Provide potable water for human consumption during construction period.
      c. Furnish potable water that meets requirements of Laws and Regulations.
      d. Non-potable water is not available on the site.
         1) Obtain water for construction by piping from existing remote source, drilling temporary wells, or by filtering and treating water from local irrigation or other surface water sources.
         2) Abide by laws and regulations when drilling temporary wells or using irrigation water.

E. Temporary sanitary facilities:
   1. Provide suitable and adequate sanitary facilities that are in compliance with applicable Laws and Regulations.
   2. Existing facility use is not allowed.
   3. At completion of the Work, remove sanitary facilities and leave site in neat and sanitary condition.

F. Temporary fire protection:
   1. Provide fire protection required to protect the Work and ancillary facilities.

G. First aid: Post first aid facilities and information posters conforming to requirements of OSHA and other applicable Laws and Regulations in readily accessible locations.

H. Utilities in existing facilities: As specified in Section 01140 - Work Restrictions.

I. Temporary piping systems:
   1. Submit layout drawings showing proposed routing of piping, including proposed pipe support and pipe restraint locations.
   2. Submit product data for piping, fittings, appurtenances, restraints, supports, and other components of the temporary piping system.
   3. Piping shall be sized and routed as needed to accommodate the temporary bypass pumping system and convey wastewater as indicated on the Drawings.
   4. Refer to Specification Section 02552 – Temporary Bypass Pumping for additional requirements.

J. Temporary pumping systems:
   1. Refer to Specification Section 02552 – Temporary Bypass Pumping for requirements.

1.05 CONSTRUCTION AIDS

A. Provide railings, kick plates, enclosures, safety devices, and controls required by Laws and Regulations and as required for adequate protection of life and property.

B. Use construction hoists, elevators, scaffolds, stages, shoring, and similar temporary facilities of ample size and capacity to adequately support and move loads.

C. Design temporary supports with adequate safety factor to ensure adequate load bearing capability:
   1. When requested, submit design calculations by professional registered engineer prior to application of loads.
   2. Submitted design calculations are for information and record purposes only.

D. Accident prevention:
   1. Exercise precautions throughout construction for protection of persons and property.
   2. Observe safety provisions of applicable Laws and Regulations.
   3. Guard machinery and equipment and eliminate other hazards.
   4. Make reports required by authorities having jurisdiction, and permit safety inspections of the Work.
   5. Before commencing construction work, take necessary action to comply with provisions for safety and accident prevention.

E. Barricades:
   1. Place barriers at ends of excavations and along excavations to warn pedestrian and vehicular traffic of excavations.
   2. Provide barriers with flashing lights after dark.
   3. Keep barriers in place until excavations are entirely backfilled and compacted.
   4. Barricade excavations to prevent persons from entering excavated areas in streets, roadways, parking lots, treatment plants, or other public or private areas.

F. Warning devices and barricades: Adequately identify and guard hazardous areas and conditions by visual warning devices and, where necessary, physical barriers:
   1. Provide devices in accordance with minimum requirements of OSHA and State agency which administers OSHA regulations where Project is located.

G. Hazards in public right-of-way:
   1. Comply with local jurisdiction standards and requirements for right-of-way barricades and other safety devices.
   2. Mark at reasonable intervals, trenches, and other continuous excavations in public right-of-way, running parallel to general flow of traffic, with traffic cones, barricades, or other suitable visual markers during daylight hours:
      a. During hours of darkness, provide markers with torches, flashers, or other adequate lights.
   3. At intersections or for pits and similar excavations, where traffic may reasonably be expected to approach head on, protect excavations by continuous barricades:
      a. During hours of darkness, provide warning lights at close intervals.

H. Hazards in protected areas: Mark or guard excavations in areas from which public is excluded, in manner appropriate for hazard.

I. Above grade protection: On multi-level structures, provide safety protection that meets requirements of OSHA and State agency which administers OSHA regulations where Project is located.

J. Protect existing structures, trees, shrubs, and other items to be preserved on Project site from injury, damage, or destruction by vehicles, equipment, worker or other agents with substantial barricades or other devices commensurate with hazards.

K. Fences:
   1. Enclose temporary offices and storage areas with fence adequate to protect temporary facilities against acts of theft, violence, and vandalism.
   2. When entire or part of site is to be permanently fenced, permanent fence may be built to serve for both permanent and temporary protection of the work site, provided that damaged or defaced fencing is replaced prior to final completion.
   3. Protect temporary and permanent openings and close openings in existing fences to prevent intrusion by unauthorized persons.
      a. Bear responsibility for protection of plant and material on site of the Work when openings in existing fences are not closed.
   4. During night hours, weekends, holidays, and other times when no work is performed at site, provide temporary closures or enlist services of security guards to protect temporary openings.
   5. Fence temporary openings when openings are no longer necessary.
   6. The location of proposed temporarily disturbed areas (site ingress/egress for construction equipment, areas for storage of material, construction activity areas, grading and trenching, etc.) that will subsequently be restored to original grade and replanted with native vegetation shall be enclosed with fencing per subparagraph 1.05 K.7.
   7. The water resource area shall be protected, prior to construction, with an anchored chain link fence (or equivalent approved by the City) at its perimeter that shall remain undisturbed, except as specifically authorized by the approval authority. Additional fencing to delineate approved temporarily disturbed areas may be required. Fencing shall be maintained until construction is complete.

1.06 SECURITY

A. Make adequate provision for protection of the work area against fire, theft, and vandalism, and for protection of public against exposure to injury.

1.07 ACCESS ROADS

A. General:
   1. Build and maintain access roads to and on site of the Work to provide for delivery of material and for access to existing and operating plant facilities on site.
   2. Build and maintain dust free roads which are suitable for travel at 20 miles per hour.

B. Off-site access roads:
   1. Build and maintain graded earth roads.
   2. Build roads only in public right-of-way or easements obtained by Owner.
   3. Obtain rights-of-way or easements when electing to build along other alignment.

C. On-site access roads:
   1. Maintain access roads to storage areas and other areas to which frequent access is required.
   2. Maintain similar roads to existing facilities on site of the Work to provide access for maintenance and operation.
   3. Protect buried vulnerable utilities under temporary roads with steel plates, wood planking, or bridges.
   4. Maintain on-site access roads free of mud.
   5. Provide controls to prevent vehicles leaving the site from tracking mud off the site onto the public right-of-way.

1.08 TEMPORARY CONTROLS

A. Dust control:
   1. Prevent dust nuisance caused by operations, unpaved roads, excavation, backfilling, demolition, or other activities.
   2. Control dust by sprinkling with water, use of dust palliatives, modification of operations, or other means acceptable to agencies having jurisdiction.

B. Noise control:
   1. Comply with noise and work hours regulations by local jurisdiction.
   2. In or near inhabited areas, particularly residential, perform operations in manner to minimize noise.
   3. In residential areas, take special measures to suppress noise during night hours.

C. Mud control:
   1. Prevent mud nuisance caused by construction operations, unpaved roads, excavation, backfilling, demolition, or other activities.

1.09 PROJECT SIGN

A. Provide and maintain Project identification sign consisting of painted 8-foot wide by 4-foot high exterior grade plywood and minimum 10-foot long, 4 by 4 lumber posts, set in ground at least 3 feet, with exhibit lettering by professional sign painter using no more than 5 sign colors:
   1. List at least the title of the Project, and names of the Owner, Engineer, and Contractor.
   2. Identify Contractor's, Engineer's, names in upper right-hand corner underneath the bid number.

B. On third and fourth lines of printing, paint appropriate dollar amounts.

C. Erect Project identification sign where directed by Engineer within 14 days after the issuance of the Notice to Proceed.

D. Replace or repair the project sign if it is damaged or covered with graffiti within 5 working days of observation or notification of damage or graffiti.

1.10 CONTRACTOR FIELD OFFICES AND SHEDS

A. Maintain on Project Site weather tight space in which to keep copies of Contract Documents, progress schedule, shop drawings, and other relevant documents.

B. Provide field office with adequate space to examine documents and provide lighting and telephone service in that space.

1.11 REMOVAL

A. Remove temporary facilities and controls before inspection for final Completion or when directed.

B. Clean and repair damage caused by installation or use of temporary facilities.

C. Remove underground installations to minimum depth of 24 inches and grade to match surrounding conditions.

D. Restore existing facilities used during construction to specified or original condition.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01550

TRAFFIC CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Traffic control requirements to keep streets and traffic ways open for the passage of vehicles and pedestrians during the construction period.

1.02 SUBMITTALS

A. Approved and signed copies of:
   1. Public Works Permit.
   2. Traffic control plan (TCP).
   3. Notification plan.

1.03 AUTHORITIES HAVING JURISDICTION (AHJ)

A. AHJ as specified in Section 01410 - Regulatory Requirements.

B. AHJ traffic control requirements supersede the requirements of this Section.

C. Comply with AHJ traffic control requirements.

1.04 MEASUREMENT AND PAYMENT

A. Contractor is responsible for costs associated with permits, plans, implementation, and maintenance as specified in Section 01220 - Measurement and Payment.

1.05 PUBLIC WORKS PERMIT

A. Obtain Public Works Permit approved by AHJ.

1.06 TRAFFIC CONTROL PLAN (TCP)

A. Approval of the TCP by the AHJ shall in no way relieve the Contractor of the responsibility for traffic and safety requirements.

B. Include labor, material, equipment, tools, and services used in the regulation of construction traffic to and from the project site as well as public vehicular and pedestrian traffic within the project limits.

C. Provide a TCP for each phase or segment of the construction meeting the requirements of the AHJ and this Section.
   1. Each TCP shall be considered separately.

D. Finalize TCP based on the draft TCP as indicated on the Drawings.

E. Obtain TCP approved by AHJ.

F. Submit approved TCP to the Engineer within 48 hours of approval by the AHJ. Changes to the TCP:
   1. If, during the execution of the work, the Contractor determines that the traffic control is not functioning as intended, the Contractor shall submit revised TCP to AHJ for approval.
   2. Submit revised approved TCP to the Engineer within 48 hours of completing a change.

G. Provide for the protection of the traveling public, pedestrians, and workers within the area covered by the limits of construction, at all times when the area is affected by construction facilities or activities including the following:
   1. Private property access.
      a. Warn, control, protect, and expedite vehicular and pedestrian traffic through the private property.
   2. Driveway access.
   3. Sanitation (trash) truck access.
   4. Protection from excavations.
   5. Limit access to work sites.

1.07 NOTIFICATION PLAN

A. Submit Notification Plan to Engineer for approval.

B. Define who will notify, how they will notify, and when they will notify.
   1. Notify affected emergency agencies, residences, and businesses within the area of current work 15 days prior to start of operations.
   2. Notify AHJ for any traffic control or work areas affecting traffic signals, public bus routes, or bus stops at a minimum of 72 hours prior to any the work.

C. Notify Engineer 15 days prior to start of construction.

D. Notify the AHJ a minimum of 2 working days prior to the anticipated beginning of construction.
   1. Emergency services, such as police and fire.
   2. Other services, such as bus service, mail and garbage collection.

E. Residential areas:
   1. Notify adjacent residents as applicable at least 4 days prior to restricting driveway access or starting any work, using "door knob type" Notices approved by the Engineer.
      a. Notices shall describe the impending work.
      b. Notices shall also identify dates and stages of work.
   2. Give special consideration to multi-family residential complexes and other high-density uses.
   3. Notices shall also identify dates and stages of work.

F. Vehicular Traffic: Define placement of the following:
   1. Project signs.
      a. Locate project signs as indicated on the Drawings.
   2. Text message boards.
      a. Locate text message boards as indicated on the Drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01562

TEMPORARY TREE AND PLANT PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Tree and plant protection.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. A300 - For Tree Care Operations - Tree, Shrub, and Other Woody Plant Maintenance Standard Practices (Pruning).

B. American Society of Consulting Arborists (ASCA).

C. International Society of Arboriculture (ISA).

1.03 MEASUREMENT AND PAYMENT

A. Payment for tree protection, including tree pruning or tree removal, shall be paid as a lump sum basis that shall include all items specified in this Section unless payment is specified otherwise in this Section.

B. Unit price procedures: As specified in Section 01220 - Measurement of Payment.

1.04 SUBMITTALS

A. As specified in Section 01330 - Submittal Procedures.

B. Certification of a Registered Consulting Arborist (designated ASCA or ISA) to review and approve temporary protection measures for trees indicated to remain.

C. Protection Zone Exhibit indicating intended location of tree protection fencing.

D. Tree maintenance plan: Arborist recommendations for care of trees, both during construction and after work is completed.

1.05 PROJECT CONDITIONS

A. Preserve and protect existing trees and plants to remain from foliage, branch, trunk, or root damage that could result from construction operations.

B. Prevent damage including, but not limited to, the following:
   1. Trunk damage from equipment operations, material storage, or from nailing or bolting.

2. Trunk and branch damage caused by ropes or guy wires.
3. Root or soil contamination from spilled solvents, gasoline, paint, lime slurry, and other noxious materials.

1.06 QUALITY ASSURANCE

A. Arborist qualifications: Certified by ISA.

B. Pre-construction conference: To establish schedule and procedures for tree protection.

C. Pre-construction documentation: To establish pre-construction condition of existing tree to remain that might be misconstrued as damage caused by construction.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pruning paint: Black latex, water-based paint, free of all petroleum products.

B. Tree protection fencing:
1. Provide continuous fencing between posts, pulled taut prior to securing to posts, and firmly attached to the posts with a minimum of 4 wire ties.
2. Orange, plastic mesh fencing:
   a. Fencing minimum height: 4-feet.
   b. “t” bar posts:
      1) Minimum height: 6-feet.
      2) Installed 10 feet on centers.

PART 3 EXECUTION

3.01 PROTECTION OF EXISTING TREES AND SHRUBS

A. Site preparation work and/or construction work shall not begin in any area where tree preservation measures have not been completed and approved.

B. Tree protection zone: Install temporary fencing outside the drip line of tree to be protected from construction damage.
1. Install fencing with a radius of 1.5 times the drip line, unless otherwise indicated by Consulting Arborist.
2. Protect tree and shrub root systems from damage due to noxious materials caused by runoff or spillage while mixing, placing, or storing construction materials.
3. Protect root systems from flooding, eroding, or excessive wetting.
4. Do not store construction materials, equipment, debris, or other material within the drip line of remaining trees.
5. Do not permit vehicles or foot traffic within the drip line; prevent soil compaction over root systems.
6. Designate limited areas as concrete washout areas away from root zones.

C. Install tree protection fencing around each tree to be preserved as indicated in the tree treatment schedule and on the tree protection plan.
    1. Each tree to be preserved shall be protected with a tree protection fence. Install tree protection fencing prior to site work or construction activity.
    2. Immediately repair damage to tree fences occurring during the progress of the work at no additional cost to Owner.
    3. Workers shall be clearly instructed to exercise caution in performance of work near trees being preserved.

D. Pruning of trees:
    1. Prune trees in accordance with the ANSI A300 for tree pruning.
        a. Pruning shall be completed by professional arborists who have received training in proper pruning techniques.
    2. Make cuts sufficiently close to the parent limb or trunk without cutting into the branch collar or leaving a protruding stub, so that closure can readily start under normal conditions.
        a. All lateral cuts shall be made to a lateral that is least 1/3 the diameter of the parent limb.
        b. Clean cuts shall be made at all times.
    3. Prune trees in a manner that will not destroy or alter the natural shape and character of the tree.
        a. Apply black latex paint to fresh wounds on Oak (Quercus) species immediately after each cut is made.
    4. Crown cleaning prune designated trees shall include selective removal of dead, diseased, and/or broken limbs.

3.02 EXCAVATION

A. Do not excavate within drip line of protected trees.

B. Within drip line of trees, hand clear to minimize damage to root systems.

3.03 TREE REPAIR AND REPLACEMENT

A. Promptly treat damaged trunks, limbs, and roots according to written instructions of Consulting Arborist.

3.04 DISPOSAL OF FENCING MATERIALS

A. Promptly remove protective fencing upon completion of construction activities.

END OF SECTION

SECTION 01573

EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Installation of erosion and sediment control filter fabric fences.
   2. Triangular filter fabric fences.
   3. Straw bale fences and brush berms used during construction and prior to final development of site.

B. Purpose of control fences is to contain pollutants from overland flow.
   1. Control fences are not for use in channelized flow areas.

1.02 UNIT PRICES

A. Measure and pay for filter fabric fence by linear foot of completed and accepted filter fabric fence installed around construction site. Limits of construction site are indicated on the Drawings.

B. Measure and pay for triangular filter fabric fence by linear feet of completed and accepted triangular filter fabric fence between limits of beginning and ending of wooden stakes.

C. Measure and pay for straw bale barrier by linear feet of completed and accepted straw bale barrier.

D. Measure and pay for brush berm by linear feet of completed and accepted brush berm.

1.03 SUBMITTALS

A. Manufacturer’s catalog sheets and other product data on geotextile fabric.

1.04 REFERENCES

A. ASTM International (ASTM):
   1. D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
   2. D4355 - Standard Test Method for Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus.
   3. D4491- Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   5. D4833 - Standard Test Method for Index Puncture Resistance of Geomembranes, and Related Products.

6. D5665- Standard Specification for Thermoplastic Fabrics Used in Cold-Applied Roofing and Waterproofing.
7. D6459 - Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Hillslopes from Rainfall-Induced Erosion.
8. D6475 - Standard Test Method for Measuring Mass per Unit Area of Erosion Control Blankets.
9. D6525 - Standard Test Method for Measuring Nominal Thickness of Rolled Erosion Control Products.
10. D6567 - Standard Test Method for Measuring the Light Penetration of a Rolled Erosion Control Product (RECP).
11. D6818 - Standard Test Method for Ultimate Tensile Properties of Rolled Erosion Control Products.

1.05 QUALITY ASSURANCE FOR EROSION CONTROL BLANKETS

A. Product shall be manufactured in accordance to a documented Quality Control Program. At a minimum, the following procedures and documentation shall be provided:
   1. Manufacturing Quality Control Program Manual.
   2. First piece inspection of products produced to assure component materials and finished product tolerances are within manufacturer specifications.
   3. Additional inspections for product conformance shall be conducted during the run after the first piece inspection.
   4. Every roll shall be visually inspected.
   5. Moisture content of straw and coconut fibers measured upon receipt.
   6. At a minimum, every third roll shall be weighed to insure conformance of manufacturer's specifications.
   7. Each individual erosion control blanket shall be inspected prior to packaging for conformance to manufacturing specifications.

1.06 PERFORMANCE REQUIREMENTS FOR EROSION CONTROL BLANKETS

A. Erosion control blanket shall provide a temporary, biodegradable cover material to reduce slope and enhance vegetation. Erosion control blanket performance capabilities shall be in accordance with ASTM D6459, "Determination of Erosion Control Blanket (ECB) Performance in Protecting Hillslopes from Rainfall-Induced Erosion."

PART 2 PRODUCTS

2.01 FILTER FABRIC

A. Provide woven or nonwoven geotextile filter fabric made of either polypropylene, polyethylene, ethylene, or polyamide material.

B. Geotextile fabric:
   1. Grab strength of 100 pounds per square inch in any principal direction in accordance with ASTM D4632.

2. Puncture strength exceeding 115 pounds per square inch in accordance with ASTM D4833.
3. Equivalent opening size between 50 and 140 for soils with more than 15 percent by weight passing No. 200 sieve and between 20 and 50 for soil with less than 15 percent by weight passing No. 200 sieve.
4. Maximum water flow rate of 40 gallons per minute per square feet in accordance with ASTM D4491.

C. Filter fabric material shall contain ultraviolet inhibitors and stabilizers to provide expected usable life comparable to anticipated construction period.
1. Ultraviolet stability shall exceed 70 percent after 500 hours of exposure in accordance with ASTM D4355.

D. Manufacturers: The following or equal:
1. Mirafi, Inc.

2.02 EROSION CONTROL BLANKETS

A. Manufacturers: One of the following or equal:
1. American Excelsior Co., AEC Premier Straw/Coconut™ Blankets.
2. Proper Geotextile Systems.

B. Product requirements:
1. Erosion control blanket shall be furnished in rolls and wrapped with suitable material to protect against moisture intrusion and extended ultraviolet exposure prior to placement.
2. Erosion control blanket shall be of consistent thickness with fibers distributed evenly over the entire area of the blanket.
3. Erosion control blanket shall be free of defects and voids that would interfere with proper installation or impair performance.

C. Materials:
1. Blend of 70 percent straw and 30 percent coconut fibers.
   a. The straw fibers shall consist of straw with 75 percent of fibers greater than 4 inches in length, and certified weed seed free.
   b. Product shall be 100 percent biodegradable.
   c. The blended fibers shall be evenly distributed throughout the entire area of the blanket.
   d. The top and bottom of each blanket is covered with biodegradable jute netting.
2. Blanket performance requirements:
   a. C factor: 0.15.
   b. Shear stress: 2.0 lb/ft^2.
   c. Velocity: 8.5 feet per second.
   d. Functional longevity: Less than 24 months.
3. Material characteristics:
   a. Width: 8.0 feet.
   b. Length: 112.5 feet.
   c. Area: 100.0 $yard^2$.
   d. Weight: 50.0 pounds.
   e. Mass per unit area: 0.50 lv/yd^2.

f. Net openings: 0.5 inch by 1.0 inch.
g. Minimum Index Values:

Index Property	Test Method	Value
Thickness	ASTM D6525	0.331 in (8.41 mm)
Light Penetration	ASTM D6567	5.8%
Mass per Unit Area	ASTM D6475	0.81 lb/yd^2 (437 g/m^2)
MD-Tensile Strength Max.	ASTM D6818	321.6 lb/ft (4.69 kN/m)
TD-Tensile Strength Max.	ASTM D6818	159.6 lb/ft (2.33 kN.m)
MD-Elongation	ASTM D6818	4.1%
TD-Elongation	ASTM D6818	4.8%
Water Absorption	ASTM D5665	382%

D. Staples:
1. Staples shall be 100 percent biodegradable with a U-shaped top. Staples shall be a minimum 4 inch biodegradable staple for cohesive soils and 6 inches for non-cohesive soils.

2.03 WATTLES

A. Product requirements:
1. Wattles are cylindrical products of netting filled with a fibrous material to prevent sediment flow in channels and slopes. Wattles are secured to ground by stakes.

B. Materials:
1. Fibers: weed free straw, coconut or other approved material.
2. Netting: Synthetic PP Netting or approved equal.
3. Diameter: 9-inches minimum.
4. Density: 1.7 pounds per cubic foot minimum.
5. Length: As determined by Contractor.

PART 3 EXECUTION

3.01 PREPARATION AND INSTALLATION

A. Provide erosion and sediment control systems at locations as indicated on the Drawings.
1. Construct in accordance with requirements as indicated on the Drawings and of type indicated as specified in this Section.
2. Appropriate erosion control measures consistent with Clackamas County Erosion Prevention and Sediment Control Planning and Design Manual, rev. 2008.

B. No clearing, grubbing or rough cutting permitted until erosion and sediment control systems are in place, other than site work specifically directed by Project Manager to allow soil testing and surveying.

C. Maintain existing erosion and sediment control systems located within project site until acceptance of Project or until directed by Project Manager to remove and discard existing system.

D. Regularly inspect and repair or replace damaged components of erosion and sediment control systems as specified in this Section.
   1. Unless otherwise directed, maintain erosion and sediment control systems until project area stabilization is accepted by the Authority.
   2. Remove erosion and sediment control systems promptly when directed by Project Manager.
   3. Discard removed materials off site.

E. Remove and dispose sediment deposits at designated spoil site for Project.
   1. If a project spoil site is not indicated on the Drawings, dispose of sediment off site at location not in or adjacent to stream or floodplain.
   2. Assume responsibility for off-site disposal.
   3. Spread sediment evenly throughout site, compacted and stabilized.
   4. Prevent sediment from flushing into a stream or drainage way.
   5. If sediment has been contaminated, dispose of in accordance with existing federal, state, and local rules and regulations.

F. Unless otherwise indicated, compact embankments, excavations, and trenches by mechanically blading, tamping, and rolling soil in maximum of 8-inch layers.
   1. Compaction density shall be at a minimum of 90 percent Standard Proctor ASTM D698 density.
   2. Make at least 1 test per 500 cubic yards of embankment.

G. Prohibit equipment and vehicles from maneuvering on areas outside of dedicated rights-of-way and easements for construction.
   1. Immediately repair damage caused by construction traffic to erosion and sediment control.

3.02 GENERAL CONSTRUCTION METHODS

A. Provide erosion and sedimentation control systems as indicated on the Drawings.
   1. Install erosion and sedimentation control systems in manner that surface runoff shall percolate through system in sheet flow fashion and allow retention and accumulation of sediment.

B. Inspect erosion and sedimentation control systems after each rainfall, daily during periods of prolonged rainfall, and at minimum once each week.
   1. Repair or replace damaged sections immediately.
   2. Remove sediment deposits when silt reaches depth 1/3 height of fence or 6 inches, whichever is less.

3.03 SITE PREPARATION FOR EROSION CONTROL BLANKETS

A. Before placing erosion control blanket, Contractor shall certify that the subgrade has been properly compacted, graded smooth, has no depressions, voids, soft or uncompacted areas, is free from obstructions such as tree roots, protruding stones or other foreign matter, and is seeded and fertilized according to project specifications.
   1. Contractor shall not proceed until all unsatisfactory conditions have been remedied.
   2. By beginning construction, Contractor signifies that the proceeding work is in conformance with this Section.

B. Contractor shall fine grade the subgrade by hand dressing where necessary to remove local deviations.

C. No vehicular traffic shall be permitted directly on the erosion control blanket.

D. Slope installation:
   1. Erosion control blanket shall be installed as directed by Owner's representative in accordance with manufacturer's Installation Guidelines, Staple Pattern Guides, and CAD details. The extent of erosion control blanket shall be as indicated on the Drawings.
   2. Erosion control blanket shall be oriented in vertical strips and anchored with staples, as identified in the Staple Pattern Guide.
      a. Adjacent strips shall be overlapped to allow for installation of a common row of staples that anchor through the nettings of both blankets.
      b. Horizontal joints between erosion control blankets shall be sufficiently overlapped with the uphill end on top for a common row of staples so that the staples anchor through the nettings of both blankets.
   3. Where exposed to overland sheet flow, a trench shall be located at the uphill termination erosion control blanket shall be stapled to the bottom of the trench.
      a. The trench shall be backfilled and compacted.
      b. Where feasible, the uphill end of the blanket shall be extended 3 feet over the crest of the slope.

3.04 FILTER FABRIC FENCE CONSTRUCTION METHODS

A. Attach filter fabric to 1-inch by 2-inch wooden stakes or driven steel rods spaced a maximum of 3 feet apart and embedded minimum of 8 inches or deeper to hold fence in place.
   1. If filter fabric is factory preassembled with support netting, then maximum spacing allowable is 8 feet.
   2. Install anchoring stakes or rods at slight angle toward source of anticipated runoff.
   3. Contractor is responsible for providing adequate fence anchoring appropriate for the varying soil and rock conditions at the well sites.

B. Trench in toe of filter fabric fence with spade or mechanical trencher so that downward face of trench is flat and perpendicular to direction of flow.
   1. V-trench configuration as indicated on the Drawings may also be used.

2. Lay filter fabric along edges of trench.
3. Backfill and compact trench.

C. Filter fabric fence shall have a minimum height of 18 inches and a maximum height of 36 inches above natural ground.

D. Provide filter fabric in continuous rolls and cut to length of fence to minimize use of joints.
   1. When joints are necessary, splice fabric together only at support post with minimum 6-inch overlap and seal securely.

3.05 TRIANGULAR FILTER FABRIC FENCE CONSTRUCTION METHODS

A. Attach filter fabric to fence structure fashioned from 6 gauge, 6-inch by 6-inch wire mesh, 18 inches on each side as indicated on the Drawings.
   1. Fabric cover and skirt should be continuous wrapping of fabric.
   2. Skirt should form continuous extension of fabric on upstream side of fence.

B. Secure triangular fabric filter fence in place using one of the following methods:
   1. Toe-in skirt 6 inches with mechanically compacted material.
   2. Weight down skirt with continuous layer of 3-inch to 5-inch graded rock.
   3. Trench-in entire structure 4 inches.

C. If provided, anchor triangular fabric filter fence structure and skirt securely in place using 6-inch wire staples on 2-foot centers on both edges and on skirt, or staked using 18-inch by 3/8-inch diameter re-bar with tee ends.

D. Lap over fabric filter material by 6 inches to cover segment joints.
   1. Fasten joints with galvanized shoat rings.

3.06 STRAW BALE FENCE CONSTRUCTION METHODS

A. Bound bales with either wire, nylon or polypropylene rope tied across hay bales.
   1. Do not use jute or cotton bindings.

B. Place bales in row with ends tightly abutting adjacent bales.
   1. Place bales with bindings parallel to ground surface.

C. Embed bale in soil a minimum of 4 inches.

D. Securely anchor bales in place by 3/8-inch rebar stakes driven through bales a minimum of 18 inches into ground.
   1. Angle first stake in each bale toward previously laid bale to force bales together.

E. Fill gaps between bales with straw to prevent water from escaping between bales.
   1. Wedge carefully in order not to separate bales.

F. Replace with new straw bale fence every 2 months.

3.07 BRUSH BERM CONSTRUCTION METHODS

A. Construct brush berm along contour lines by hand placing method.
   1. Do not use machine placement of brush berm.

B. Use woody brush and branches having diameter less than 2-inches with 6-inches overlap.
   1. Avoid incorporation of annual weeds and soil into brush berm.

C. Use minimum height of 18-inches measured from top of existing ground at upslope toe to top of berm.
   1. Top width shall be 24 inches minimum and side slopes shall be 2:1 or flatter.

D. Embed brush berm into soil a minimum of 4-inches and anchor using either wire, nylon or polypropylene rope across berm with a minimum tension of 50 pounds.
   1. Tie rope securely to 18-inch x 3/8-inch diameter rebar stakes driven into ground on 4-foot centers on both sides of berm.

3.08 WATTLES

A. Install in field as indicated on the Drawings.

END OF SECTION

SECTION 01601

PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for tangible materials, raw or manufactured, that become part of the project.

1.02 TERMINOLOGY

A. The words and terms listed below, are not defined terms that require initial capital letters, but, when this Section is referenced in other Specifications, have the indicated meaning.
   1. Calculations:
      a. Documentation of the process of transforming the design and prescriptive criteria into a design meeting the performance criteria.
   2. Certificates:
      a. An official document that attests a fact is in accordance with the Contract Documents.
   3. Manufacturer's Certificate of Source Testing:
      a. Form used to confirm that the applicable source tests have been performed and the results conform to the Contract Documents. The form template is provided at the end of this Section.
   4. Manufacturer's instructions:
      a. Stipulations, directions, and/or recommendations issued by the manufacturer of the product addressing handling, storage, installation, protection, erection, and/or application of the product.
   5. Products:
      a. Raw materials, finished goods, equipment, systems, and shop fabrications that will become part of the Work.
   6. Product data:
      a. Information about the product, which is typically found in the manufacturer's catalogs or on their web site, including data sheets, bulletins, layout drawings, exploded views, and brochures.
   7. Samples:
      a. As defined in the General Conditions and Supplementary Conditions.
      b. Full-size actual products or pieces of products intended to illustrate the products to be incorporated into the project. Sample submittals are often necessary for such characteristics as colors, textures, and other appearance issues.
   8. Shop Drawings:
      a. As defined in the General Conditions and Supplementary Conditions.

b. Shop Drawings are prepared specifically for the project to illustrate details, dimensions, and other data necessary for satisfactory fabrication or construction.
c. Shop Drawings could include graphic line-type drawings and single-line diagrams.

9. Source Quality Control:
   a. Testing and inspections at the location of fabrication or assembly.
      1) Includes Factory Acceptance Testing (FAT), Factory Testing, and Source Testing.
   b. Test reports including the following information:
      1) Test description.
      2) List of equipment used.
      3) Name of the person conducting the test.
      4) Date and time the test was conducted.
      5) Ambient temperature and weather conditions.
      6) Raw data collected.
      7) Calculated results.
      8) Clear statement if the test passed or failed the requirements stated in Contract Documents.
      9) Signature of the person responsible for the test.
10. Special tools:
    a. Special wrenches, gauges, circuit setters, and other similar devices required for the proper operation or maintenance of a system that would not normally be in the Owner's tool kit and that have been specifically made for use on a product for assembly, disassembly, repair, or maintenance.
11. Submittals:
    a. As defined in the General Conditions and Supplementary Conditions.
    b. Samples, product data, Shop Drawings, and other materials that demonstrate how Contractor intends to conform to the Contract Documents.

1.03 QUALITY CONTROL

A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as required by the Contract Documents.
   1. Material testing, inspection procedures, and manufacturing process are subject to inspection by Engineer.
   2. Contractor shall notify Engineer in writing of the manufacturing start date not less than 14 days prior to the start of manufacturer of project pipe.
   3. Perform manufacturer’s tests and inspections required by the referenced standards and as specified in this Section including the following:
      a. Provide the Manufacturer's Certificate of Source Testing.
      b. Calibration within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe as required by ISO 9001.
         1) Each device used in the manufacturer of pipe is required to have a tag recording date of last calibration.
         2) Provide calibration certificate.
         3) Devices are subject to inspection by Engineer.

1.04 SERVICES OF MANUFACTURER'S REPRESENTATIVES

A. Qualification of manufacturer's representative as specified in the Contract Documents Technical Sections include the following:
   1. Authorized representative of the manufacturer, factory trained and experienced in the technical applications and installation of respective products with full authority by the product manufacturer to issue the certifications required of the manufacturer.
   2. Competent, experienced technical representative of the product manufacturer for installation.
   3. Additional qualifications may be specified in the individual sections.
   4. No substitute representatives will be allowed until written approval by Owner and Engineer has been obtained.

B. Completion of manufacturer on-site services: Engineer approval required.
   1. Manufacturer’s representative will advise aspects of installation, including, but not limited to:
      a. Handling.
      b. Storing.
      c. Cleaning and inspecting.
      d. Coating and lining repairs.
      e. Tapping.
      f. General construction methods.

C. Manufacturer is responsible for determining the time required to perform the specified services.
   1. No additional costs associated with performing the required services will be approved.
   2. Manufacturer required to schedule services in accordance with the Contractor's project schedule up to and including making multiple trips to project site when there are separate milestones associated with installation of each occurrence of manufacturer's product.

D. Manufacturer's on-site services as specified in the Contract Documents include the following:
   1. Assistance during Construction.
   2. Provide 1 copy of daily manufacturer's representative’s field notes and data to Engineer.
   3. Other requirements as specified in the Contract Documents.

1.05 GENERAL TEST REQUIREMENTS

A. Testing prerequisites:
   1. Prior to testing, verify equipment protective devices and safety devices have been installed, calibrated, and tested.

B. Acceptable test definition:
   1. Demonstrate the product performance meets the requirements stated in the Contract Documents.
      a. When the product fails to meet the specified requirements, perform additional, more detailed, testing to determine the cause, correct, repair,

or replace the causative components and repeat the testing that revealed the deficiency.

C. Test Plan requirements:
   1. As specified in this Section and other Technical Sections.
   2. Prepared by Contractor as a result of discussions and planning emerging from regularly conducted meetings for test planning.
   3. Define the following items for each Test:
      a. Purpose of the test.
      b. Identification of each item of equipment/system, including system designation, location, tag number, control loop identifier, etc.
      c. Description of the pass/fail criteria that will be used.
      d. Listing of pertinent reference documents (Contract Documents and industry standards or sections applicable to the testing).
      e. Credentials of test personnel.
      f. Test equipment:
         1) Product data.
         2) Appropriate calibration records.
         3) Drawings or photographs of test stands and/or test apparatus.
      g. Duration: Determine test durations with Owner's input.
      h. Detailed step-by-step test procedures.
         1) Setup.
         2) Level of detail shall be sufficient for any witness with a rudimentary technical aptitude to be able to follow the steps and develop confidence that the tests were being performed as planned.
         3) Include all steps in the procedures.
         4) Define temporary systems (pumps, piping, etc.), shutdown requirements for existing systems.
         5) Furnish labor, power, tools, equipment, instruments, and services required for and incidental to completing testing activities.
      i. Test forms: Include, but not limited to, the following information:
         1) Name of product to be tested.
         2) Test date.
         3) Names of persons conducting the test.
         4) Names of persons witnessing the test, where applicable.
         5) Test data.
         6) Applicable project requirements.
         7) Check offs for each completed test or test step.
         8) Place for signature of person conducting tests and for the witnessing person, as applicable.

D. Submit Test Plan.
   1. Submit forms as specified in the Technical Sections.
   2. Submit a copy of the Test Plan at least 21 days before any scheduled test date.
   3. Engineer approval of Test Plan required prior to beginning testing.

E. Request proposed test dates.
   1. Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

F. Implement approved Test Plans.

G. Submit Test Report.

1.06 SOURCE TESTING

A. As specified in Section 01450 - Quality Control.

B. Also referred to as factory testing or factory acceptance testing (FAT).

C. Source Test Plan:
   1. As specified in this Section and other Technical Sections.
   2. Purpose: Test products for proper performance at point of manufacture or assembly as specified in the Technical Sections.
   3. Source testing requirements as specified in Technical Sections.
      a. Non-witnessed:
         1) Provide completed Attachment A - Manufacturer's Certificate of Source Testing.
      b. Witnessed:
         1) 2 Owner's representative and 2 Engineer's representative present during testing, unless otherwise specified.
         2) Provide completed Attachment A - Manufacturer's Certificate of Source Testing.
   4. Duration: Define.
   5. Contractor is responsible for providing fuel, chemicals, and other consumables needed for Source Testing.

D. Contractor is responsible for witness trip costs associated with Owner's representatives and Engineer's representative.
   1. Include costs for at least the following:
      a. Transportation:
         1) Travel on commercial airline to and from site including related fees.
         2) Rental car to and from airport, hotel, and test site including related fees.
      b. Hotel/Meals:
         1) Hotel costs at a facility with an American Automobile Association 4-star rating or higher equivalent for single occupancy room per person per day.
         2) Meal allowance based on government per diem guidelines per location.
      c. Witness labor costs:
         1) The greater of $200 per hour or $1,600 per day.
   2. If Source Test is not ready when the witnesses arrive or if the Source Test fails, the witnesses will return home with Contractor responsible for costs associated with the trip including costs described above.
      a. Contractor is responsible for rescheduling the Source Test and witnesses' costs associated with the second trip including costs described above.
      b. Contractor is responsible for witnesses' costs associated with retests including costs described above.

1.07 INSTALLATION VERIFICATION

A. Installation Verification Plan:
   1. Purpose:
      a. Has been properly installed, adjusted, and aligned.
      b. Is free of any stresses imposed by connecting piping or anchor bolts.
      c. Is able to be operated as necessary for Functional Testing.
   2. Field test backfill, welded joints, alignment and grade, and pipeline pressure as specified in the Technical Sections.
   3. Duration: Define.
   4. Coordinate Installation Verification with restrictions and requirements as specified in Section 01140 - Work Restrictions.

1.08 FUNCTIONAL TESTING

A. Functional Test Plan:
   1. Purpose: Test piping system to verify conformance with the Contract Documents.
   2. Duration: Define.
   3. Perform testing in the presence of the Engineer.
   4. Contractor is responsible for providing fuel, chemicals, and other consumables needed.
   5. Coordinate Functional Testing with restrictions and requirements as specified in Section 01140 - Work Restrictions.

1.09 SHIPMENT

A. Prepare products for shipment by:
   1. Tagging or marking to agree with delivery schedule or Shop Drawings.
   2. Including complete packing lists and bills of material with each shipment.
   3. Packaging products to facilitate handling and protection against damage during transit, handling, and storage.
   4. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

B. Transport products by methods that avoid product damage.

C. Deliver products in undamaged condition in manufacturer's unopened containers or packaging.

1.10 DELIVERY AND HANDLING

A. Handle product in accordance with manufacturer's instructions.

B. Deliver products in undamaged condition in manufacturer's unopened containers or packaging.

C. Provide construction equipment and personnel to handle products by methods in accordance with manufacturer’s instructions.

D. Upon delivery, promptly inspect shipments:
   1. Verify compliance with Contract Documents, correct quantities, and undamaged condition of products.
   2. Acceptance of shipment does not constitute final acceptance of product.

1.11 STORAGE

A. Immediately store and protect products until installed in Work.

B. Store products with seals and legible labels intact.

C. Protect painted or coated surfaces against impact, abrasion, discoloration, and damage.

D. Storage of spare parts, maintenance products, special tools.
   1. Immediately store in accordance with the manufacturer's instructions.
   2. Store spare parts, maintenance products, and special tools in enclosed, weather-proof, and lighted facility during the construction period.
   3. Protect parts subject to deterioration, such as ferrous metal items and electrical components with appropriate lubricants, desiccants, or hermetic sealing.
   4. Store large items individually:
      a. Weight: Greater than 50 pounds.
      b. Size: Greater than 24 inches wide by 18 inches high by 36 inches long.
      c. Clearly labeled:
         1) Equipment tag number.
         2) Equipment manufacturer.
         3) Subassembly component, if appropriate.
   5. Store smaller items in spare parts boxes:
      a. Weight: Less than 50 pounds.
      b. Size: Less than 24 inches wide by 18 inches high by 36 inches long.
      c. Clearly labeled:
         1) Equipment tag number.
         2) Equipment manufacturer.
         3) Subassembly component, if appropriate.
   6. Spare parts and special tools box:
      a. Box material: Waterproof, corrosion resistant.
      b. Hinged cover with locking hasp:
      c. Inventory list taped to underside of cover.
         1) Clearly labeled:
            a) “Spare Parts and/or Special Tools”.
            b) Equipment tag number.
            c) Equipment manufacturer.
            d) Subassembly component, if appropriate.

E. Exterior storage of fabricated products:
   1. Place on aboveground supports that allow for drainage.
   2. Cover products subject to deterioration with impervious sheet covering.
   3. Provide ventilation to prevent condensation under covering.

F. Store moisture sensitive products in watertight enclosures.

G. Store loose granular materials on solid surfaces in well-drained area.
   1. Prevent materials mixing with foreign matter.
   2. Provide access for inspection.

H. When needed and approved by the Engineer, offsite storage location shall be within 20 miles of the project site.
   1. Provide proof of insurance coverage for products stored offsite.

I. Payment will not be made for product and materials improperly stored or stored without providing Engineer with the manufacturer's instructions for storage.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Provide products as Engineer has approved by the Submittal process or by other written documents.

B. Provide products by same manufacturer when units are of similar nature, unless otherwise specified.

C. Provide like parts of duplicate units that are interchangeable.

D. Provide equipment or product that has not been in service prior to delivery, except as required by tests.

E. Provide products produced by manufacturers regularly engaged in the production of these products.

F. Provide products that bear approvals and labels as specified such as Factory Mutual (FM), Underwriters Laboratory (UL), or National Sanitation Foundation (NSF International) that are acceptable to the Authority Having Jurisdiction.

2.02 MATERIAL

A. Dissimilar metals:
   1. Separate contacting surfaces with dielectric material.
   2. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials as specified.

B. Edge grinding:
   1. Sharp projections of cut or sheared edges of ferrous metals which are not to be welded shall be ground to a radius required to ensure satisfactory paint adherence.

C. Use anti-galling compound on threads of stainless steel fasteners during factory assembly.

D. Provide anti-galling compound with stainless steel fasteners shipped for field assembly.

E. Aluminum in contact with concrete or masonry: Apply epoxy mastic as specified in Section 09960 - High-Performance Coatings, coating system EPX-M-5.

F. Pipes:
   1. Provide new pipe manufactured for the following:
      a. Piping 24-inch diameter and larger.
      b. AWWA C200 steel piping.
   2. Piping provided from manufacturers/distributors inventory is subject to the following condition:
      a. Provide proof pipe manufactured more than 6 months prior to delivery was stored properly and the material and/or coating was not subjected to ultraviolet (UV) degradation.
   3. Mark each length of pipe in accordance with applicable standards.

2.03 PRODUCT SELECTION

A. When products are specified without named manufacturers, provide products that meet or exceed the Specifications.

B. When products are specified with names of manufacturers but no model numbers or catalog designations, provide products by one of named manufacturers that meet or exceed specifications.

C. When products are specified with names of manufacturers and model numbers or catalog designations, provide products with model numbers or catalog designations by one of the named manufacturers.

D. When products are specified with names of manufacturers, but with brand or trade names, model numbers, or catalog designations by one manufacturer only, provide:
   1. Products specified by brand or trade name, model number, or catalog designation.
   2. Products by another named manufacturers proven, in accordance with requirements for an “or equal”, including Engineer’s approval, to meet or exceed quality, appearance and performance of specified brand or trade name, model number, or catalog designation.

E. When products are specified with only one manufacturer followed by “or Equal,” provide:
   1. Products meeting or exceeding Specifications by specified manufacturer.
   2. Engineer deemed “or equal” evidenced by an approved Shop Drawing or other written communication.

F. When products are specified by naming 2 or more manufacturers with 1 manufacturer as a “Basis of Design”:
   1. Any of the named manufacturers can be submitted.
   2. If the product submitted is not by the named “Basis of Design” product and requires a change in the scope (dimensions, configuration, physical properties, etc.), schedule (longer lead time), or budget, the Contractor must submit a substitution request.

PART 3 EXECUTION

3.01 INSTALLATION

A. Inspect equipment or product prior to product installation.

B. Repaint or recoat damaged painted or coated surfaces.

C. Use anti-galling compound on stainless steel threads used for field assembly.

3.02 PROTECTION AFTER INSTALLATION

A. Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations.
   1. Remove covering when no longer needed.
   2. Replace corroded, damaged, or deteriorated product before acceptance of the project.

END OF SECTION

ATTACHMENT A - MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

OWNER _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

Comments: _____

_____

_____

_____

_____

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

Date of Execution: _____

Manufacturer: _____

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

_____

(Authorized Signature)

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

_____

(Witness Signature)

SECTION 01722

FIELD ENGINEERING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Field engineering to establish lines and grades for the Work.

1.02 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Qualifications of the professional land surveyor or licensed civil engineer with the authority to provide land surveying in Oregon that will be performing the field engineering.

C. Pre-Excavation Report.

1.03 PRE-EXCAVATION REPORT

A. Prior to the start of the Work, create a report confirming the verification of the following data:
   1. Site elevation.
   2. Existing structures including but not limited to buildings, manholes (sanitary, storm, electrical, and other), drainage inlets:
      a. Location coordinates.
      b. Top of wall elevation and coordinates.
      c. Floor elevations.
      d. Invert elevations.
   3. Existing utilities.
   4. Proposed building corners, tank, and equipment locations.
   5. Verify existing electrical, instrumentation, and phone utilities.

B. Incorporate information from Pre-Excavation Report into the record drawings.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SURVEY REFERENCE POINTS

A. Basic reference line, a beginning point on basic reference line, points with referenced coordinates, and a benchmark will be provided by Owner.

B. From these reference points, establish other control and reference points as required to properly lay out the Work.

C. Locate and protect control points prior to starting site work, and preserve permanent reference points during construction:
   1. Make no changes or relocations without prior written notice.
   2. Replace Project control point, when lost or destroyed, in accordance with original survey control.

D. Set monuments for principal control points and protect them from being disturbed and displaced:
   1. Re-establish disturbed monuments.
   2. When disturbed, postpone parts of the Work that are governed by disturbed monuments until such monuments are re-established.

3.02 PROJECT SITE SURVEY REQUIREMENTS

A. Perform verifications and checking in accordance with industry standard surveying practice.

B. Maintain complete, accurate log of control points and survey.

C. Affix civil engineer's or professional land surveyor's signature and license number to Record Drawings to certify accuracy of information shown.

3.03 CONSTRUCTION STAKES, LINES, AND GRADES

A. Execute the Work in accordance with the lines and grades indicated.

B. Make distances and measurements on horizontal planes, except elevations and structural dimensions.

3.04 QUALITY CONTROL

A. Accuracy of stakes, alignments, and grades may be checked randomly by Engineer:
   1. Notice of when checking will be conducted will be given.
   2. When notice of checking is given, postpone parts of the Work affected by stakes, alignments, or grades to be checked until checked.
   3. Engineer's check does not substitute or complement required field quality control procedures.

3.05 RECORD DOCUMENTS

A. Prepare and submit Record Documents as specified in Section 01770 - Closeout Procedures.

B. Provide certified site survey in a scale as determined by the Engineer, including buildings, benchmarks, and appurtenances sealed and signed by professional land surveyor or duty authorized licensed civil engineer.
   1. Submit to permitting agency, as required.
   2. Survey must be provided in AutoCAD Civil 3D to provide an as-built cut/fill determination for the site.

END OF SECTION

SECTION 01734

WORK WITHIN PUBLIC RIGHT-OF-WAY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for maintenance, support, protection, relocation, reconstruction and adjusting-to-grade, restoration, construction of temporary and new facilities, and abandonment of existing utilities affected by construction work within the public right-of-way.

1.02 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Trenching:
      a. Open trench:
         1) General: Includes excavation, pipe laying, backfilling, and pavement replacement.
      b. Any excavated areas shall be considered as “open trench” until all pavement replacement has been made, or until all trenches outside of pavement replacement areas have been backfilled and compacted in accordance with these Contract Documents.
   2. Utility:
      a. For the purpose of this Section, utility means any public or private service, such as electric light and power systems; gas distribution systems; telephone, telegraph, cable television and other communication services; water distribution; storm drain and sanitary sewer services; police and fire communication systems; street lighting and traffic signs and signals; parking meters; and steam distribution systems.

1.03 SUBMITTALS

A. Traffic control plan: Submit detailed traffic control plan for acceptance by jurisdictional agency.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Trenching:
   1. Except where otherwise specified, indicated on the Drawings, or accepted in writing by the Engineer, the maximum length of open trench, where construction is in any stage of completion, shall not exceed the linear footage as set forth below. Descriptions under following area designations are general in nature and may be amended in writing by the Engineer due to particular or peculiar field conditions:
      a. Business district areas - maximum 100 linear feet: Store front areas.
      b. Commercial areas - maximum 400 linear feet: Industrial, shopping centers, churches, schools, hotels, motels, markets, gas stations, government and private office buildings, hospitals, fire and police stations, and nursing homes.
      c. Residential areas - maximum 1 block or 600 linear feet, whichever is the least: Single and multi-family residences, apartments, and condominiums.
      d. Undeveloped areas - maximum 1,000 linear feet: Parks, golf courses, farms, undeveloped subdivided land.
   2. Completely backfill trenches across streets and install temporary or permanent pavement as soon as possible after pipe laying.

B. Site conditions:
   1. Use substantial steel plates with adequate trench bracing to bridge across trenches at street and alley crossings, commercial driveways, and residential driveways where trench backfill and temporary patch have not been completed during regular working hours.
   2. Provide safe and convenient passage for pedestrians.
   3. Maintain access to fire stations, fire hydrant, and hospitals at all times.
   4. Provide traffic control devices, barricades, and signage as required by the regulating agency.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01738

SELECTIVE ALTERATIONS AND DEMOLITION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cutting or modifying of existing and new work.
   2. Partial demolition of structures.
   3. In-place abandonment of pipe.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. A10.6 - Safety and Health Program Requirements for Demolition Operations.

B. International Concrete Repair Institute (ICRI):
   1. Guideline No. 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
   2. Guideline No. 310.3R - Guide for the Preparation of Concrete Surfaces for Repair Using Hydrodemolition Methods.

1.03 DEFINITIONS

A. Chipping hammer: A hand-operated electrical or pneumatic demolition device for removal of hardened concrete or masonry materials having a weight of less than 15 pounds and an impact frequency of greater than 2,000 blows/minute.

B. Concrete breaker: A hand-operated electrical or pneumatic demolition device for removal of hardened concrete or masonry materials having a weight greater or impact frequency less than the limits defined for a chipping hammer.

C. Coring equipment: Non-impact rotary drill with diamond cutting edges.

D. Heavy abrasive blast: Cleaning procedure by which various abrasives materials, or steel shot, are forcibly propelled by high pressure against a surface to remove loose material and produce a concrete surface roughened to ICRI Surface Profile CSP-7, or higher, as specified in ICRI 301.3R.

E. Salvage material: Materials removed from existing facilities and stored for Owner's future reuse.

1.04 DESCRIPTION OF WORK

A. The work includes partial demolition, cutting, and modifying of existing facilities, utilities, and/or structures.

B. These facilities may be occupied and/or operational. Satisfactory completion of the work will require that the Contractor plan activities carefully to work around unavoidable obstacles and to maintain overall stability of structures and structural elements. It will further require restoration of existing facilities, utilities, and structures that are to remain in place and that are damaged by demolition or removal operations.

1.05 SUBMITTALS

A. General:
   1. Submit specified in Section 01330 - Submittal Procedures.

B. Shop drawings: Include:
   1. The location of all embedded items shall be documented using diagrams and/or other media that clearly show dimensions and locations of existing structural elements, existing embedded items and any new embedded items and their relationship to each other.

C. Submittals for information only:
   1. Permits and notices authorizing demolition.
   2. Certificates of severance of utility services.
   3. Permit for transport and disposal of debris.
   4. Selective Demolition Plan.
   5. Pipe Abandonment Plan.

D. Quality assurance submittals:
   1. Qualifications of non-destructive testing agency/agencies.

E. Project record documents.

F. Drawings and/or other media documenting locations of service lines and capped utilities.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Assign relocation, removal, cutting, coring and patching to trades and workers qualified to perform the Work in manner that causes the least damage and that provides means of returning surfaces to an appearance at least equal to that of the surrounding areas unaffected by the Work.
   2. Non-destructive testing agencies: Minimum of 5 years' experience performing non-destructive testing for location of steel reinforcement in existing concrete under conditions similar to that required for this Work.

1.07 SEQUENCING

A. Perform Work in sequences and within times specified in Section 01140 - Work Restrictions.

B. If the facility or utility to be modified cannot be removed from service, perform the Work while the facility is in operation using procedures and equipment that do not jeopardize operation or materially reduce the efficiency of that facility.

C. Coordinate the Work with operation of the facility:
   1. Do not begin alterations of designated portions of the Work until specific permission for activities in each area has been granted by Owner in writing.
   2. Complete Work as quickly and with as little delay as possible.

D. Operational functions of the facility that are required to be performed to facilitate the Work will be performed by facility personnel only.

E. Owner will cooperate to assist in expediting the Work.

F. When necessary for the proper operation or maintenance of portions of the facility, reschedule operations so the Work will not conflict with required operations or maintenance.

1.08 REGULATORY REQUIREMENTS

A. Dispose of debris in accordance with governing regulatory agencies.

B. Comply with applicable air pollution control regulations.

C. Obtain permits for building demolition, transportation of debris to disposal site and dust control.

1.09 PREPARATION

A. Non-destructive evaluation of existing concrete:
   1. Prior to cutting, drilling, coring, and/or any other procedure that penetrates existing concrete, retain and pay for the services of a qualified non-destructive testing agency to perform investigations to determine the location of existing steel reinforcement, plumbing, conduit, and/or other embedments in the concrete.
   2. Submit documentation of the investigations to the Engineer for review and approval as specified in Section 01330 - Submittal Procedures, before any work involving penetration of existing concrete is initiated.

B. Obtain permission from adjacent property owners when outriggers, swinging cranes, and other equipment may have to traverse or extend into adjacent property.

1.10 PROJECT CONDITIONS

A. Do not interfere with use of adjacent structures and elements of the facility not subject to the Work described in this Section. Maintain free and safe passage to and from such facilities.

B. Provide, erect, and maintain barricades, lighting, guardrails, and protective devices as required to protect building occupants, general public, workers, and adjoining property:
   1. Do not close or obstruct roadways without permits.
   2. Conduct operations with minimum interference to public or private roadways.

C. Prevent movement, settlement, or collapse of structures, adjacent services, sidewalks, driveways and trees:
   1. Provide and place bracing or shoring.
   2. Cease operations and notify Engineer immediately when safety of structures appears to be endangered. Take precautions to properly support structure. Do not resume operations until safety is restored.
   3. Assume liability for movement, settlement, or collapse. Promptly repair damage.

D. Arrange and pay for capping and plugging utility services. Disconnect and stub off.
   1. Notify affected utility company in advance and obtain approval before starting demolition.
   2. Place markers to indicate location of disconnected services.

E. Unknown conditions:
   1. The drawings may not represent all conditions at the site and adjoining areas. Compare actual conditions with drawings before commencement of Work.
   2. Existing utilities and drainage systems below grade are located from existing documents and from surface facilities such as manholes, valve boxes, area drains, and other surface fixtures.
   3. If existing active services encountered are not indicated or otherwise made known to the Contractor and interfere with the permanent facilities under construction, notify the Engineer in writing, requesting instructions on their disposition. Take immediate steps to ensure that the service provided is not interrupted, and do not proceed with the Work until written instructions are received from the Engineer.

PART 2 PRODUCTS

2.01 SALVAGE MATERIALS

A. Materials designated for salvage:
   1. None.

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to beginning selective demolition operations, perform a thorough inspection of the facility and site.
   1. Report to the Engineer defects, structural damage, and deterioration of existing construction to remain in place.

B. Examine areas affected by the Work and verify the following conditions prior to commencing demolition:
   1. Disconnection of utilities as required.
   2. Verify that utilities serving occupied or active portions of surrounding facilities will not be disturbed, except as otherwise indicated.

C. If unsatisfactory conditions exist, notify the Engineer, and do not begin demolition operations until such conditions have been corrected.

3.02 PREPARATION

A. Plan and organize Work to minimize inconvenience to adjacent buildings and to plant operations.

B. Selective Demolition Plan:
   1. Prepare and submit a comprehensive selective demolition plan for the Work including the following elements, at a minimum:
      a. Proposed sequence, methods, temporary support, and equipment for demolition, removal, and disposal of portions of structure(s).
      b. Provisions and procedures for salvage and delivery to Owner of salvaged items, if required.
   2. Submit plan a minimum 4 weeks before demolition is scheduled to begin.

C. Pipe Abandonment Plan:
   1. Prepare and submit a comprehensive Pipe Abandonment Plan for the Work.
      a. Include provisions to demonstrate and verify with camera inspection that all solids have been removed and that pipe is free of residuals.
   2. At a minimum, define the following elements:
      a. Proposed sequence, methods, cleaning procedures, or demolition, removal, and disposal of contents of the piping.
      b. Method of verification of final pipe condition.
      c. Detailed drawings showing treatment of pipe ends**.**
   3. Submit plan a minimum 4 weeks before abandonment is scheduled to begin.

D. Protection:
   1. Erect weatherproof closures to protect the interior of facilities and elements or equipment that are not designed for exposure to the weather.
   2. Provide temporary heat, cooling, and humidity control as necessary to prevent damage to existing and new equipment and construction.
   3. Maintain existing exiting paths and/or provide new paths in compliance with Building Code requirements.

4. Erect and maintain dustproof partitions as required to prevent spread of dust, to other parts of building. Maintain negative pressure in the area where the Work is being performed to prevent the accidental spread of dust and to minimize the spread of fumes related to the Work.
5. Upon completion of Work, remove weatherproof closures and dustproof partitions.
6. Repair damaged surfaces to match adjacent surfaces.
7. Provide and maintain protective devices to prevent injury from falling objects.
8. Locate guardrails in stairwells and around open shafts to protect workers. Post clearly visible warning signs.
9. Protect the following from damage or displacement during Work.
    a. Benchmarks and survey points.
    b. Existing construction that will remain in place.
    c. Trees and landscaping designated to remain in place.
10. Carefully remove designated materials and equipment to be salvaged by Owner or reinstalled.
11. Store and protect materials and equipment to be reinstalled.

E. Layout:
1. The limits of selective demolition are indicated on the Drawings. Confine demolition operations within the limits indicated on the Drawings.
2. Lay out demolition and removal work at the site and coordinate with related Work for which demolition and removal is required.
3. Clearly mark the extent of structural elements to be removed on the actual surfaces that will be removed.
4. Arrange for Engineer's inspection of the lay out extents.
5. Do not begin demolition/removal operations until the lay out markings have been reviewed by the Engineer.

3.03 DEMOLITION

A. General:
1. Perform demolition work in accordance with ANSI A10.6.
2. Demolish designated portions of structures and appurtenances in orderly and careful manner in accordance with the Selective Demolition Plan.
3. Conduct demolition and removal work in a manner that will minimize dust and flying particles.
    a. Use water or dust palliative when necessary to prevent airborne dust.
    b. Provide and maintain hoses and connections to water main or hydrant.
4. Remove materials carefully, to the extent indicated and as required.
    a. Provide neat and orderly junctions between existing and new materials.
    b. Use methods that terminate surfaces in straight lines at natural points of division.
5. Do not remove anything beyond the limits of Work indicated without prior written authorization from the Engineer.
    a. If in doubt about whether to remove an item, obtain written authorization from the Engineer prior to proceeding.
6. Perform work so as to provide the least interference and most protection to existing facilities to remain.

7. Demolished materials:
    a. Assume possession of materials unless otherwise indicated on the Drawings or specified.
    b. Remove demolished materials from site at least weekly and dispose of them in accordance with Laws and Regulations.
    c. Do not burn or bury materials on site.

B. Demolition of concrete and masonry:
1. Demolish concrete and masonry in small sections.
    a. Perform demolition with small tools as much as possible.
    b. Blasting with explosive charges is not permitted.
2. Sawcut concrete to establish the edges of demolition, wherever possible.
    a. Do not use a concrete breaker within 6 inches of reinforcing or structural metals that are designated to remain in place.
    b. At edges that are not sawcut, remove the final 6 inches of material with a chipping hammer as defined herein. At surfaces where material is removed with a chipping hammer, follow with a heavy abrasive blast to remove all loose material and microcracking.
    c. Alternate techniques to remove concrete may be used if acceptable to the Engineer; however, techniques other than those deemed by ICRI Guideline No. 310.2R to provide a low risk of introducing microcracking will require a subsequent procedure to remove loose material and microcracked.
    d. Provide final surface preparation for repairs as specified in Section 03926 - Structural Concrete Repair.
3. At locations indicated on the Drawings where the existing reinforcing is to be preserved, remove concrete using methods that do not damage the reinforcing. Use one of the following techniques:
    a. Hydrodemolition techniques as outlined in ICRI Guideline No. 310.3R.
    b. Chipping hammer, as defined herein, followed by heavy abrasive blast to remove all loose material and microcracking at remaining surfaces impacted by the chipping hammer.
    c. Alternate methods may be used, only when accepted in advance by the Engineer.
    d. For all methods, provide a small completed area for Engineer's review and acceptance. If the proposed method, in the opinion of the Engineer, damages the reinforcing, revise the removal method to remove the concrete with a less aggressive technique to protect the reinforcing.

C. Sizing of openings in existing concrete or masonry:
1. Make openings large enough to permit final alignment of pipe and fittings without deflections, but without oversizing.
2. Allow adequate space for packing around pipes and conduit to ensure watertightness.
3. If the Engineer deems the opening to be insufficient in size to accomplish this criteria, remove additional material using the procedures outlined in this Section.

D. Cutting openings in existing concrete or masonry:
    1. Do not allow saw cuts to extend beyond limits of openings.
    2. Create openings by the following method or other means acceptable to the Engineer that prevents over-cutting of member at corners:
        a. Core-drill through slab or wall at corners, being careful not to damage materials beyond the area to be removed.
        b. Saw cut completely through the member, between the core holes at the corners.
        c. As an alternate to sawcutting through the member, score the edges of the opening with a saw to a 1-inch depth.
            1) Provide score on both surfaces (when accessible).
            2) Remove concrete or masonry to within 6 inches of material to remain with a concrete breaker.
            3) Remove the remaining material with a chipping hammer.
        d. Remove the remaining material at the corners left by the core-drilling with a chipping hammer.
    3. Prevent debris from falling into adjacent tanks or channels in service or from damaging existing equipment and other facilities.

E. In-place Abandonment of Pipe:
    1. Abandoned pipe in-place as indicated on the Drawings.
    2. Provide closure of abandoned pipe, if pipe is greater than 6-inches in diameter, cut ends as indicated on the Drawings using one of the following methods:
        a. Leave one end open.
        b. Install cap.
        c. Install plug.
        d. Install drain valves, pressure relief valves, vents, etc.

F. Immediately upon discovery, remove and dispose of contaminated, vermin-infested, or dangerous materials using safe means that will not endanger health of workers and public.

G. Remove trees and shrubs within marked areas, and clear undergrowth and dead plant material as specified in Section 02300 - Earthwork.

H. Backfill open pits and holes caused by demolition as specified in Section 02300 - Earthwork.

I. Rough grade areas affected by demolition.

J. Remove demolished materials, tools, and equipment upon completion of demolition.

3.04 RESTORATION

A. General:
    1. Repair damage caused by demolition to conditions equal to those that existed prior to beginning of demolition.
        a. Patch and replace portions of existing finished surfaces that are damaged, lifted, and discolored. Refinish patched portion surfaces in a manner

which produces uniform color and texture to entire surface, and that matches color and texture of adjacent surfaces.
        b. When existing finish cannot be matched, refinish entire surface to nearest change of plane where angle of change exceeds 45 degrees.
    2. The cost of repairs shall be at the Contractor's expense at no increase in the Contract Price.
    3. When new construction abuts or finishes flush with existing construction, make smooth transitions. Match finish of existing construction.
    4. Where partitions are removed, patch floors, walls, and ceilings with finish materials that match existing materials.
    5. Where removal of partitions results in adjacent spaces becoming one, rework floors, walls, and ceilings to provide smooth planes without breaks, steps, or bulkheads.
        a. Where change of plane between adjacent surfaces exceeds 2 inches, request and obtain instructions for making transition from Engineer.
            1) Refinish door surfaces and edges as necessary.
    6. Trim existing doors as necessary to clear new floors.
    7. Match patched construction with adjacent construction in texture and appearance so that patch or transition is invisible at 5-foot distance.
    8. When finished surfaces are cut so that smooth transition is impossible, terminate existing surface in neat manner along straight line at natural line of division and provide appropriate trim.

B. Restore existing concrete reinforcement as follows:
    1. Where existing reinforcement is to be incorporated into the new Work, protect, clean, and extend into new concrete.
    2. Where existing reinforcement is not to be retained, cut off as follows:
        a. Where new concrete joins existing concrete at the removal line, cut reinforcement flush with concrete surface at the removal line.
        b. Where concrete surface at the removal line will become the finished surface, cut reinforcement 2 inches below the surface, paint ends with epoxy, and patch holes with dry pack mortar.

C. Restore areas affected by removal of existing equipment, equipment pads and bases, piping, supports, electrical panels, electric devices, conduits, and fasteners so little or no evidence of the previous installation remains:
    1. After removal of piping, conduit, fasteners, and other construction, fill areas in existing concrete and masonry floors, walls, and ceilings with non-shrink grout and finish smooth.
    2. Remove concrete bases for equipment and supports by:
        a. Saw cutting clean, straight lines with a depth equal to the concrete cover over reinforcement minus 1/2 inch below finished surface.
            1) Do not cut existing reinforcement in slab.
        b. Chip concrete within scored lines.
        c. Cut exposed reinforcing steel and anchor bolts that will project above the repaired surface.
        d. Patch with non-shrink grout to match adjacent grade and finish.

3. Terminate abandoned piping and conduits with blind flanges, caps, or plugs.
4. Where existing fasteners are not to be retained, cut off as follows:
    a. Where new concrete joins existing concrete at the removal line, cut fasteners flush with concrete surface at the removal line.
    b. Where concrete surface at the removal line will become the finished surface, cut fasteners 1 inch below the surface, paint ends with epoxy, and patch holes with epoxy grout.

3.05 FIELD QUALITY CONTROL

A. Do not proceed with demolition without Engineer's inspection of lay out.

B. Do not deviate from the submitted demolition plan without notifying the Engineer prior to Work.

END OF SECTION

SECTION 01756

COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Commissioning.

1.02 DEFINITIONS

A. Commissioning: The process of planning for, testing of, and start-up of systems, subsystems, equipment, components, and devices of the Work to demonstrate, through documented verification, that the Work has successfully met the Contract Documents. It includes training the Owner's staff on operation and maintenance of the installed Work.

B. Commissioning Phases: The activities of commissioning are grouped into the phases defined in the following table.
   1. Table 1 - Commissioning Phases.
   2. Attachment A provides Commissioning Flowcharts.

C. Component: A part of a system that does not have an electrical connection or internal electronics. Examples: Piping and pressure gauges.

D. Device: A part of a system that has electrical connections or internal electronics. Examples: level transmitter or pressure transmitter.

E. Electrical Energization Plan: A plan to manage how and when power is applied to electrical equipment.

F. Equipment: A factory or field assembled apparatus that performs an identifiable function. Examples: pumps, motors, VFDs, MCCs.

G. Functional Testing: Testing performed on a completed subsystem or system to demonstrate that the system meets the specified requirements. Example systems: backwash system, dewatering system.

H. Installation Verification: Testing to demonstrate that equipment or system and associated components or devices have been properly installed. Example equipment: pumps, meters, and blowers with associated piping.

I. Manufacturer’s Certificate of Functional Compliance: The form completed by the manufacturer to confirm that testing of the installed equipment or system has been performed and the results conform to the specified performance. The form is provided in Attachment D provided at the end of this Section.

J. Manufacturer's Certificate of Installation Verification: The form completed by the manufacturer to confirm that the equipment or system is installed in conformance with the Contract. The form is provided in Attachment C at the end of this Section.

K. Manufacturer's Certificate of Source Testing: The form completed by the manufacturer to confirm that the specified source tests have been performed and the results conform to the specified requirements. The form is provided in Attachment B at the end of this Section.

L. Owner Training: The Owner's staff is trained by the Contractor, with assistance from manufacturer, to operate and maintain the completed Work. This is sometimes referred to as Vendor Specific Training.

M. Process Stream: A series of liquid or solids flow processes that are designed to improve the water quality to meet regulatory permit requirements.

N. Source Testing: Test equipment or products for performance at point of manufacture or assembly for the requirements specified in the Contract Documents. Also referred to as factory testing and factory acceptance testing (FAT).

O. Start-Up Phase: The phase when Start-Up occurs.

P. Start-Up: Operating the Work with process water to verify the Work meets the Contract Documents.

Q. Subsystem: A grouping of equipment, components, and devices that is a part of a larger system and that perform a single definable function. Examples: sand filters, filter backwash.

R. System: A grouping of equipment, components, and devices that perform a single definable function. If a system is a part of a larger system, it is referred to as a subsystem Examples: Flocculation and sedimentation, filtration.

S. System Testing: Testing of a completed system for an extended time period. Examples: Headworks, filtration.

T. Water Management Plan: A plan to manage the test water used for commissioning from source to disposal. The test water may be clean water, potable water, non-potable water, or process water (e.g., raw water, plant water, sludge). The plan demonstrates how water will be produced, conveyed, treated, disposed of as directed by the plant manager, and/or recycled.

1.03 SUBMITTALS

A. Project commissioning:
   1. Commissioning Coordinator's qualifications.
      a. Submit to Engineer no later than 30 days after Notice to Proceed.
      b. Describe previous similar experience on similar projects with a list of references including phone numbers.
      c. Provide names and qualifications of commissioning assistants, if applicable.

2. Schedules:
    a. Commissioning Schedule containing all commissioning activities.
    b. Owner Training Schedule.
3. Test Plans:
    a. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
        1) Engineer approval of draft Test Plans required for successful completion of Planning Phase.
    b. Submit final Test Plan a maximum of 45 calendar days prior to testing.
    c. Engineer approval of final Test Plan required prior to start of testing.
4. Test Reports:
    a. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
        1) Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.
    b. Submit final Test Report a maximum of 30 calendar days after testing.

B. Technical Sections commissioning:
1. Manufacturer’s representative’s qualifications.
    a. Submit to Engineer no later than 30 days in advance of required services.
    b. Representative's name, phone, and e-mail address:
        1) May use 2 representatives: 1 for field testing and 1 for Owner Training.
        2) Provide resume stating instructor’s technical expertise and instructional technology skills and experience.
2. Test Plans:
    a. Submit draft Test Plan outlined in the Planning Phase, unless specified otherwise.
        1) Engineer approval of draft Test Plans required for successful completion of Planning Phase.
    b. Submit final Test Plan a maximum of 45 calendar days prior to testing.
    c. Engineer approval of final Test Plan required prior to start of testing.
3. Test Reports:
    a. Submit draft Test Reports outline in the Planning Phase, unless specified otherwise.
        1) Engineer approval of draft Test Reports outline required for successful completion of Planning Phase.
    b. Submit final Test Report a maximum of 30 calendar days after testing.
4. Manufacturer's representatives field notes and data.
5. Owner Training:
    a. Prior to the training session:
        1) Training instructor qualifications.
        2) Training course materials: Due 30 calendar days prior to initial training session.
            a) If Owner requires, Continuing Education Units (CEUs), submit training materials to state regulatory agency in sufficient time to obtain approval for training prior to the training.
            b) Drafts of training agenda, lesson plan, presentation, handouts, and list of audio-visual aids.
            c) Format: 1 electronic copy in format specified by Owner and 3 hard copies organized in notebooks.

b. Post training session:
    1) Training course materials: Due 14 calendar days after class completion.
        a) Recordings.
        b) Class attendance sheet.
        c) Final version of training agenda, final lesson plan, presentation, handouts, and audio-visual aids.
        d) Format: 1 electronic copy in format specified by Owner and 3 hard copies organized in notebooks.
    2) Provide materials for all sessions of the class in a single transmittal.
    3) If the Owner requires training CEUs, issue training CEU certificates approved by the state regulatory agency to Owner's staff who successfully completed the training.

1.04 COMMISSIONING COORDINATOR (CC)

A. Responsibilities include the following:
    1. Part-time person.
    2. Become thoroughly familiar with Contract commissioning requirements.
    3. Provide the primary interface with Engineer and Owner for Commissioning efforts.
    4. Lead Commissioning efforts - all phases and tasks.
    5. Coordinate training efforts.
    6. Meetings:
        a. CC is responsible for setting commissioning coordination meeting dates and times, as well as preparing the agendas and meeting minutes.
        b. CC shall conduct commissioning progress meetings throughout construction, to plan, scope, coordinate, and schedule future activities, resolve problems, etc.
        c. Frequency: Monthly minimum. Increase frequency as needed based on complexity and quantity of commissioning activities.

1.05 MANUFACTURER'S REPRESENTATIVES

A. Qualifications: as specified below and in the Technical Sections:
    1. For Installation and Functional Testing:
        a. Factory trained and experienced in the technical applications, installation, operation, and maintenance of respective equipment/system with full authority by the equipment/system manufacturer to issue the certifications required of the manufacturer.
    2. Training instructor qualifications:
        a. Provide resume stating instructor's technical preparation and instructional technology skills and experience.
        b. If CEUs are required, the operator training instructors must comply with state regulatory.
        c. Knowledgeable in the equipment/system for which they are training.
        d. Experienced in conducting classes.
        e. Sales representatives are not qualified instructors unless they possess the detailed operating and maintenance knowledge required for proper class instruction.

3. Representatives to be approved by Owner and Engineer.
4. No substitute representatives without written approval by Owner and Engineer.

B. Duties:
1. Determine if additional time and/or trips (beyond those specified in the Technical Sections) is required to perform the specified services.
2. Coordinate services in accordance with the Contractor's project schedule up to and including making multiple trips to project site when there are separate milestones associated with installation of each occurrence of manufacturer's equipment.
3. Perform on-site services as specified in the Technical Sections:
4. Provide daily copies of manufacturer's representatives field notes and data to Contractor.

1.06 PLANNING PHASE

A. Overview of Planning Phase:
1. Define approach and timing for commissioning.
2. Obtain Engineer approval of draft Test Plans.

B. Test Plans.
1. Define approach and timing for:
   a. Testing and Training Phases.
      1) Major systems, with separate plans for each system.
   b. Start-Up Phase.
2. Source Test (Factory Acceptance Test) and Functional Test Plans:
   a. As specified in this Section and other Technical Sections.
   b. Based on approved shop drawings.
   c. Prepared by Contractor.
   d. Include the following items for each test:
      1) Purpose of the test.
      2) Identification of each item of equipment/system to be tested, including system designation, location, tag number, control loop identifier, etc.
      3) Description of the pass/fail criteria that will be used.
      4) Listing of pertinent reference documents (Contract and industry standards or sections applicable to the testing).
         a) Credentials of test personnel.
      5) Test equipment:
         a) Include Product Data for the test equipment.
         b) Appropriate calibration records.
            (1) Drawings or photographs of test stands and/or test apparatus.
      6) Duration: Determine test durations with Owner's input.
      7) Detailed step-by-step test procedures.
         a) The level of detail shall be sufficient for the witness to follow the steps.

e. Define for Functional Testing:
1) Required temporary systems (pumps, piping, etc.).
2) Shutdown requirements for existing systems.
f. Furnish labor, power, tools, equipment, instruments, and services required for and incidental to testing activities.

3. Test forms minimum requirements:
a. Name of product to be tested.
b. Test date.
c. Names of persons conducting the test.
d. Names of persons witnessing the test, where applicable.
e. Test data.
f. Applicable project requirements as specified in the Technical Sections.
g. Check offs for each completed test or test step.
h. Place for signature of person conducting tests and for the witnessing person, as applicable.

4. Owner responsibilities:
a. Schedule Owner's staff within the constraints of their workloads.
1) Those who will participate in this test have existing full-time work assignments, and testing is an additional assigned work task, therefore, scheduling is imperative.
2) Owner staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.
3) Maximum hours per week: 4.
4) Days available: Monday to Thursday.
5) Scheduling coordination:
6) CC is responsible for the following:
a) Coordinate schedule with the Owner's personnel and manufacturer's representatives (instructors).

C. Test Reports:
1. Minimum requirements:
a. Title.
b. Abstract.
c. Equipment.
d. Procedures.
e. Results.
1) Complete disclosure of the calculation methodologies.
f. Conclusions.
g. Signature by an authorized party.
h. Appendices.
1) Completed test forms signed by witnesses.

2. Water Management Plan:
a. Requirements:
1) Demonstrate how water will be produced, conveyed, treated, recycled, and or disposed until testing verifies specified requirements.

3. Commissioning Schedule:
a. Content:
1) Comply with Attachment G - Functional Testing Requirements and provide activities organized by system and subsystem.

2) Include:
a) Source testing when required.
b) Functional testing.
c) Owner Training.
3) Comply with Attachment F - Commissioning Roles and Responsibilities Matrix.

b. Procedures:
1) Submit commissioning schedule as specified in Section 01321 - Schedules and Reports.

1.07 TESTING AND TRAINING PHASE

A. Overview of Testing and Training Phase:
1. General:
a. Contractor tests the Work to verify it meets the Contract requirements.
b. Contractor trains the Owner to operate and maintain the Work.
2. Contractor responsibilities:
a. Furnish labor, tools, equipment, instruments, and services required for and incidental to completing commissioning activities in accordance with the approved Commissioning Plans.
3. Owner responsibilities:
a. Furnish labor, and services required for and incidental to completing commissioning activities in accordance with the approved Commissioning Plans.
b. Owner provided services, equipment, and/or materials to be as specified in Section 01110 - Summary of Work.

B. Source Testing:
1. As specified in the Technical Section.
2. Source Test Plan:
a. Engineer approval of Source Test Plan required prior to testing.
3. Witnessed in person:
a. As specified in the Technical Section.
b. Contractor is responsible for trip costs associated with Owner's and Engineer’s representatives.
1) Transportation:
a) Commercial airline costs to and from Project Site Airport including related fees.
b) Rental car to and from arrival airport, hotel, and test site including related fees.
2) Hotel/Meals:
a) Hotel with an American Automobile Association 3 Diamond rating or higher equivalent for single occupancy room per person per day.
b) Meal allowance based on state government per diem guidelines per test site location.
4. Virtual witness testing:
a. As specified in the Technical Sections.
b. Contractor is responsible for costs associated with virtual witness.

c. Provide the following:
1) An agenda detailing start time of each major phase in the procedure defined in the approved Test Plan.
2) A dedicated operator (separate from the test technician) to operate the camera, provide commentary throughout test, and inspect devices at the request of the attendees.
d. Online meeting platform: Microsoft Teams.
e. Share video through a high-definition camera.
f. Establish methods to communicate, convey, and record information clearly even in environments with loud background noise.
1) Electronic feed for screen sharing of the control panel, HMI, or other screens used throughout testing.
2) Provide recording of virtual sharing within 1 day after testing.
g. Test run of virtual sharing a minimum of 1 week prior to the test:
1) Use current record documents in PDF format.
2) Provide recording of virtual sharing within 1 day after the test run.
3) Engineer approval of test run virtual sharing is required before source testing.

5. If the Source Test is not ready on the scheduled date or if the Source Test fails:
a. Contractor is responsible for associated costs:
1) First test costs that are non-refundable, if applicable.
2) Repeat test costs:
a) Trip costs, if applicable.
6. Source testing is complete after successful testing, submittal of test report, and Manufacturer's Certificate of Source Testing.
7. Engineer approval of Source Testing Report is required.

C. Installation Verification:
1. Overview:
a. Verifying the installation of equipment to be in accordance with Manufacturer's Instructions.
2. Prerequisite:
a. Engineer approval of Source Testing Report.
3. Perform checks:
a. Structural anchorage check.
b. Electrical energization check.
1) As specified in the flowchart shown in Attachment A.
c. Health and safety check.
4. Submit Manufacturer's Certificate of Installation Verification.
5. Engineer approval of Manufacturer's Certificate of Installation Verification is required.

D. Functional Testing:
1. Overview:
a. Testing the function of a system or subsystem.
2. Prerequisites:
a. Engineer approval of Manufacturer's Certificate of Installation Verification.
b. Engineer approval of Functional Test Plan required prior to testing.

c. Draft Operations and Maintenance Manual as specified in Section 01782 - Operations and Maintenance Manual.
d. Completed pipe, valve, and gate labeling of system or subsystem.
1) As specified in Section 15076 - Pipe Identification prior to the start of Functional Testing.

3. Witnessed.
4. Discipline checks:
a. Verify support systems function properly, such as seal water, pipes, valves, etc.
b. As specified in the individual Technical Sections.
5. Consecutive Day Test:
a. Operate the Work as specified in Attachment G - Functional Testing Requirements and as specified in the individual Technical Sections.
1) Successful completion of subsystem testing required prior to system testing.
b. Failure response time:
1) Be equipped and ready to provide emergency repairs, adjustments, and corrections to comply with the "Significant Interruption Duration" requirements as specified in Attachment G - Functional Testing Requirements.
c. Duration:
1) As specified in Attachment G - Functional Testing Requirements.
2) Restart the consecutive day test when the system performance failures exceed the "Significant Interruption Duration" time period specified in Attachment G - Functional Testing Requirements.
a) Individual equipment/system failures that are corrected within the "Significant Interruption Duration" time specified in Attachment G - Functional Testing Requirements shall not require the consecutive day test to be restarted unless the failure recurs.
b) Engineer has the authority to reject the consecutive day test if individual equipment/system failures are repetitive.
6. Instrumentation and controls tests.
a. Loop Validation Tests.
b. Complete End-to-End Testing (CEET):
1) Signal are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
7. Restore to condition prior to testing.
8. Submit Manufacturer's Certificate of Functional Compliance.
9. Engineer approval of Manufacturer's Certificate of Functional Compliance is required.

E. Documentation:
1. Provide records generated during Commissioning Phase of Project including but not limited to:
a. Training documentation.
b. Manufacturer's Certificate of Source Testing.
c. Manufacturer's Certificate of Installation Verification.
d. Manufacturer's Certificate of Functionality Compliance.
e. Daily logs of equipment/system testing identifying tests conducted and outcome.

f. Test forms and documentation.
g. Functional Testing results.
h. Logs of time spent by manufacturer's representatives performing services on the job site.
i. Equipment lubrication records.
j. Electrical phase, voltage, and amperage measurements.
k. Insulation resistance measurements.
l. Bearing temperature measurements.
m. Data sheets of control loop testing including testing and calibration of instrumentation devices and setpoints.
n. Provide: 1 electronic copy in format specified by Owner and 3 hard copies organized in notebooks.
o. Store the data within 24 hours of the test or document creation in the project web-based document management system.
p. Due date: Within 14 calendar days of Substantial Completion.

2. Engineer approval of documentation is required.

F. Owner Training:
1. Train Owner’s staff on the operation and maintenance of the equipment/system.
2. Train on each topic of the approved Operation and Maintenance Manual.
   a. Include classroom instruction and field demonstration with all necessary tools and test equipment.
3. Training tailored to the skills and job classifications of the staff attending the classes (e.g., plant superintendent, treatment plant operator, maintenance technician, electrician, etc.).
4. Training outcomes:
   a. Owner’s staff can safely operate, maintain, and repair the equipment/systems provided as recommended by the manufacturer.
5. Training plan:
   a. CC shall meet with Engineer and Owner’s designated training coordinator to develop list of personnel to be trained and to establish expected training outcomes and objectives at least 90 calendar days prior to commissioning of equipment/system.
   b. Coordinate and arrange for manufacturer’s representatives to provide both classroom-based learning and field (hands-on) training, based on training module content and stated learning objectives.
   c. Conduct classroom training at location designated by Owner.
   d. Scope and sequence:
      1) Plan and schedule training in the correct sequence to provide prerequisite knowledge and skills to trainees.
         a) Describe recommended procedures to check/test equipment/system following a corrective maintenance repair.
      2) If multiple classes are needed to meet the training objectives, they shall be included in the training plan.
6. Owner Training Schedule:
   a. Schedule Owner’s staff training within the constraints of their workloads.
      1) Those who will participate in this training have existing full-time work assignments, and training is an additional assigned work task, therefore, scheduling is imperative.

2) Owner staff work schedules regularly shift, as treatment facilities are typically operated on an around-the-clock basis.
3) Maximum training hours per week: 8.
4) Days available for training:
a) Monday to Thursday.

b. Training scheduling coordination:
1) CC is responsible for the following:
a) Coordinate schedule for training periods with the Owner's personnel and manufacturer's representatives (instructors).
2) Complete Owner Training no sooner than 15 calendar days prior to Functional Testing of each system.

c. Class logistics:
1) Delivery time minimum: 1 hours.
2) Delivery time maximum: 4 hours.
3) Class agenda:
a) Refreshment break: One 10-minute break.
b) Meal break: One 45-minute break, unless otherwise specified.
c) Schedule refreshment breaks and meal breaks to meet the class needs and Owner work rules.
4) Schedule specific sessions:
a) Minimum of 30 days in advance to allow Owner staffing arrangements to take place.
b) At the times requested by the Owner, within the period 7 a.m. to 4 p.m. Monday through Thursday.
(1) Times scheduled will be at Owner's discretion.
c) Owner approval and confirmation required for session schedules.
d) Provide minimum of 1 sessions for each class unless otherwise noted.
(1) The purpose of having multiple sessions on each class is to accommodate the attendance of as many Owner personnel working different shifts as possible.
e) A maximum of 1 session per day for each class.

d. Number of students:
1) Estimated class size maximum: 5 staff.
2) Engineer will confirm the headcount 1 week prior to the class, so that the instructor can provide the correct number of training aids for students.

7. Submittals:
a. Submit Training Plan Schedule 30 calendar days before the first scheduled training session, including but not limited to lesson plans, participant materials, instructor's resumes, and training delivery schedules.
b. Submit training documentation including the following:
1) Training plan:
a) Training modules.
b) Scope and sequence statement.
c) Contact information for manufacturer's instructors including name, phone, and e-mail address.
d) Instructor qualifications.

2) Training program schedule:
    a) Format: Bar chart:
        (1) Include in the Project Progress Schedule.
    b) Contents:
        (1) Training modules and classes.

8. Lesson plans:
    a. Divide training into discrete modules appropriate for the equipment and trades.
    b. State performance-based learning objectives in terms of what the trainees will be able to do at the end of the lesson.
    c. Define student conditions of performance and criteria for evaluating instructional success.
    d. Minimum requirements:
        1) Hands-on demonstrations planned for the instructions.
        2) Cross-reference training aids.
        3) Planned training strategies such as whiteboard work, instructor questions, and discussion points or other planned classroom or field strategies.
        4) Attach handouts cross-referenced by section or topic in the lesson plan.
        5) Indicate duration of outlined training segments.
    e. Provide instruction lesson plans for each trade:
        1) Detailed component description:
            a) Identify each component function and describe in detail.
            b) Identify equipment's mechanical, electrical, and electronic components and features.
            c) Where applicable, group relative components into subsystems.
            d) Identify and describe in detail equipment safety features, permissive and controls interlocks.
        2) Equipment operation:
            a) Describe equipment's operating (process) function and system theory.
            b) Describe equipment's fundamental operating principles and dynamics.
            c) Identify support equipment associated with the operation of subject equipment.
            d) Detail the relationship of each piece of equipment or component to the subsystems, systems, and process.
            e) Cite hazards associated with the operations, exposure to chemicals associated with the component, or the waste stream handled by the component.
            f) Specify appropriate safety precautions, equipment, and procedures to eliminate, reduce, or overcome hazards.
        3) Define Preventative Maintenance (PM) inspection procedures required on equipment in operation, spot potential trouble symptoms (anticipate breakdowns), and forecast maintenance requirements (predictive maintenance).
            a) Review preventive maintenance frequency and task analysis table.

4) Define equipment Corrective Maintenance (CM) troubleshooting:
   a) Describe recommended equipment preparation requirements as they relate to specific craft problems.
   b) Identify and describe the use of any special tools required for maintenance of the equipment as they relate to specific craft problems.
   c) Provide component specific troubleshooting checklists as they relate to specific craft problems.
   d) Describe component removal/installation and disassembly/assembly procedures for specific craft repairs.
   e) Perform at least 2 hands-on demonstrations of common corrective maintenance repairs.
5) Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.

9. Training instruction format:
   a. The training for operations and maintenance personnel shall be provided as 1 entity.
   b. Instructors shall apply adult education best practices, emphasizing learner participation and activity.
   c. Lecturing should be less than 30 percent of class time.
   d. Training delivery may include problem solving, question/answer, hands-on instruction, practice, evaluation/feedback tools, and lecture to support training objectives.
   e. Conduct hands-on instruction according to the following descriptions:
      1) Present hands-on demonstrations of at least the following tasks:
         a) Proper start-up, shutdown, and normal and alternative operating strategies.
         b) Common corrective maintenance repairs for each group.
         c) Recommended procedures to check/test equipment/system following a corrective maintenance repair.
         d) Preventative maintenance points.
         e) Calibration, if applicable.
      2) Use tools and equipment provided by manufacturer to conduct the demonstrations.
         a) Submit requests for supplemental assistance and facilities with the Contractor's proposed lesson plans.
      3) Contractor remains responsible for equipment disassembly or assembly during hands-on training situations involving equipment disassembly or assembly by Owner's personnel.
   f. Training aids:
      1) Instructors shall provide needed audio-visual devices such equipment (televisions, video recorder/player, computer, projectors, screens, easels, etc.), models, charts, etc. for each class.
      2) Instructor to confirm with Engineer in advance of each class that the classroom will be appropriate for the types of audiovisual equipment to be employed.
10. Training sessions:
    a. Provide training sessions for equipment/system as specified in the individual equipment/system section.

b. Include the following information in the agenda:
    1) Instructor name.
    2) Listing of subjects to be discussed.
    3) Time estimated for each subject.
    4) Allocation of time for Owner staff to ask questions and discuss the subject matter.
    5) List of documentation to be used or provided to support training.
c. Owner may request that particular subjects be emphasized, and the agenda be adjusted to accommodate these requests.
d. Digitally record audio and video of each training session.
    1) Include classroom and field instruction with question and answering periods.
    2) Engineer approval required for producer of video materials from one of the following options:
        a) Qualified, professional video production company or individual.
    3) Record in digital format and recording shall become property of the Owner with exclusive rights.
        a) No video recording agreements will be entered into by the Owner.
    4) Media:
        a) Video quality shall be 720p HD or greater in MPG, AVCHD, AVI, or MP4 format.
        b) Digital color video format.
        c) Provide audio portion of the composite CD sufficiently free from electrical interference and background noise to provide complete intelligibility of oral report.
        d) Identification: On each copy provide a label with the following information:
            (1) Name of training.
            (2) Date video was recorded.
        e) Display continuous running time.
        f) At start of each video recording, record training class name, date, instructor’s name.
        g) Provide audio quality that is not degraded during the recording of the field sessions due to background noise, space, distance or other factors.
    5) The Contractor shall provide a written release from all claims to the recorded training material produced, if required.
e. Distribute copies of the agenda to each student at the beginning of each training class.
f. Trainees will keep training materials and documentation after the session.
g. Distribute Training Evaluation Form following each training session.
    1) Training Evaluation Form is included in this Section.
    2) Return completed Training Evaluation Forms to Owner’s designated training coordinator immediately after session is completed.
    3) Revise training sessions judged "Unsatisfactory" by a majority of attendees.
        a) Conduct training sessions again until a satisfactory rating is achieved.

11. Engineer approval of Owner Training is required.

1.08 START-UP PHASE

A. Overview of Start-Up Phase:
   1. General:
      a. Confirm reliability requirements.

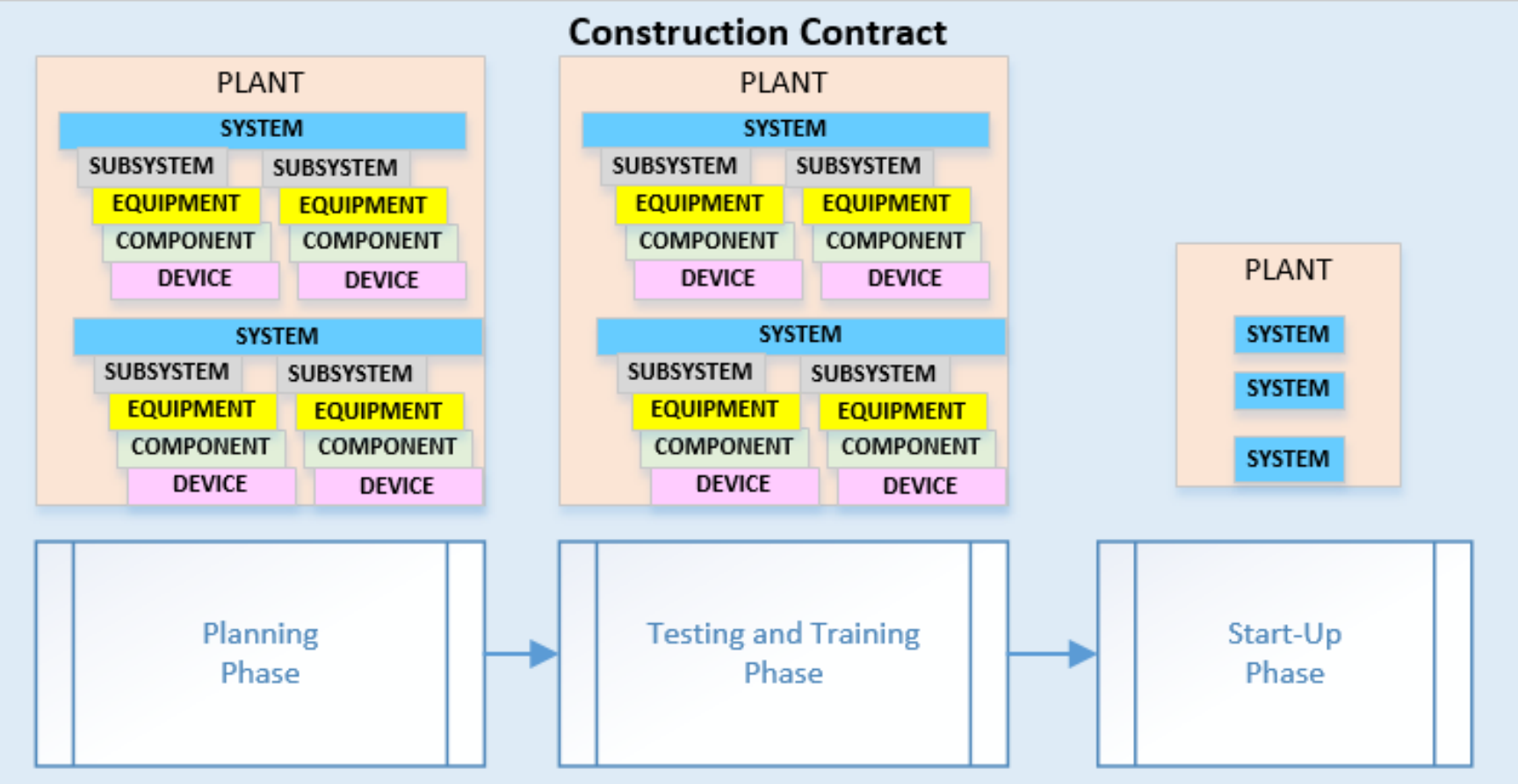
B. Start-Up Period:
   1. Contractor responsibilities:
      a. Support Owner to operate the Work.
   2. Owner responsibilities:
      a. Owner to operate the Work.
      b. Owner-provided services, equipment, and/or materials to be as specified in Section 01110 - Summary of Work.
      c. Furnish labor, tools, equipment, instruments, and services required for and incidental to completing commissioning activities in accordance with the approved Commissioning Plans.
   3. Prerequisites:
      a. Engineer approval of Testing and Training Phase.
   4. Witnessed.
   5. Duration: 4 days.
   6. Engineer approval of Start-Up Period is required to achieve substantial completion.

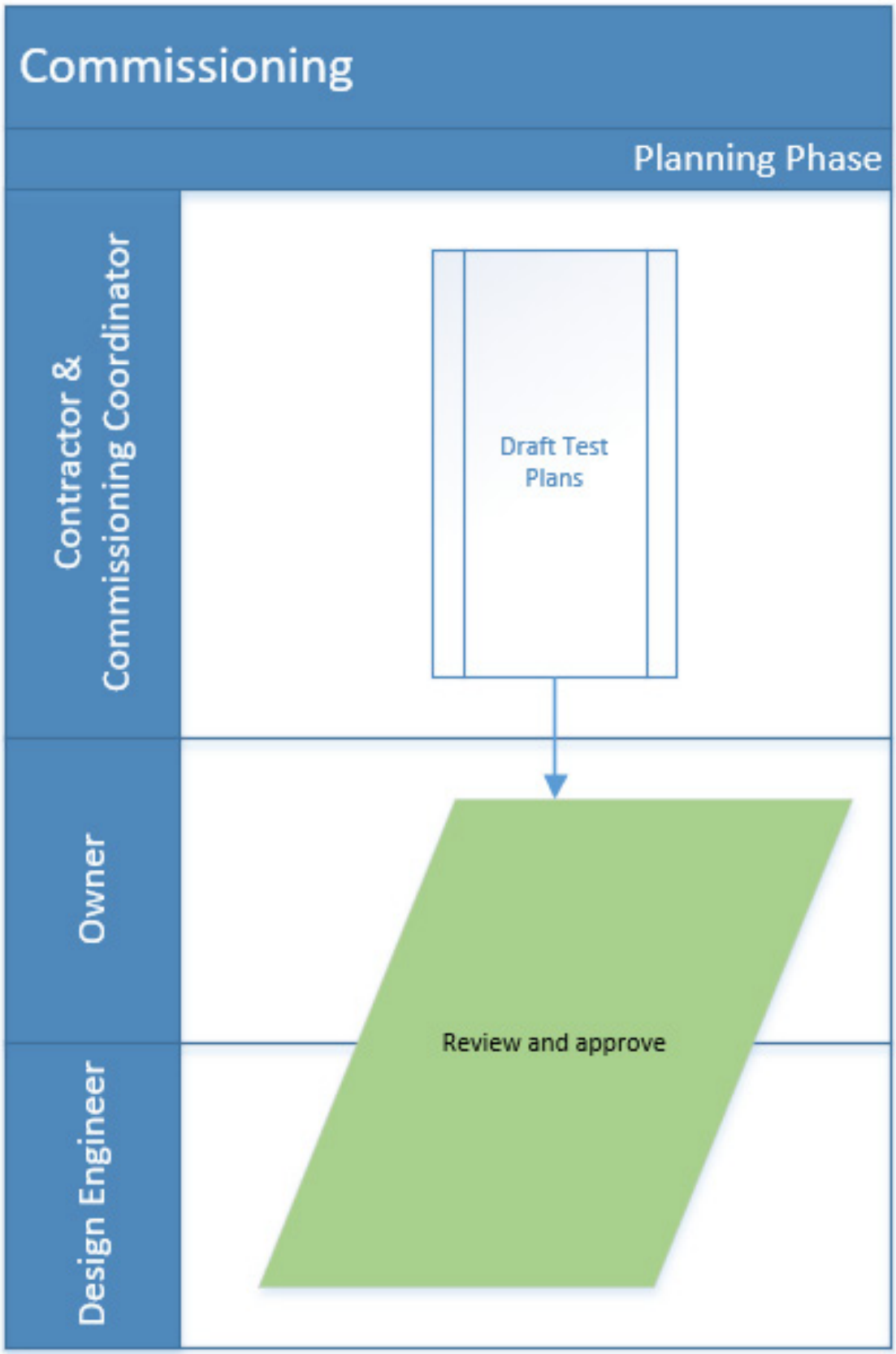
PART 2 PRODUCTS (NOT USED)

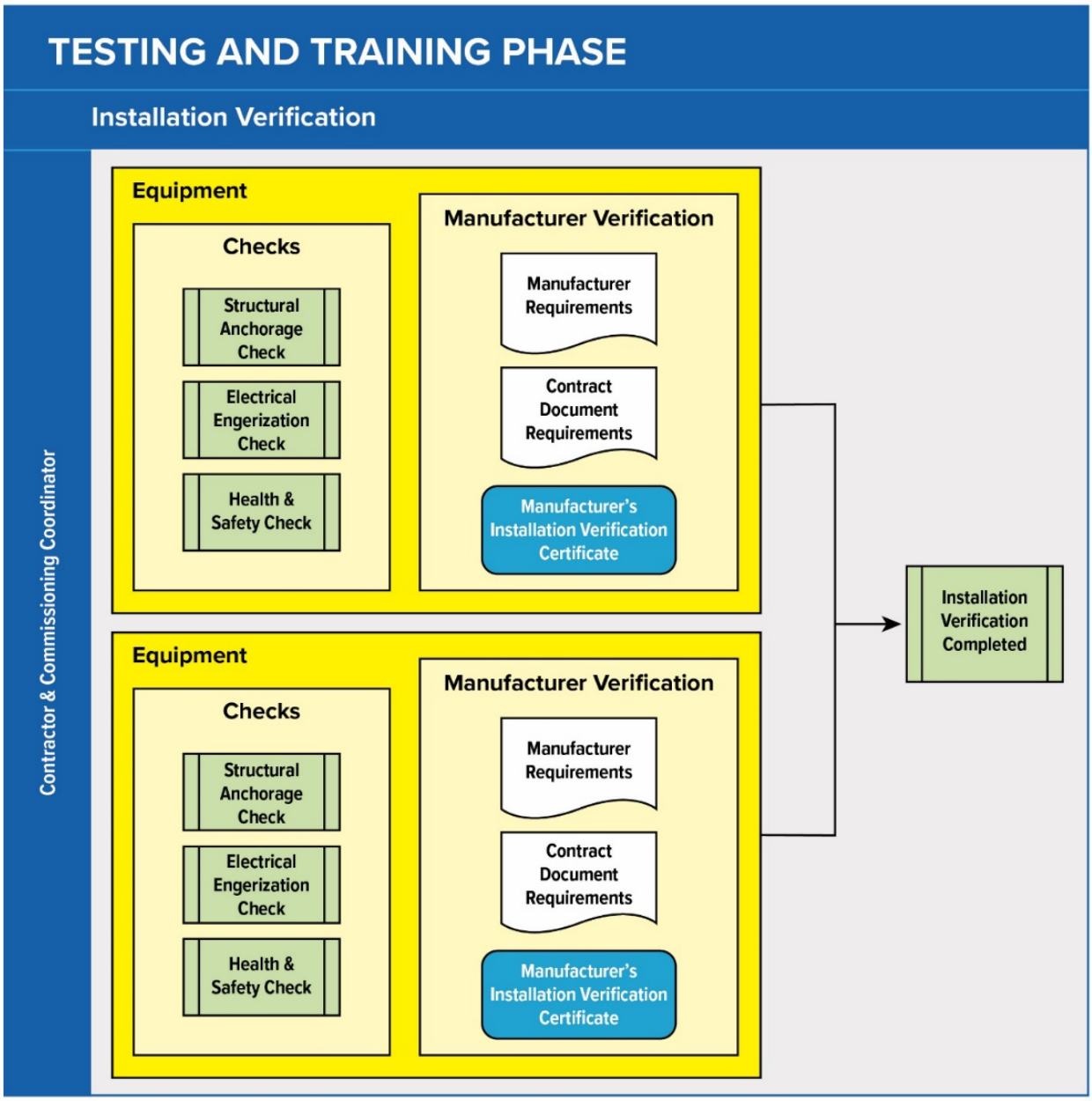
PART 3 EXECUTION (NOT USED)

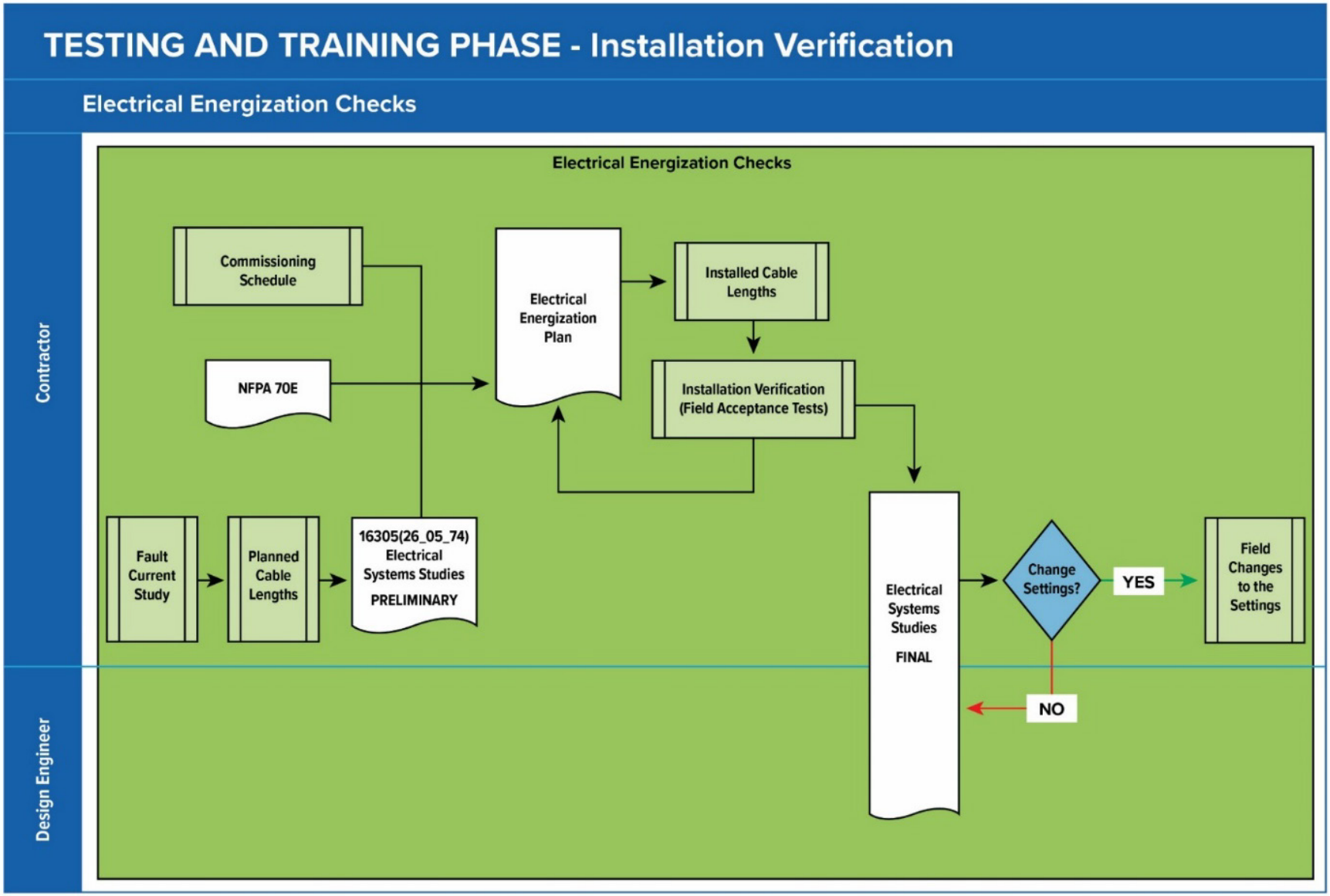
END OF SECTION

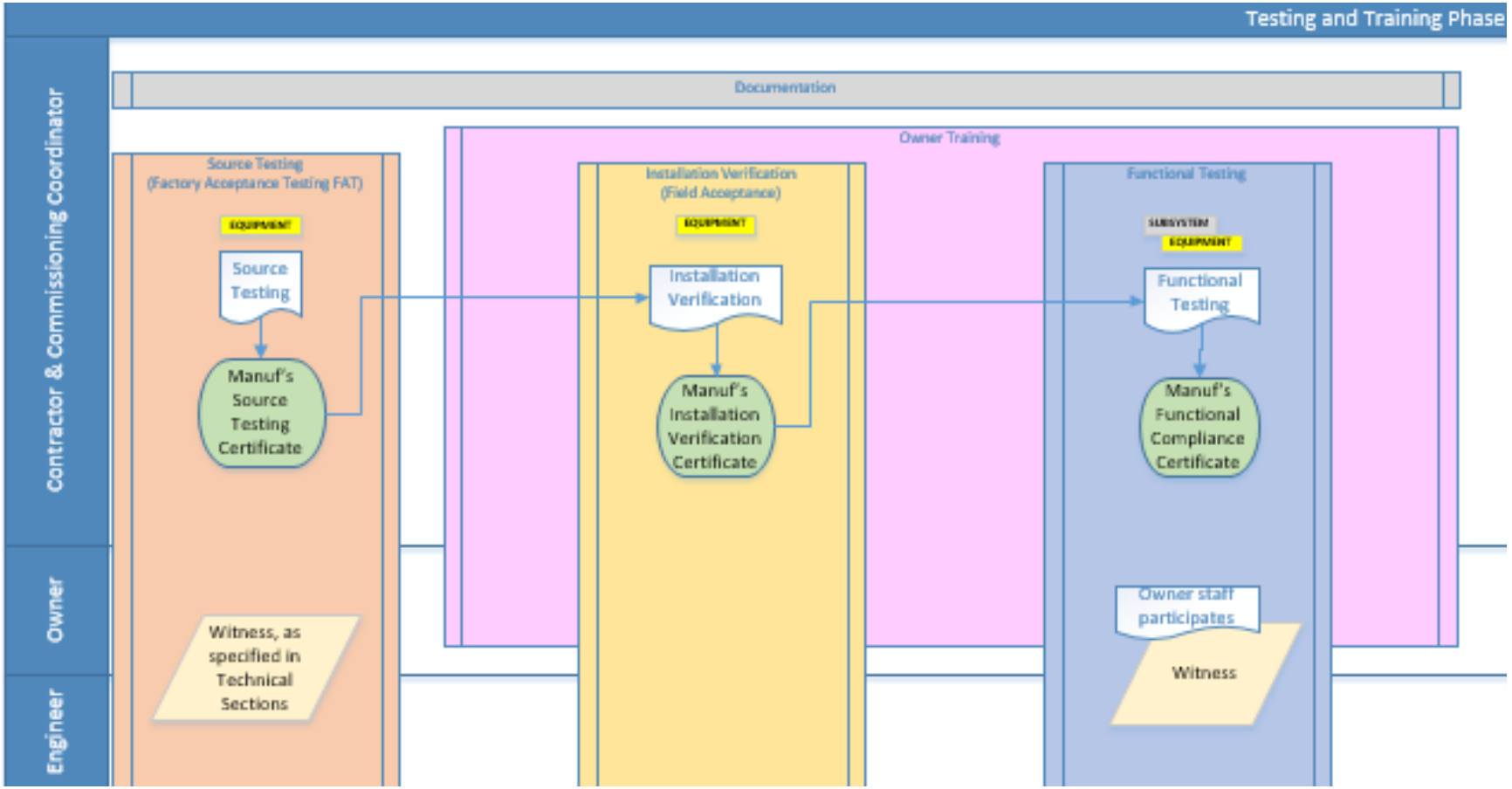
ATTACHMENT A - COMMISSIONING FLOWCHARTS

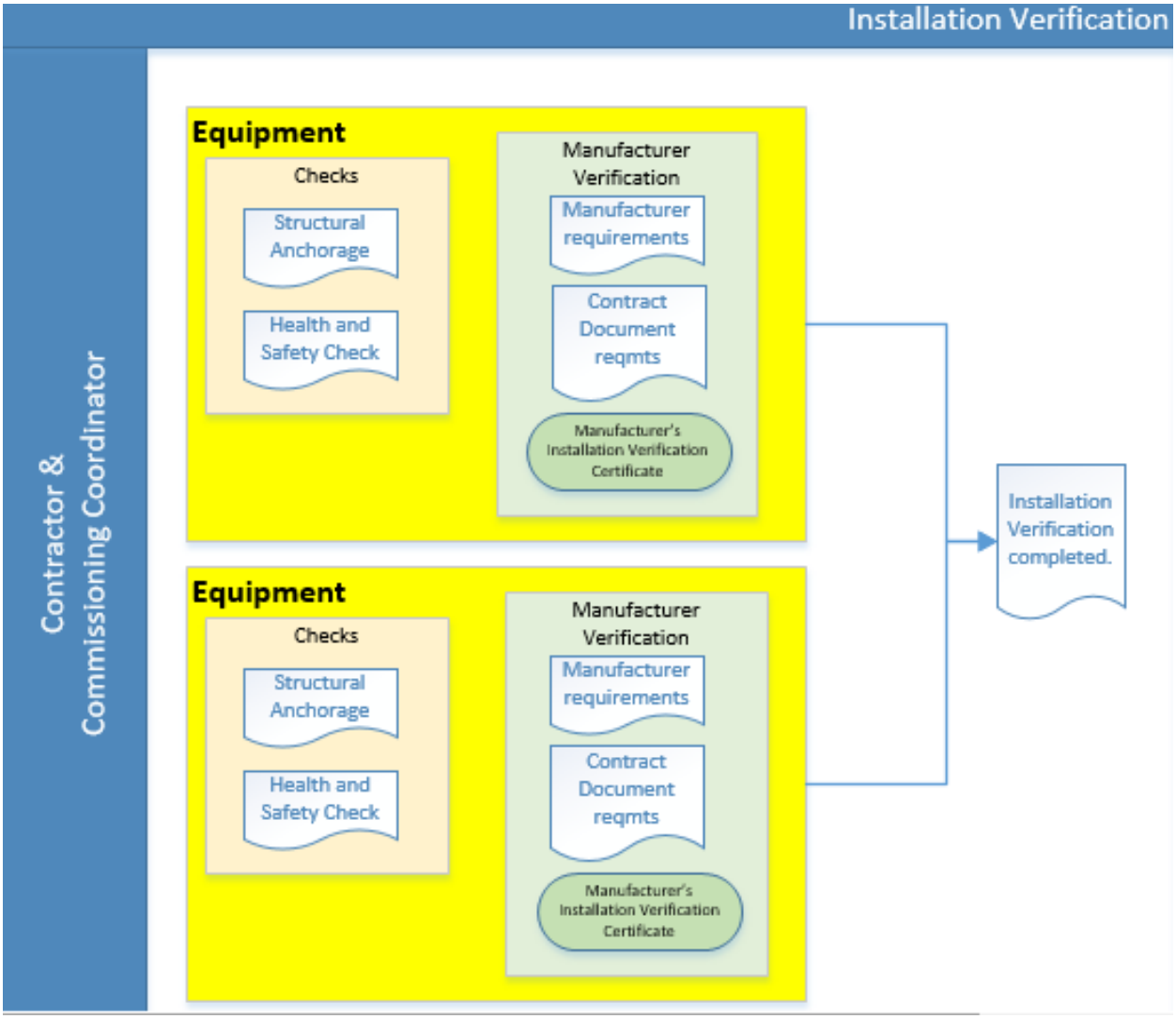

Construction Contract
PLANT
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
PLANT
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
SYSTEM
SUBSYSTEM
SUBSYSTEM
EQUIPMENT
EQUIPMENT
COMPONENT
COMPONENT
DEVICE
DEVICE
PLANT
SYSTEM
SYSTEM
SYSTEM
Planning Phase
Testing and Training Phase
Start-Up Phase

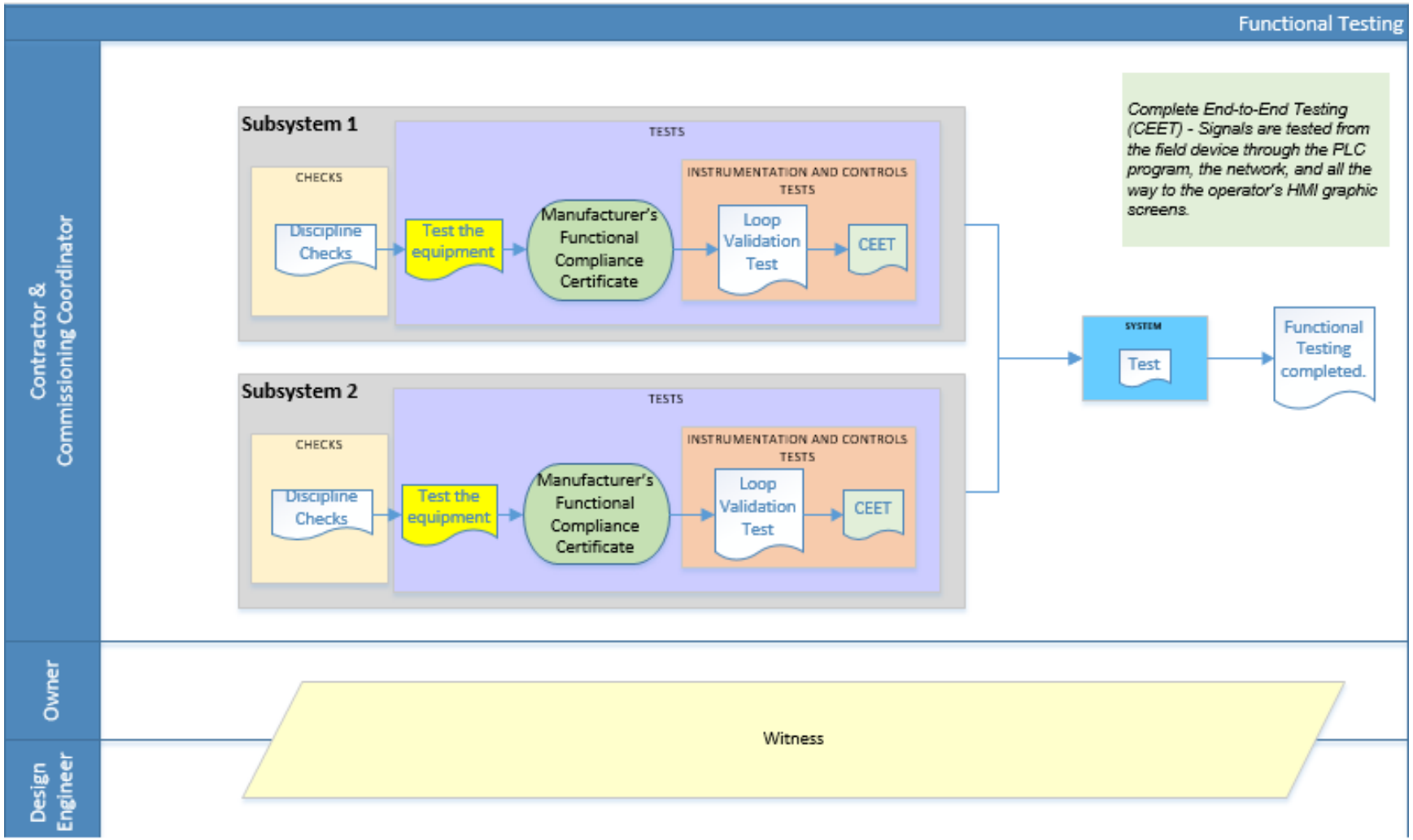

Commissioning
Planning Phase
Contractor & Commissioning Coordinator
Draft Test Plans
Owner
Review and approve
Design Engineer

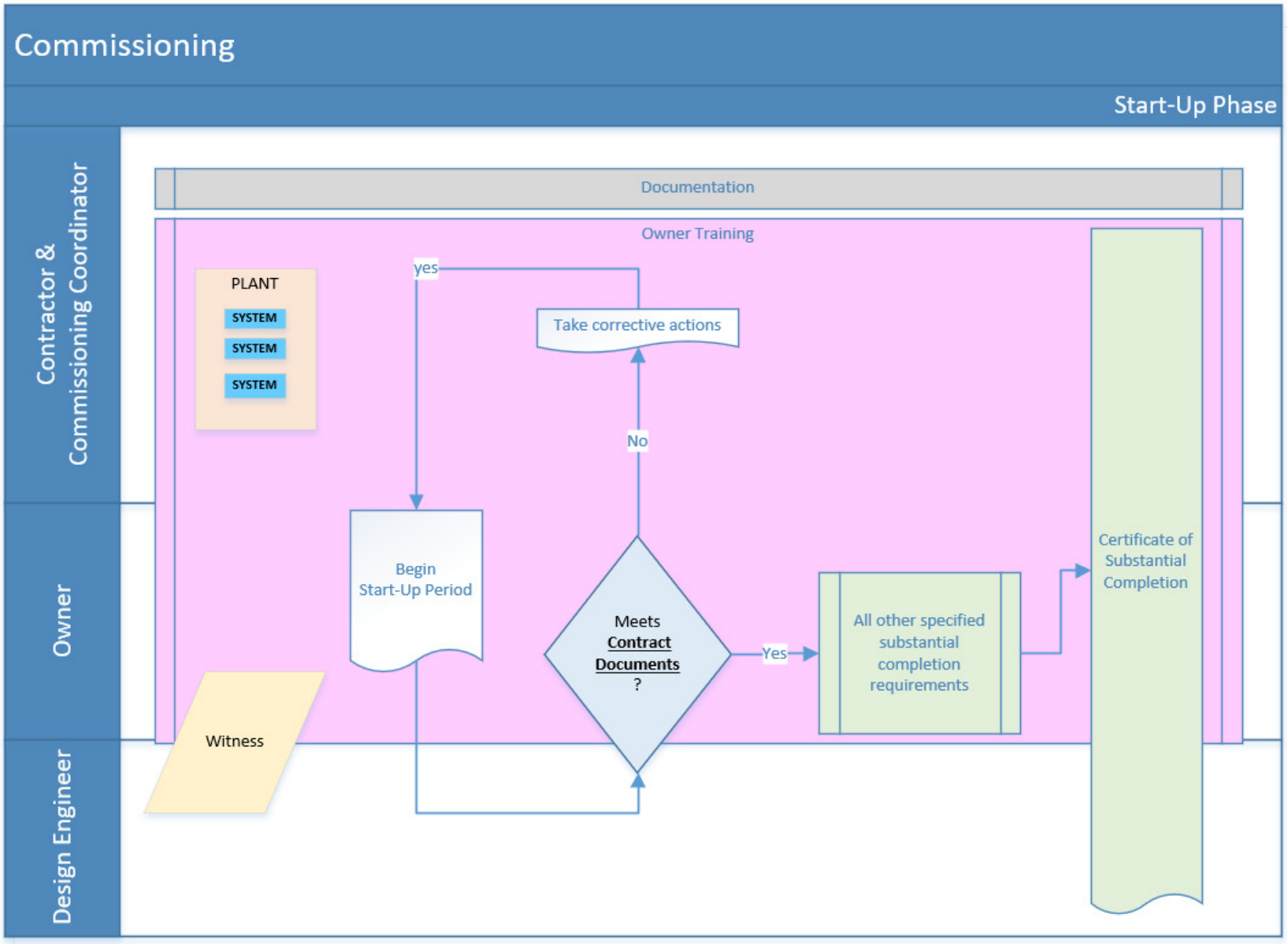

TESTING AND TRAINING PHASE
Installation Verification
Contractor & Commissioning Coordinator
Equipment
Checks
Structural Anchorage Check
Electrical Engerization Check
Health & Safety Check
Manufacturer Verification
Manufacturer Requirements
Contract Document Requirements
Manufacturer's Installation Verification Certificate
Equipment
Checks
Structural Anchorage Check
Electrical Engerization Check
Health & Safety Check
Manufacturer Verification
Manufacturer Requirements
Contract Document Requirements
Manufacturer's Installation Verification Certificate
Installation Verification Completed


TESTING AND TRAINING PHASE - Installation Verification
Electrical Energization Checks
Contractor
Design Engineer
Electrical Energization Checks
Commissioning Schedule
NFPA 70E
Electrical Energization Plan
Installed Cable Lengths
Installation Verification (Field Acceptance Tests)
Fault Current Study
Planned Cable Lengths
16305(26_05_74) Electrical Systems Studies PRELIMINARY
Electrical Systems Studies FINAL
Change Settings?
YES
NO
Field Changes to the Settings


Testing and Training Phase
Contractor & Commissioning Coordinator
Owner
Engineer
Documentation
Owner Training
Source Testing
(Factory Acceptance Testing FAT)
EQUIPMENT
Source Testing
Manuf's Source Testing Certificate
Witness, as specified in Technical Sections
Installation Verification
(Field Acceptance)
EQUIPMENT
Installation Verification
Manuf's Installation Verification Certificate
Functional Testing
SUBSYSTEM
EQUIPMENT
Functional Testing
Manuf's Functional Compliance Certificate
Owner staff participates
Witness


Installation Verification
Contractor & Commissioning Coordinator
Equipment
Checks
Structural Anchorage
Health and Safety Check
Manufacturer Verification
Manufacturer requirements
Contract Document reqmts
Manufacturer's Installation Verification Certificate
Equipment
Checks
Structural Anchorage
Health and Safety Check
Manufacturer Verification
Manufacturer requirements
Contract Document reqmts
Manufacturer's Installation Verification Certificate
Installation Verification completed.


Functional Testing
Contractor & Commissioning Coordinator
Owner
Design Engineer
Subsystem 1
TESTS
CHECKS
Discipline Checks
Test the equipment
Manufacturer's Functional Compliance Certificate
INSTRUMENTATION AND CONTROLS TESTS
Loop Validation Test
CEET
Subsystem 2
TESTS
CHECKS
Discipline Checks
Test the equipment
Manufacturer's Functional Compliance Certificate
INSTRUMENTATION AND CONTROLS TESTS
Loop Validation Test
CEET
Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
SYSTEM
Test
Functional Testing completed.
Witness


Commissioning
Start-Up Phase
Contractor & Commissioning Coordinator
Owner
Design Engineer
Documentation
Owner Training
PLANT
SYSTEM
SYSTEM
SYSTEM
yes
Take corrective actions
No
Begin Start-Up Period
Meets Contract Documents ?
Yes
All other specified substantial completion requirements
Certificate of Substantial Completion
Witness

ATTACHMENT B - MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

MANUFACTURER'S CERTIFICATE OF SOURCE TESTING

OWNER _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

Comments: _____

_____

_____

_____

_____

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

Date of Execution: _____, 20____

Manufacturer: _____

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

_____

(Authorized Signature)

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

_____

(Witness Signature)

ATTACHMENT C - MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

MANUFACTURER'S CERTIFICATE OF INSTALLATION VERIFICATION

OWNER _____ EQPT/SYSTEM _____

PROJECT NAME _____ EQPT TAG NO. _____

PROJECT NO. _____ EQPT SERIAL NO. _____

SPECIFICATION NO. _____

SPECIFICATION TITLE _____

I hereby certify the installation of the above-referenced equipment/system as defined in the Contract Documents.

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

Comments: _____

_____

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

Date: _____

Manufacturer: _____

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

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

ATTACHMENT D - MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

MANUFACTURER'S CERTIFICATE OF FUNCTIONAL COMPLIANCE

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

I hereby certify the Functional Testing of the above-referenced equipment/system as defined in the Contract Documents.

NOTES:
Attach test results with collected data and test report.

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

Comments: _____

_____

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

Date: _____

Manufacturer: _____

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

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

WITNESSES

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

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

ATTACHMENT E - TRAINING EVALUATION FORM

TRAINING EVALUATION FORM

EQUIPMENT/SYSTEM ITEM: _____

VENDOR/MANUFACTURER: _____

DATE: _____ NAME OF REPRESENTATIVE: _____

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

Note:

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

ATTACHMENT F - COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

COMMISSIONING ROLES AND RESPONSIBILITIES MATRIX

NO.	TASK	OWNER	CONTRACTOR	ENGINEER
Testing and Training Phase				
Source Testing				
	Source Testing	Non-Witnessed	Lead	Non-Witnessed Review
	Manufacturer's Certificate of Source Testing	No Action	Lead	Review
Installation Verification				
	Structural Anchorage Check	Witness	Lead	Review
	Health and Safety Check	Witness	Lead	Review
	Manufacturer Requirements Verification	No Action	Lead	Review
	Contract Documents Verification	No Action	Lead	Review
	Manufacturer's Certificate of Installation Verification	No Action	Lead	Review
Functional Testing				
	Checks	Witness	Lead	Witness, Review
	Tests	Witness	Lead	Witness, Review
	Manufacturer's Certificate of Functional Compliance	No Action	Lead	Witness, Review
System Testing				
	System Testing	Witness	Lead	Witness, Review
Start-Up Phase				
	Start-Up	Lead	Support	Witness, Review

Legend:
Lead: Primarily responsible for organization, coordination, and execution of task work product or result.
Support: Assist the lead with organization, coordination, and execution of task work product or result.
Witness: Observe and document completion of task work product or result.
No Action: Limited or no involvement.
Review: Approve for compliance with Contract Documents or reject.

ATTACHMENT G - FUNCTIONAL TESTING REQUIREMENTS

FUNCTIONAL TESTING REQUIREMENTS

System	Subsystem	Consecutive Day Test Duration (Days)	Significant Interruption Duration (Hours)	Test Liquid	System Operated By
Pump Station		4	2	Raw Sewage	Owner
	Pumps				
	Valves				

Notes:
1. As specified in Section 01110 - Summary of Work.
2. As specified in this Section under Functional Testing.
3. As specified in this Section under Functional Testing.

A. Schedule delays:
   1. Changes in the dates for source testing less than 30 days of the date provided in the latest approved Commissioning Schedule are considered delays.
   2. Contractor is responsible for associated costs resulting from delays:
      a. In person and/or virtual witnessing.
      b. Travel costs and witness labor costs.
         1) Witness labor costs at $250 per hour.

B. Repeat test costs:
   1. Contractor is responsible for associated costs for repeat testing:
      a. In person and/or virtual witnessing.
      b. Travel costs and witness labor costs.
         1) Witness labor costs at $250 per hour.

SECTION 01770

CLOSEOUT PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Contract closeout requirements.

1.02 REFERENCES

A. American Water Works Association (AWWA).

1.03 FINAL CLEANING

A. Perform final cleaning prior to inspections for Final Completion.

B. Employ skilled workers who are experienced in cleaning operations.

C. Use cleaning materials which are recommended by manufacturers of surfaces to be cleaned.

D. Prevent scratching, discoloring, and otherwise damaging surfaces being cleaned.

E. Clean roofs, gutters, downspouts, and drainage systems.

F. Broom clean exterior paved surfaces and rake clean other surfaces of site work:
   1. Police yards and grounds to keep clean.

G. Remove dust, cobwebs, and traces of insects and dirt.

H. Clean grease, mastic, adhesives, dust, dirt, stains, fingerprints, paint, blemishes, sealants, plaster, concrete, and other foreign materials from sight-exposed surfaces, and fixtures and equipment.

I. Remove non-permanent protection and labels.

J. Polish waxed woodwork and finish hardware.

K. Wash tile.

L. Wax and buff hard floors, as applicable.

M. Wash and polish glass, inside and outside.

N. Wash and shine mirrors.

O. Polish glossy surfaces to clear shine.

P. Vacuum carpeted and soft surfaces.

Q. Clean permanent filters and replace disposable filters when heating, ventilation, and air conditioning units were operated during construction.

R. Clean ducts, blowers, and coils when units were operated without filters during construction.

S. Clean light fixtures and replace burned-out or dim lamps.

T. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

1.04 WASTE DISPOSAL

A. Arrange for and dispose of surplus materials, waste products, and debris off-site:
   1. Prior to making disposal on private property, obtain written permission from Owner of such property.

B. Do not fill ditches, washes, or drainage ways which may create drainage problems.

C. Do not create unsightly or unsanitary nuisances during disposal operations.

D. Maintain disposal site in safe condition and good appearance.

E. Complete leveling and cleanup prior to Final Completion of the Work.

1.05 TOUCH-UP AND REPAIR

A. Touch-up or repair finished surfaces on structures, equipment, fixtures, and installations that have been damaged prior to inspection for Final Completion.

B. Refinish or replace entire surfaces which cannot be touched-up or repaired satisfactorily.

1.06 CLOSEOUT DOCUMENTS

A. Submit the following Closeout Submittals before Substantial Completion:
   1. Punch list of items to be completed or corrected with the request for issuance of Substantial Completion.
   2. Evidence of Compliance with Requirements of Governing Authorities.
   3. Project Record Documents.
   4. Approved Operation and Maintenance Manuals.
   5. Approved Warranties and Bonds.
   6. Keys and Keying Schedule.
   7. Completed contract requirements for commissioning and process start-up.
   8. scies are corrected.
   9. Evidence of Payment and Release of Liens or Stop Payment Notices as outlined in Conditions of the Contract.
   10. Release of claims as outlined in Conditions of the Contract.

11. Submit certification of insurance for products and completed operations, as specified in the General Conditions.
12. Final statement of accounting.
13. Submit Final (As-Built) Schedule as specified in Section 01321 - Schedules and Reports.

1.07 EVIDENCE OF COMPLIANCE WITH REQUIREMENTS OF GOVERNING AUTHORITIES

A. Submit the following:
   1. Certificate of Occupancy.
   2. Certificates of Inspection.

1.08 PROJECT RECORD DOCUMENTS

A. Maintain at Project site, available to Owner and Engineer, 1 copy of the Contract Documents, shop drawings, and other submittals in good order:
   1. Mark and record field changes and detailed information contained in submittals and change orders.
   2. Record actual depths, horizontal and vertical location of underground pipes, duct banks, and other buried utilities. Reference dimensions to permanent surface features.
   3. Identify specific details of pipe connections, location of existing buried features located during excavation, and the final locations of piping, equipment, electrical conduits, manholes, and pull boxes.
   4. Identify location of spare conduits including beginning, ending, and routing through pull boxes and manholes. Record spare conductors, including number and size, within spare conduits and filled conduits.
   5. Provide schedules, lists, layout drawings, and wiring diagrams.
   6. Make annotations in electronic format. conforming to the following color code:

Additions:	Red
Deletions:	Green
Comments	Blue
Dimensions:	Graphite

B. Maintain documents separate from those used for construction:
   1. Label documents "RECORD DOCUMENTS."

C. Keep documents current:
   1. Record required information at the time the material and equipment is installed and before permanently concealing.
   2. Engineer will review Record Documents weekly to ascertain that changes have been recorded.

D. Affix civil engineer's or professional land surveyor's signature and registration number to Record Drawings to certify accuracy of information shown.

E. Deliver Record Documents with transmittal letter containing date, Project title, Contractor's name and address, list of documents, and signature of Contractor.

F. Record Documents will be reviewed monthly to determine the percent complete for the monthly pay application.

G. Updated Record Documents are a condition for Engineer's recommendation for progress payment.

H. Final Schedule Submittal as specified in Section 01321 - Schedules and Reports.

1.09 MAINTENANCE SERVICE

A. Maintenance service as specified in technical specifications.

1.10 SUBSTANTIAL COMPLETION

A. Obtain Certificate of Substantial Completion.

1.11 FINAL COMPLETION

A. When Contractor considers the Work is complete, submit written certification that:
   1. Work has been completed in accordance with the Contract Documents:
   2. Punch list items have been completed or corrected.
   3. Work is ready for final inspection.

B. Engineer will make an inspection to verify the status of completion with reasonable promptness.

C. Should the Engineer consider that the Work is incomplete or defective:
   1. Engineer will promptly notify the Contractor in writing, listing the incomplete or defective work.
   2. Contractor shall take immediate steps to remedy the stated deficiencies and send a second written certification to the Engineer that the Work is complete.
   3. Engineer shall re-inspect the Work.

1.12 FINAL ADJUSTMENT OF ACCOUNTS

A. Submit a final statement of accounting to the Engineer at least 7 days prior to final Application for Payment.

B. Statement shall reflect all adjustments to the Contract amount.
   1. The original Contract amount.
   2. Additions and deductions resulting from:
      a. Change Orders.
      b. Units installed and unit prices.
      c. Set-offs for uncorrected or incomplete Work.
      d. Set-offs for liquidated damages.
      e. Set-offs for reinspection payments.
      f. Extended engineering and/or inspection services and inspection overtime.
      g. Excessive shop drawings review cost by the Engineer.
      h. Other adjustments.

3. Total Contract amount, as adjusted.
4. Previous payments.
5. Remaining payment due.

C. Engineer will prepare a final Change Order reflecting approved adjustments to the Contract amount which were not previously made by Change Orders.

1.13 FINAL APPLICATION FOR PAYMENT

A. Contractor shall submit the final Application for Payment reflecting the agreed upon information provided in the final statement of accounting.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01782

OPERATION AND MAINTENANCE MANUALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Preparation and submittal of manual with requirements to operate and maintain the equipment.

1.02 PREPARATION

A. General requirements:
   1. Provide dimensions in English units.
   2. Assemble material, where possible, in the same order within each volume.
   3. Reduce drawings and diagrams to 8 1/2 inch by 11-inch size, if possible unless otherwise specified.
   4. Complete forms on computer, handwriting not acceptable.
   5. Delete items or options not provided in the supplied equipment or system.
   6. Provide package control system annotated ladder logic for PLC, if applicable.

B. Hard copy requirements:
   1. Binders: 3-ring with rigid covers.
      a. Break into separate binders as needed to accommodate large size.
   2. Utilize numbered tab sheets to organize information.
   3. Provide original and clear text on reproducible non-colored paper, 8 1/2 inch by 11-inch size, 24 pound paper.
   4. Drawings larger than 8 1/2 by 11 inch:
      a. Fold drawings separately and place in envelope bound into the manual.
      b. Label each drawing envelope on the outside regarding contents.

C. Electronic requirements:
   1. File format:
      a. Entire manual in PDF format.
         1) Include text and drawing information.
         2) Provide a single PDF file even if the hard copy version is broken into separate binders due to being large.
         3) Create PDF from the native format of the document (Microsoft Word, graphics programs, drawing programs, etc.).
            a) If material is not available in native format and only available in paper format, remove smudges, fingerprints, and other extraneous marks before scanning to PDF format.
            b) Hard copy record drawing requirements:
               (1) Provide a single multipage PDF file of each set of the scanned drawings.
               (2) Page 1 shall be the cover of the drawing set.

c) At file opening, display the entire cover.
(1) Scan drawings at 200 to 300 dots per inch (DPI), black and white, Group IV Compression, unless otherwise specified.
(2) Scan drawings with photos in the background at 400 dots per inch (DPI), black and white, Group IV Compression.
4) Pagination and appearance to match hard copy.
5) Searchable.
6) Scanned images are not acceptable.
7) Bookmarks:
a) Bookmarks shall match the table of contents.
b) Bookmark each section (tab) and heading.
c) Drawings: Bookmark at a minimum, each discipline, area designation, or appropriate division.
d) At file opening, display all levels of bookmarks as expanded.
8) Thumbnails optimized for fast web viewing.
b. Drawing requirements:
1) Provide additional copy of drawings in most current version of AutoCAD format.
2) Drawings shall have a white background.
3) Drawing shapes shall not degrade when closely zoomed.
4) Screening effects intended to de-emphasize detail in a drawing must be preserved.
5) Delete items or options not provided in the supplied equipment or system.
2. Media:
a. USB flash drive.
b. Secure File Transfer Protocol (SFTP).
3. Label media with the following information:
a. Operation and Maintenance Manual.
b. Equipment name.
c. Specification Section Number.
d. Equipment tag number.
e. Owner's name.
f. Project number and name.
g. Date.
4. If multiple submittals are made together, each submittal must have its own subdirectory that is named and numbered based on the submittal number.

1.03 CONTENTS

A. Table of Contents: General description of information provided within each tab section.

B. Complete Attachment A - Equipment Summary Form.

C. Description of system and components.

D. Description of equipment function, normal operating characteristics, and limiting conditions.

E. On-line resources.

F. Telephone resources.

G. Approved submittals.
   1. Markup with any field changes.
   2. Final programming.

H. Start-up procedures: Recommendations for installation, adjustment, calibration, and troubleshooting.

I. Operating procedures:
   1. Step-by-step instructions including but not limited to the following:
      a. Safety precautions and applicable Safety Data Sheets.
      b. Guidelines.
      c. Other information as needed for safe system operation and maintenance.

J. Preventative maintenance procedures:
   1. Recommended steps and schedules for maintaining equipment.
   2. Troubleshooting.

K. Lubrication information: Required lubricants and lubrication schedules.

L. Overhaul instructions: Directions for disassembly, inspection, repair and reassembly of the equipment; safety precautions; and recommended tolerances, critical bolt torques, and special tools that are required.

M. Manufacturer's technical reference manuals.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

ATTACHMENT A - EQUIPMENT SUMMARY FORM

EQUIPMENT SUMMARY FORM

1. EQUIPMENT ITEM_____
2. MANUFACTURER_____
3. EQUIPMENT TAG NUMBER(S)_____
4. LOCATION OF EQUIPMENT_____
5. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS)_____

_____

_____

_____

6. NAMEPLATE DATA -
   - Horsepower_____
   - Amperage_____
   - Voltage_____
   - Service Factor (S.F.)_____
   - Speed_____
   - ENC Type_____
   - Capacity_____
   - Other_____
7. MANUFACTURER'S LOCAL REPRESENTATIVE
   - Name_____
   - Address_____
   - Telephone Number_____
8. MAINTENANCE REQUIREMENTS:

Maintenance Operation	Frequency	Lubricant (if applicable)	Comments
(List each operation required. Refer to specific information in Manufacturer's Manual, if applicable)	(List required frequency of each maintenance operation)	(Refer by symbol to lubricant list as required)	

9. LUBRICANT LIST:

Reference Symbol	Conoco Phillips	Exxon/Mobil	BP/Amoco	Other (List)
(Symbols used in Item 7 above)	(List equivalent lubricants, as distributed by each manufacturer for the specific use recommended)			

10. SPARE PARTS (recommendations) _____

_____

11. COMMENTS _____

12. GENERAL INFORMATION:

Date Accepted*: _____

Expected Life*: _____

Project Name & Number: _____

Design Engineer: _____

13. WARRANTY:

Start Date: _____

Expiration Date: _____

Prorated: _____

SECTION 01783

WARRANTIES AND BONDS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Warranty and bonds requirements.

1.02 SUBMITTALS

A. For each item of material or equipment furnished under the Contract:
   1. Submit manufacturer's warranty prior to fabrication and shipment of the item from the manufacturer's facility.
   2. Submit manufacturer's special warranty when specified.

B. Provide consolidated warranties and bonds within 15 calendar days of Substantial Completion.
   1. Contents:
      a. Organize warranty and bond documents:
         1) Include Table of Contents organized by Specification Section number and the name of the product or work item.
      b. Include each required warranty and bond in proper form, with full information, certified by manufacturer as required, and properly executed by Contractor, or subcontractor, supplier, or manufacturer.
      c. Provide name, address, phone number, and point of contact of manufacturer, supplier, and installer, as applicable.
   2. Hardcopy format:
      a. Submit 2 copies.
      b. Assemble in 3 D-side ring binders with durable cover.
      c. Identify each binder on the front and spine with typed or printed title “Warranties and Bonds”; Project Name or Title, and the Name, Address, and Telephone Number of the Contractor.
   3. Electronic copy in PDF format:
      a. Submit 1 copy.

1.03 OWNER'S RIGHTS

A. Owner reserves the right to reject warranties.

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

1.04 RELATIONSHIP TO GENERAL WARRANTY AND CORRECTION PERIOD

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

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

1.05 MANUFACTURER'S 1 YEAR WARRANTY MINIMUM REQUIREMENTS

A. Written warranty issued by item's manufacturer.

B. Project-specific information, properly executed by product manufacturer, and expressly states that its provisions are for the benefit of the Contractor.

C. Covers all costs associated with the correction of the defect, including but not limited to removal of defective parts, new parts, labor, and shipping.

D. Provides a timely response to correct the defect.
   1. Manufacturer shall provide, in a timely fashion, temporary equipment as necessary to replace warranted items requiring repair or replacement, when warranted items are in use and are critical to the treatment process, as defined by Owner.

E. Warranty commence running on the date of substantial completion.
   1. For items of Work for which acceptance is delayed beyond Date of Substantial Completion, submit warranty within 10 calendar days after acceptance, listing date of acceptance as beginning of warranty period.

F. Duration of Warranty: 1 year.

1.06 MANUFACTURER'S SPECIAL WARRANTY

A. Manufacturer's special warranty is a written warranty published by the manufacturer which includes the requirements as specified in the Technical Section.
   1. Project-specific information and requirements.
   2. Properly executed by product manufacturer.
   3. Expressly states that its provisions are for the benefit of the Contractor or Owner.
   4. Manufacturer's special warranties commence on the date that the associated item is certified by Engineer as substantially complete.

1.07 WARRANTY WORK

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

B. Replacement cost:
   1. Upon determination that work covered by warranty has failed, replace or rebuild the work to an acceptable condition complying with requirement of the Contract Documents.
      a. Contractor is responsible for the cost of replacing or rebuilding defective work regardless of whether Owner has benefited from the use of the work through a portion of its anticipated useful service life.

C. Related damages and losses:
   1. When correcting warranted work that has failed, remove and replace other work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted work.

D. Owner's recourse:
   1. Written warranties are in addition to implied warranties, and shall not limit the duties, obligations, rights, and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitation on time in which Owner can enforce such other duties, obligations, rights, or remedies.

E. Reinstatement of warranty:
   1. When work covered by a warranty has failed and has been corrected by replacement or rebuilding, reinstate the warranty by written endorsement.
      a. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

1.08 IMPLIED WARRANTIES

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

B. Implied warranties: Duration in accordance with Laws and Regulations.

1.09 BONDS

A. Equipment bond and other bond requirements as specified in the Technical Sections.

B. Bonds commence running on the date of substantial completion.
   1. For items of Work for which acceptance is delayed beyond Date of Substantial Completion, submit warranty within 10 calendar days after acceptance, listing date of acceptance as beginning of bond period.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01850

DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design criteria for use in the selection of equipment and appurtenances specified in Technical Sections of these Specifications.
   2. Criteria for design of systems, components and equipment fabricated off site and shipped to the Work for installation.
   3. Criteria for design of anchors to connect equipment and appurtenances to supports and structures.

B. The criteria in this Section apply throughout the Work, unless additional criteria, or more restrictive criteria, are indicated.
   1. Additional criteria and requirements relevant to specific locations, specific materials, and specific equipment are indicated on the Drawings, and in the Technical Sections.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 7-16 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures. (ASCE 7).

B. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):
   1. ASHRAE Fundamentals Handbook.

C. International Code Council (ICC):
   1. International Energy Conservation Code (IECC).
   2. International Plumbing Code (IPC).

D. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA):
   1. Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd edition 2008.

PART 2 PRODUCTS

2.01 DESIGN CRITERIA - SITE INFORMATION

A. Site name: Calaroga Sanitary Sewer Pump Station.
   1. Street address: As specified in Section 01110 - Summary of Work.
      a. Coordinates (approximate): Latitude 45.3958; Longitude -122.6377.
   2. Site elevation (approximate):
      a. Varies: 31 to 46 feet above mean sea level.
   3. Groundwater elevation:
      a. 29-feet elevation.
      b. For design of buried and partially buried construction:
         1) Assume groundwater level at grade.

2.02 DESIGN CRITERIA - REGULATORY REQUIREMENTS

A. Requirements of authorities having jurisdiction over the Project are included in Section 01410 - Regulatory Requirements.

2.03 DESIGN CRITERIA - OPERATING ENVIRONMENT

A. Drawings and Technical Sections include additional criteria and requirements relevant to specific locations, materials, and equipment.

B. Outdoor conditions:
   1. International Energy Conservation Code (IECC): Climate Zone 4C .
   2. Site climatic data location: Aurora, OR, WMO: 726959 .
   3. Temperature criteria: As specified in the following Table:
      Design Temperatures – Outdoor Criteria in Accordance with ASHRAE Fundamentals Handbook.

Table: Design Temperatures - Outdoor Criteria in Accordance with ASHRAE Fundamentals Handbook	
Hottest Month Daily mean range:	25.2 degrees Fahrenheit.
Winter:	At or above this temperature 99.6 percent of the time: 25.4 degrees Fahrenheit dry-bulb.
Summer:	At or above this temperature 0.4 percent of the time: 92.4 degrees Fahrenheit dry-bulb.

   4. Rainfall intensity:
      a. Reference: International Plumbing Code (IPC):
         1) 1.5 inches per hour (100-year, 1-hour rainfall).

C. Indoor conditions:
   1. Humidity:
      a. Moisture/humidity conditions: As specified, and as defined in individual equipment sections.

2.04 DESIGN CRITERIA - STRUCTURAL

A. General:
   1. Criteria for structural design of:
      a. Equipment at locations subject to seismic events.
      b. Equipment exposed to outdoor environments.
      c. Equipment supports and bracing, and anchorage of such items to building and non-building structures.
      d. Structures provided for the Work through Delegated Design.
      e. Manufactured and prefabricated structures, and anchorage of such structures to foundations or other supporting elements.
   2. Structural design criteria used by the Engineer of record and required by the building code to be indicated on the Drawings are included on the Contract Drawings.

B. Structure risk category:
   1. Develop design loads and provide detailing in accordance with the provisions of ASCE 7 and the building code specified in Section 01410 - Regulatory Requirements, based on the Structure Risk Category indicated in Table: Project Structures - Risk Category and Seismic Design Information.

C. Seismic loads:
   1. Seismic design parameters: Basic parameters - ASCE 7:
      a. Ground motion MCE_R, 5 percent damped:
         1) Short periods, Ss = 0.863 g.
         2) 1 second period, S_1 = 0.384 g.
      b. Peak ground acceleration, MCE_G:
         1) Peak ground acceleration, PGA = 0.388 g.
   2. Structures - General:
      a. Seismic Design Category (SDC): As indicated in the following Table: Project Structures - Risk Category and Seismic Design Information.

Table: Project Structures - Risk Category and Seismic Design Information

Description: Wastewater Treatment (pumping) Station

Area	Description	Risk Category	Site Class	S_{DS}	S_{D1}	Seismic Design Category[(1)]
All	All Structures	III	C	0.690 g	0.384 g	D

Notes:
1. Seismic Design Category for Delegated Design, and for seismic certification of electrical and mechanical equipment as required by ASCE 7.

      b. Structure response modification coefficient, R:
         1) In accordance with ASCE 7 and the requirements of the Technical Sections.

3. Structures - Tanks and vessels.
    a. Includes: Tank structures, tank supports, and anchorage to structures or foundations.
    b. Liquid storage structures (e.g., basins and tanks).
        1) Include impulsive and convective (“sloshing”) effects.
        2) Component response modification factor - impulsive effects, Ri: In accordance with ASCE 7, Table 15.4-2.
        3) Component response modification factor - convective effects, Rc = 1.0.
    c. Dry material storage structures (e.g., silos, hoppers):
        1) Include effects of stored materials.
        2) Component response modification factor - impulsive effects, Ri: In accordance with ASCE 7, Table 15.4-2.
4. Non-structural components - General:
    a. Includes:
        1) Mechanical and electrical equipment; anchorage of equipment to structures or supports; design of supports; and anchorage of supports to structures or foundations.
        2) Distribution systems associated with mechanical and electrical equipment such as piping, ductwork, conduits, cable trays, raceways, bus ducts, and similar items; anchorage of such systems to supports and structures; and bracing or such systems.
    b. Seismic design requirements for non-structural components are based on the Seismic Design Category (SDC) of the structure or facility where the equipment is installed.
    c. Design components, component anchorage, and component connections to piping and utilities in accordance with the requirements of ASCE 7, Table 13.2-1.
    d. Component amplification factor (ap), response factor (Rp), and overstrength factor for anchorage to concrete (Ωo):
        1) Mechanical and electrical components and systems: In accordance with ASCE 7, Table 13.6-1, unless otherwise indicated in the Technical Sections for these items.
        2) Architectural components and systems: In accordance with ASCE 7, Table 13.6-1, unless otherwise indicated in the Technical Sections for these items.
    e. Component importance factor, I_p:
        1) In accordance with the following Table: Component Importance Factor for Seismic Design, I_p.
        2) For items not listed in Table: Component Importance Factor for Seismic Design, I_p, designate importance factor in accordance with the provisions of ASCE 7, Chapter 13, and submit to the Engineer for review prior to developing calculations and details related to that component.

Table: Component Importance Factor (I_p) for Seismic Design		
Structure Seismic Design Category	**Components**	**I_p**
All	Electrical: Items and distribution system components specified in Division 16 - Electrical.	1.5
All	Process Control and Instrumentation Systems: Components and distribution systems specified in Division 17 - Instrumentation and Controls.	1.5
All	Equipment and components specified in Divisions 11 through 15, except HVAC and plumbing components listed below.	1.5
All	Other equipment not listed above.	1.0

D. Wind loads:
   1. Design structures and non-structural components that are exposed to wind to withstand design wind loads.
      a. Reduction of wind loads based on shielding effects of surrounding structures or components is not allowed.
      b. Design for wind loading is not required for non-structural components and for non-building structures located inside enclosed buildings.
   2. Design parameters:
      a. Basic wind speed:
         1) 103 miles per hour (33 feet, 3 second gust).
      b. Exposure category: C.
      c. Topographic factor (Kzt): 1.0.
      d. Wind pressure for design of “components and cladding”.
         1) “Components and cladding” includes doors, windows, siding panels, skylights, parapets and similar architectural elements.

E. Snow loads:
   1. Design for snow loading is not required for non-structural components and for non-building structures located inside enclosed buildings.
   2. Design parameters:
      a. Ground snow load: p_g = 11 pounds per square foot.

F. Rainfall loads:
   1. Determine rainfall loads using rainfall intensity specified in this Section, and including effects of exposed surface slope, height above surface to discharge elevation, and deflection of ponded surfaces.

G. Operational loads:
   1. Loads may include equipment vibration, torque, thermal effects, effects of internal contents (weight and sloshing), surge or “water hammer,” and other load conditions.
   2. Design for loads indicated by equipment manufacturer.
   3. Design for loads indicated in the Technical Sections for equipment and appurtenances.

PART 3 EXECUTION

3.01 GENERAL

A. Design approach and criteria in accordance with:
   1. Regulatory requirements, including but not limited to the building code specified in Section 01410 - Regulatory Requirements.
   2. Reference standards and project-specific design criteria listed in this Section.
   3. Specific requirements for individual elements and components of the Work as specified in subsequent Technical Sections.

B. In the event of conflicts between design criteria, contact Engineer for interpretation.

C. Where Owner-Delegated Design is required by the Specifications, prepare and submit designs as specified in Section 01357 - Delegated Design Procedures.

3.02 DELEGATED DESIGN

A. Where Delegated Design is required by the Technical Sections, prepare and submit designs as specified in Section 01357 - Delegated Design Procedures.

B. Calculations:
   1. Where submittal of calculations is required:
      a. Provide complete calculations, including sketches to illustrate the design concepts being evaluated, and details to fully describe proposed construction.
   2. Requirements for seismic design calculations will be waived for the following:
      a. Furniture and storage racks 6 feet in height or less.
      b. Moveable equipment.
      c. Mechanical and electrical equipment and components located in structures designated as Seismic Design Category A or B.
      d. Mechanical and electrical equipment and components located in structures designated as Seismic Design Category C and where the component importance factor, I_p, is equal to 1.0.
   3. Requirements for wind design calculations will be waived for the following:
      a. Equipment and components located inside structures, and away from the effects of wind loads.

C. Shop Drawings:
   1. Describing components and manufacturer’s requirements for connections.
      a. Include details for connections of components to structures and supports.
      b. Include details for anchoring bracing to structures where required.

3.03 DESIGN - ANCHORS FOR EQUIPMENT, COMPONENTS, AND BRACING

A. General:
   1. Engineer's approval of anchor designs is required before placement of construction that supports or provides bracing for anchored equipment and components.
      a. Prepare anchor designs after Engineer's approval of the products and layout, and before placement of concrete or masonry that supports them.
   2. Adjust equipment pad sizes and add additional anchor confinement reinforcing to provide required strength at anchorage points between equipment and pad, and between pad and structure.
   3. Supports and bracing:
      a. Design and install braces and anchors to transfer forces from equipment and components to the lateral force resisting system of the surrounding structure.
      b. Anchor and brace piping, ductwork, and electrical distribution components so that lateral or vertical displacement does not result in damage to or failure of essential architectural, mechanical, or electrical equipment.
         1) Provide supplementary framing where required to transfer forces.
         2) Detail and locate braces and anchors to minimize differential movements between components and structure.

B. Preparation:
   1. Obtain manufacturer's information:
      a. Weight and dimensions of components.
      b. Layout and location of anchors that connect to equipment base plates, sole plates, skids, or pads.
      c. Sizes of holes for anchors that will be provided in equipment bases or support frames.

C. Analysis and design:
   1. Perform and submit calculations to determine anchor designs at locations where equipment and equipment supports are connected to the supporting structure.
      a. Indicate number, size, type, and material for anchors.
   2. In determining forces at locations where equipment is anchored to structures, include effects of:
      a. Equipment self-weight and operating weight.
      b. Location of equipment center of mass.
      c. Forces from equipment operation including, but not limited to:
         1) Effects of internal contents including weight and sloshing.
         2) Effects of thrust, surge, and water hammer where specified.
         3) Equipment reactions and operating torque.
         4) Equipment vibration.
         5) Thermal effects from equipment and from distribution systems connected to the equipment (piping, ducts, and electrical).
         6) Other load or displacement inducing conditions.

d. Forces on equipment from loads specified in this Section.
    1) Include effects of wind, snow, and icing loads where applicable.
    2) Design for load combinations indicated in ASCE 7, unless otherwise specified or indicated on the Drawings.
    3) Seismic and wind loads: For equipment and tanks with weight that varies based on the volume of contained material, determine anchor forces to accommodate the full range of filled, partially filled, and empty conditions.

3. Determine forces and overturning moments at equipment supports and at locations where supports are anchored to structures.
    a. Indicate shear force and associated axial force at each anchor.
4. Do not use friction to resist sliding resulting from seismic or wind forces.
    a. Resist sliding only by direct application of sliding loads to fasteners as bearing, shear, tension, or compression forces.
5. Using combined shears and axial forces at each anchor, design anchors and anchor groups for ductile failure.
    a. Ductile failure: Anchor yield before failure of base material, typically concrete or masonry, at the anchor.
6. Anchor selection:
    a. Provide anchors type indicated on the Drawings.
    b. Where anchors are not specifically indicated on the Drawings, select in accordance with the following:
        1) Anchors that resist seismic and wind forces:
            a) Cast-in-place forged hex-head anchor bolt.
        2) Anchors loaded in sustained tension:
            a) Cast-in-place forged hex-head anchor bolt.
        3) Anchors for reciprocating, vibrating, and rotating equipment:
            a) Cast-in-place forged hex-head anchor bolt.
    c. Do not use post-installed anchors, mechanical or adhesive, unless:
        1) Post-installed anchors are indicated on the Drawings, or
        2) Post-installed are approved by the Engineer prior to placement of the surrounding concrete or masonry.
    d. Anchor diameter:
        1) Select diameter so that hole in base plate is not greater than 125 percent of the nominal diameter of the anchor, nor greater than the diameter of the anchor plus 1/4 inch.
7. Determine number, size, layout, and minimum effective embedment for anchors.
    a. Layout includes anchor spacing and required distance(s) from anchor to edge(s) of supporting concrete or masonry.
    b. Anchors in concrete: Design based on minimum specified 28-day compressive strength, f'c, as follows, unless otherwise indicated on the Drawings for the Work area:
        1) Concrete placed for this Work: See Sheet GS01 – General Structural Notes.
8. Prepare Drawings showing construction details of anchor designs.
9. Submit design calculations and Drawings prior to placement of anchors, and of the structural elements to which they will connect.

END OF SECTION

SECTION 02050

SOILS AND AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Material requirements for soils and aggregates.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   5. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   6. D4829 - Standard Test Method for Expansion Index of Soils.

B. Oregon Department of Transportation (ODOT):
   1. Oregon Standard Specifications for Construction (Standard Specifications).

1.03 SUBMITTALS

A. Product data:
   1. Material source.
   2. Gradation.
   3. Testing data.

B. Quality control for aggregate base course:
   1. Test reports: Reports for tests required by Sections of Standard Specifications.
   2. Certificates of Compliance: Certificates as required by Sections of Standard Specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Protect from segregation and excessive moisture during delivery, storage, and handling.

B. Comply with Standard Specifications storage requirements, if applicable.

PART 2 PRODUCTS

2.01 MATERIALS - GENERAL

A. Provide material having maximum particle size not exceeding 4 inches and that is free of trash, lumber, debris, leaves, grass, roots, stumps, and other organic matter.

B. Materials derived from processing demolished or removed asphalt concrete are not acceptable.

C. Comply with soil and aggregate material requirements in the Standard Specifications., unless specified otherwise.

2.02 NATIVE MATERIAL

A. Native soil-select:
   1. Sound earthen material.
   2. Sum of plasticity index when tested in accordance with ASTM D4318 and the percent of material by weight passing a Number 200 sieve shall not exceed 23 when tested in accordance with ASTM C136.
   3. Organic content not be greater than 3 percent by volume.
   4. Corrosion resistance requirements:
      a. Resistivity minimum (wet aggregates): 5,000 ohm-cm.
      b. pH: 5.0 to 12.0.
      c. Chlorides maximum: 100 parts per million.
      d. Sulfates maximum: 200 parts per million.

2.03 AGGREGATE BASE COURSE

A. Aggregate base course meeting the requirements of Section 00641 and 02630 of the Standard Specifications with the following requirement amendments:
   1. Aggregate Size: 3/4-inch minus.
   2. No more than 8 percent passing the No.200 sieve (ASTM D1140) will be accepted.

2.04 DRAIN ROCK

A. All drain rock shall be 100 percent crushed rock material and meet the requirements of Section 00430.11 of the Standard Specifications.

2.05 GABION BASKET FILL

A. Durable 4 to 8-inch size rock material meeting the requirements of Section 00390.11(b) of the Standard Specifications.

2.06 SAND

A. Clean, coarse, natural sand.

B. Non-plastic when tested in accordance with ASTM D4318.

C. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1/2 inch	100
Number 200	0 - 20

2.07 DRAIN ROCK

A. Material requirements:
   1. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C131.
   2. Consists of hard, durable particles of stone or gravel; screened or crushed to specified size and gradation; and free from organic matter, lumps or balls of clay, or other deleterious matter.
   3. Crush or waste coarse material and waste fine material as required to meet gradation requirements.
   4. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent By Weight Passing Sieve
2 inch	100
1-1/2 inch	95 - 100
3/4 inch	50 - 100
3/8 inch	15 - 55
Number 200	0 - 2

2.08 PERMEABLE FILL

A. Material requirements:
   1. Durability: Percentage of wear not greater than 40 percent when tested in accordance with ASTM C131.
   2. Consists of hard, durable particles or fragments of stone or gravel; crushed to required size and grading; and free from organic matter, lumps or balls of clay, alkali, adobe, or other deleterious matter.
   3. Materials derived from processing demolished or removed asphalt concrete are not acceptable.
   4. Aggregate base course for structures:
   5. Consist of crushed or fragmented particles.
   6. When sampled and tested in accordance with specified test methods, material shall comply with following requirements: Sand equivalent: Not less than 75 when tested in accordance with ASTM D2419.
   7. Conforms to size and grade within the following limits when tested in accordance with ASTM C117 and C136:

Sieve Size (Square Openings)	Percent by Weight Passing Sieve
1 inch	100
3/4 inch	90 - 100
3/8 inch	40 - 100
Number 4	25 - 40
Number 8	18 - 33
Number 30	5 - 15
Number 50	0 - 7
Number 200	0 - 3

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 02084

PRECAST DRAINAGE STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Onsite utility structures:
      a. Precast drainage inlets.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. ASTM International (ASTM):
   1. C361 - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
   2. C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
   3. C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   4. C858 - Standard Specification for Underground Precast Concrete Utility Structures.

1.03 SUBMITTALS

A. Shop Drawings: Submit for precast utility structures.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Precast drainage inlets:
   1. Construct precast concrete drainage inlets in accordance with the size, shape, form, details, and at locations indicated on the Drawings and specified.
   2. Base design and manufacture to A-16 (HS 20-44) loading in accordance with ASTM C857.
   3. In accordance with ASTM C858.
   4. Construct precast drainage inlets of Class A concrete as specified in Section 03300 - Cast-in-Place Concrete.

B. Precast concrete utility trench:
   1. Manufacturers: One of the following, or equal:
      a. Trenwa, Inc. Road Crossing Trench with Removable Concrete Lid (BHC3024-120).

2. Contractor to coordinate trench manufacture details as needed to accommodate curb and gutter crossings, as indicated on the Drawings.
3. Construct precast concrete utility trench in accordance with design, size, shape, form, details, and at locations indicated on the Drawings and as specified.
4. Provide precast sections meeting strength requirements in accordance with ASTM C478.
5. Base design and manufacture on A-16 (AASHTO HS 20-44) loading in accordance with ASTM C857.
6. Sections of the trench designated for road crossing use shall be designed to carry AASHTO HS20 loading, 32,000 pound axle loading and shall be furnished in standard 10-foot lengths (except where special length requirements are necessary to fulfill the overall trench length requirement).
7. Lids for the road crossing trench shall be made of steel reinforced concrete designed to carry AASHTO HS20 loading, 32,000 pound axle loading.
8. Utility trench shall be water resistant and free from infiltration or exfiltration.
9. Interior dimensions of utility trench shall be as indicated on the Drawings.
10. Seal joints with precast concrete joint sealant.
11. Piping penetrations:
    a. Manufacturers: The following or equal:
        1) Kor-N-Seal, rubber gasket boots with steel clamps.
12. Piping connections to the utility trench shall be as indicated on the Drawings.
13. End plates: Positively connected to the trench to minimize liquid seepage in or out of the trench.
14. Cast weld plates into trench wall for Contractor-installed pipe supports at the following locations:
    a. Vertical wall placement at 6 inches and 12 inches from the base of the utility trench.
    b. Linear maximum spacing of weld plates at the vertical wall locations: 5 feet.
15. Provide welded tie plates that positively connect the trench sections to minimize shifting and differential settlement.
16. Provide galvanized steel impact channels at the utility trench to concrete lid connections.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
    1. Appurtenances shall be watertight and free from infiltration or exfiltration.

2.03 ACCESSORIES

A. Precast drainage inlets:
    1. Covers: As indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Precast drainage inlets:
   1. Excavation and backfill: As specified in Section 02318 - Trenching.

END OF SECTION

SECTION 02085

PRECAST CONCRETE VAULTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Precast concrete vaults.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO).
   1. LRFD Bridge Design Specifications.

B. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

C. ASTM International (ASTM):
   1. C150 - Standard Specification for portland Cement.
   2. C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   3. C858 - Standard Specification for Underground Precast Concrete Utility Structures.

D. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. General:
   1. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. Show dimensions, locations, lifting inserts, reinforcement, and joints.
   2. Structural design calculations for vaults, signed by a licensed registered Civil or Structural Engineer licensed in the State where project is located.

C. Manufacturer's Certification for Vaults: Written certification that the vault complies with the requirements of this Section.

1.04 QUALITY ASSURANCE

A. Inspection:
   1. After installation, the Contractor shall demonstrate that vaults have been properly installed, level, with tight joints, at the correct elevations and orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

PART 2 PRODUCTS

2.01 VAULTS

A. Manufacturers: One of the following or equal:
   1. Utility Vault Co.
   2. Oldcastle Precast.

B. Provide precast vaults for the size indicated on the Drawings.

C. The minimum structural member thickness for vaults shall be 5 inches.
   1. Cement shall be Type V portland cement in accordance with ASTM C150.
   2. The minimum 28-day concrete compressive strength shall be 4,000 pounds per square inch.
   3. All reinforcing steel shall be embedded in the concrete with a minimum clear cover as recommended by ACI 318.

D. Design requirements: Loads on structures:
   1. In accordance with ASTM C857, except as modified in this Section.
   2. Loads at the ground surface:
      a. ”Roadway”: Load from heavy, frequently repeated vehicle traffic:
         1) ASTM C857, Table 1, Designation A-16 (AASHTO HS20-44).
   3. Loads against walls. Include effects of groundwater and seismic accelerations on earth pressures.
      a. Equivalent lateral pressure:
         1) Triangular distribution: 60 pounds per square foot per foot of depth (triangular distribution).
         2) Rectangular distribution backfill-induced live load surcharge: 240 pounds per square foot.
      b. Surface surcharge load: In accordance with ASTM C857 A-16 wheel load if such surcharge exceeds backfill loads described in the preceding paragraph.
      c. Groundwater effects: Include groundwater effects on lateral earth pressure loads using final grade elevation.
         1) Use equivalent lateral pressure of 90 pounds per square foot per foot of depth (triangular distribution) for soil below the design groundwater elevation.
      d. Seismic acceleration effects:
         1) As indicated on the Drawings.
         2) On opposite sides of the structure, uniform equivalent lateral leave in pressure type distribution, with a pressure of 37.5 in pounds per square foot where it is the depth of structure.
         3) Adding lateral force for soil accelerating toward structure:
            a) Direct uniform pressure distribution toward the wall, effectively increasing the static lateral soil pressure.
         4) Reducing lateral force for soil accelerating away from structure:
            a) Direct inverted pressure distribution away from the wall, effectively reducing the static lateral soil pressure.

4. Groundwater and flood loads, and buoyancy effects:
    a. As specified in Geotechnical Report for design groundwater and design flood elevations.
    b. Lateral pressure effects: Determine based on groundwater and flood elevations specified.
    c. Buoyancy: For groundwater and flood conditions, provide factor of safety against flotation of at least 1.20.
        1) If the weight of soil overlying footing projections on the structure is considered to resist flotation, use a buoyant unit weight of soil equal to not more than 40 pounds per cubic foot.
        2) Concrete fill may be provided in the bottom section of precast portland cement concrete structures to add weight. Submit proposed details.
5. Soil bearing pressure at base:
    a. Maximum 1,500 pounds per square foot total pressure on prepared subgrade soils.
6. Lifting and handling loads:
    a. Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or erection.
7. Load combinations:
    a. Design structures to sustain the specified loads individually or in combination.

E. Design requirements: Structural analysis, design and detailing:
1. Analyze and design structures including the effects of 2-way action (“plate action”) and of load transfer around current and future openings.
2. Where structures include panels designed for future removal (“knockout panels”), design structures for loads and stresses with any combination of any or all such panels in place or removed.
3. Design structures in accordance with the requirements of ACI 318 and this Section.
4. Provide reinforcement at all areas subject to tensile stress when loaded with the specified loads and combinations thereof.
5. Provide temperature and shrinkage reinforcement to equal or exceed ACI 318 requirements in all concrete sections.
6. Provide minimum clear concrete cover over reinforcement at both interior and exterior faces of all members in accordance with the following:
    a. Vaults: 2 inches.
7. Reinforcement details:
    a. Walls: For structures with wall thickness of 8 inches or less, locate a single mat of reinforcement at the center of the wall.
    b. Slabs: For structures with slab thickness of 7 inches or less, locate a single mat of reinforcement at the center of the slab.
    c. Structures with wall or slab thicknesses exceeding these limits shall have a reinforcement at each face of the member.
8. Joints:
    a. Provide structures with watertight joints between sections, and detailed to minimize water infiltration at duct bank and conduit penetrations.
    b. Provide structures with non-skid, shiplap, or tongue and groove joints between sections.

F. Design requirements: Materials:
   1. Portland cement concrete vaults:
      a. In accordance with ASTM C858, except as modified in this Section.
      b. Proportion concrete mixes to resist damage from freezing and thawing in a moist environment, and for exposure to deicing chemicals. In accordance with ACI 318 requirements for minimum specified compressive strength and air entrainment.
   2. Seal joints watertight with precast concrete joint sealant.

G. Where joints are designed in pre-cast concrete vaults, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil through the joint. Structural sections at joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint.

H. Vault shall be solid walled construction.
   1. Where penetrations of the pre-cast concrete vault are required for piping, conduit, or ducts, such penetrations shall be accommodated through pre-cast openings or core-drilled sections.
   2. Openings for penetrations shall be smooth and free of surface irregularities and without exposed steel reinforcing.
   3. Vaults need not be designed to resist thrust from piping passing through the vault.
   4. Coordinate pipe penetration locations with piping arrangement as indicated on the Drawings.

I. Slope bottom of vault to Drainage Sump as indicated on the Drawings.

J. Drainage Sump: Dimensions as indicated on the Drawings.
   1. Drainage Sump shall consist of an open knockout in the bottom of the vault. Provide additional reinforcing as required to accommodate knockout.
   2. Provide FRP grating with rebate as indicated on the Drawings.
      a. Grating shall be designed for 300 pounds per square foot load with L/200 maximum deflection.
      b. Provide removable grating sections to facilitate grating removal without disconnecting Automatic Sump Drain Ejector Assembly indicated on the Drawings.

K. Ladders:
   1. General:
      a. Type:
         1) Safety type conforming to local, State, and OSHA standards as minimum.
         2) Furnish guards for ladder wells.
      b. Size: 18 inches wide between side rails of length, size, shape, detail, and location indicated on the Drawings.

2. Aluminum ladders:
    a. Materials: 6063-T5 aluminum alloy.
    b. Rungs:
        1) 1-inch minimum solid square bar with 1/8-inch grooves in top and deeply serrated on all sides.
        2) Capable of withstanding 1,000 pound load without failure.
    c. Side rails: Minimum 4-inch by 1/2-inch flat bars.
    d. Fabrication:
        1) Welded construction, of size, shape, location, and details indicated on the Drawings.

2.02 ACCESS HATCH

A. Where openings for access to the vault are required, the full clear space opening indicated shall be provided, without obstructions from brackets or supports. For large openings where brackets or supports are designed to protrude into the opening for support of required covers, such brackets or supports shall be designed to be easily removed and replaced with a minimum of effort and without cutting or welding.

B. Access hatch shall be Heavy Duty Off-Street Floor Access Doors as specified in Section 08320 - Floor Access Doors for access floor requirements.

PART 3 EXECUTION

3.01 INSTALLATION

A. Pre-cast concrete sections shall be transported and handled with care in accordance with the manufacturer’s written recommendations.
    1. Where lifting devices are provided in pre-cast sections, such lifting devices shall be used as intended.
    2. Where no lifting devices are provided, the Contractor shall follow the manufacturer’s recommendations for lifting procedures to provide proper support during lifting.

B. Buried pre-cast concrete vaults shall be assembled and placed in excavations on properly compacted soil foundations as indicated. Pre-cast concrete vaults shall be set to grade and oriented to provide the required dimensions and clearances from pipes and other structures.

C. Apply coatings in accordance with manufacturer's instructions.

D. Ladders:
    1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
    2. Anchorage by manufacturer.
    3. Where exit from ladder is forward over top rung, extend side rails 3 feet 3 inches minimum above landing, and return the rails with a radius bend to the landing.

4. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
5. Erect rail straight, level, plumb, and true to position indicated on the Drawings. Correct deviations from true line or grade which are visible to the eye.

END OF SECTION

SECTION 02241

DEWATERING

1.01 SUMMARY

A. Section includes:
   1. Requirements to dewater excavations.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 COORDINATION REQUIREMENTS

A. Coordinate the dewatering system design with excavation and shoring design.

B. Excavation and shoring design shall consider changes in groundwater conditions and associated earth pressures in compliance with project geotechnical report requirements.

C. Do not place concrete or masonry foundations or concrete slabs in water. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.
   1. Maintain operation of dewatering system:
      a. Until complete structure has been constructed, including walls, slabs, beams, struts, and other structural elements.
      b. Concrete has attained its specified compressive strength.
      c. Backfill has been completed to 3 feet above normal static groundwater level at the site.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 01601 - Product Requirements.

B. Dewatering Plan.

C. Copies of correspondence with the authorities having jurisdiction, regarding dewatering operations, including but not limited to the authorization to drill, well driller's license, well driller’s permits, and completion report.

D. Well construction logs: Include the following at a minimum:
   1. Descriptions of actual materials encountered, categorized in accordance with the Unified Soil Classification System.
   2. Construction details.
   3. Well development procedures and results.
   4. Deviations from original design.

E. Submit a drainage encroachment permit.

F. Submit a Settlement Monitoring Plan.

G. Qualifications:
   1. Dewatering Contractor.
   2. Dewatering design Engineer.
      a. Civil Engineer, licensed in state where the project is located.
      b. Minimum experience: 8 years of experience in designing similar systems of equal type, size, and complexity to that required for the Work.
   3. Testing laboratory.

H. Flowmeter:
   1. Product information on flowmeter and chart recorder.
   2. Recent flowmeter calibration documentation.
   3. Flowmeter chart recorder.

1.05 CONTROLS

A. Dewatering shall be performed at the discretion of Contractor as approved by the Engineer.

B. Contractor shall demonstrate the system proposed and verify that adequate equipment, personnel, and materials are provided to dewater the excavations.

C. Contractor shall discharge water without damaging adjacent property, and in conformance with discharge permit and regulations, including meeting discharge limitation parameters.
   1. Any penalties and fees due to Non-Conformance with permit shall be the responsibility of the Contractor.

D. Contractor shall control the rate and effect of the dewatering in such a manner as to avoid objectionable settlement and subsidence, defined shows settlement or damage that resulted from the dewatering.

E. Contractor shall be responsible for ensuring dewatering operations shall be adequate to ensure the integrity of the finished project.
   1. Contractor shall coordinate with Owner to obtain readings from two existing groundwater monitoring wells equipped with a piezometer.
   2. Protect monitoring wells in place during excavation.
   3. Contractor shall maintain operability of monitoring wells and reroute or extend wire as necessary for use by both Contractor and Owner where within excavation limits.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Contractor shall design the dewatering system to keep excavations reasonably free from water.

B. Contractor must detail in the dewatering plan the limits of the system, and what additional measures will be taken (such as cut-off grouting) in the event excavations encounter fractures or fracture zones with high flow rates; the Contractor must perform injection/cut-off grouting (see Specification Section 02256 – Subgrade Probing and Grouting) due to the inherent variability of fractured weathered basalt.

C. Dewatering design and analysis. Include the following:
   1. Evaluation of anticipated subsurface conditions.
   2. Pump size.
   3. Plans for treatment of groundwater treatment.
   4. Plans for de-silting of groundwater before discharge.
   5. Anticipated area influenced by dewatering system and potential impacts to adjacent structures, existing and proposed.
      a. Mitigation measures needed to prevent any expected settlements.
      b. Contingency plan for restoring nearby structures if settlement is observed as result of dewatering operations.

D. Contractor shall include water drawdown curves in dewatering calculations.

E. Provide dewatering design sealed by a registered Professional Engineer, licensed in the project location.

2.02 DESIGN CRITERIA

A. Prior to excavation, submit a detailed Dewatering Plan and operation schedule for dewatering of excavations.

B. Design the dewatering system to keep excavations reasonably free from water.
   1. Select appropriate method to dewater, subject to Engineer's review and concurrence.
   2. Shored excavation dewatering as specified in Section 02318 – Trenching and Section 02260 – Excavation Support and Protection.
   3. Dewatering analysis shall determine the following:
      a. Evaluation of anticipated subsurface conditions.
      b. Pump size.
      c. Plans for treatment of groundwater treatment.
   4. Prevent unstable excavation due to pumping and heave.
   5. Dewatering plan prepared by a professional Engineer licensed in the state where the project is located.
   6. Dewatering plan shall include, but not be limited to the following:
      a. Dewatering design analysis and supporting calculations.
      b. Required permits.
      c. Arrangement, location, and depths of dewatering system components including monitoring wells.
      d. Type of proposed pumps to be used and their locations.
      e. Header piping size, material, and piping alignments.
      f. Meter type and locations.
      g. Valve type and locations.
      h. Proposed discharge locations, as identified in this Section.
      i. Settling tanks and filters.

j. Pipeline material, alignment, and connection details.
k. Materials added to borehole during drilling and construction of wells.
l. Settlement Monitoring Plan for existing above and underground structures adjacent to the dewatering system.
m. Standby pumping equipment.
n. Required power supply equipment.
o. Design of any needed water treatment facilities shall comply with the NPDES Discharge Permit.

C. Locate dewatering facilities where they will not interfere with utilities and construction work.

D. Contractor shall design and install a water treatment system if necessary to comply with discharge limitation parameters.

E. Decommissioning:
1. Contractor shall obtain Engineer's approval to begin decommissioning activities.
2. Contractor shall decommission and remove dewatering system.
3. Contractor shall abandon existing monitoring wells located along the alignment.

2.03 EQUIPMENT

A. Provide and maintain equipment necessary for dewatering.

B. Keep standby equipment available at all times to ensure efficient dewatering and maintenance of dewatering operation during power failure.

2.04 DEWATERING PUMPS

A. Pumps shall be specifically designed for dewatering applications where pumping sand may be encountered.
1. The impeller and rotor shaft shall be hardened, heat-treated stainless steel. The mechanical seal material shall be silicon carbide.
2. Pump motor shall have thermal overload protection.

2.05 FLOWMETER AND CHART RECORDER

A. Flowmeter and chart recorder: One of the following or equal:
1. Badger Turbo Series Meter with totalizer.

PART 3 EXECUTION

3.01 DEWATERING PROCEDURES

A. The designer of the dewatering system shall oversee dewatering operations.

B. Site grading shall promote drainage. Surface runoff shall be diverted away from excavations.

C. Complete dewatering prior to excavation:
   1. Ensure that the subsurface soil is not being removed by the dewatering operation.

D. Continue dewatering operations throughout construction to achieve the following:
   1. Preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation.

E. Contractor shall make provisions to maintain continuous dewatering.
   1. Provide standby power to maintain dewatering during power outages and interruptions.
   2. Provide 24-hour monitoring by personnel skilled in operation and maintenance of the system, and capable of providing or obtaining work required to maintain system operation.

F. If foundation soils are disturbed or loosened by the upward seepage of water or an uncontrolled flow of water, excavate the affected areas and replaced with drain rock at no additional cost to Owner.

G. Maintain a trench bottom and excavated area free from standing water.

H. Prevent flotation by maintaining a positive and continuous removal of water.

I. Contractor shall be fully responsible and liable for damages that may result from failure to adequately keep excavations dewatered.

J. Do not place concrete or masonry foundations or concrete slabs in water.
   1. Do not allow water to rise over these elements until concrete or mortar has set for at least 24 hours.

K. Maintain operation of dewatering system until the pipeline has been installed and backfill has been completed to 3 feet above normal static groundwater level at the site.

L. Wells, well points, and drain lines for dewatering:
   1. Obtain Engineer's written acceptance prior to commencing operations.
   2. Fill wells, pipes, and French drains to be left in place within structure foundation limits with Class “C” concrete as specified in Section 03300 - Cast-In-Place Concrete, or grout as specified in Section 03600 - Grouting.

3.02 GROUNDWATER LEVEL MONITORING

A. Conduct dewatering operation in a manner that will protect adjacent structures and facilities.

B. Repair damage to adjacent structures and restore facilities at no expense to Owner.

C. Dispose of water from the work in suitable manner:
   1. Without damage to adjacent property.
   2. That will not be a menace to public health or safety.

D. Do not drain dewatering water or associated debris into the Work built or under construction.
   1. Under no conditions shall water or associated debris from dewatering operations be allowed to enter into any sanitary sewer system.

E. For discharge of water into holding tanks or infiltration ponds, include a means of overflow protection that is acceptable to the Engineer.

3.03 FIELD QUALITY CONTROL

A. Monitoring wells:
   1. Record groundwater levels at least once a week. Submit readings to Engineer within 1 week.

B. Flowmeter and chart recorder:
   1. Provide flowmeter and continuous 24-hour chart recorder for recording dewatering flow.
   2. Maintain meter recorder and provide continuous reading charts with minimum capacity of 24 hours each.
   3. Calibrate flowmeter and recorder device to provide accuracy within 5 percent.
   4. Submit written evidence of calibration of meter and recorder signed by a Professional Engineer registered in the state where Project is located.
   5. Portable recorder (bench mount), dual scale, and mounted in NEMA Type 4X enclosure with transparent plastic door and latch. Operate unit off 115-volts, 60-hertz power supply.
   6. Submit readings to the Engineer on a weekly basis.

C. Infiltration pond:
   1. Perform percolation testing in the area of any proposed infiltration pond.
   2. Submit percolation test results with the Dewatering Plan.

END OF SECTION

SECTION 02256

SUBGRADE PROBING AND GROUTING

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the minimum requirements for drilling and grouting subgrade probe holes. The work includes mobilizing equipment for drilling and grouting; developing suitable drilling methods, grouting procedures, and grout mixing parameters; furnishing, handling, transporting, storing, mixing and injecting the grouting materials; handling and disposal of drill cuttings, waste water, and waste grout; cleanup of the areas upon completion of the work; and all labor, equipment, materials, and other incidentals to complete this work as specified herein. The work consists of drilling and grouting probe holes at specified locations, to depths specified in the Contract documents, or as directed by the Engineer, to detect and properly fill subsurface cavities or voids that may be encountered during probing with grout meeting requirements specified herein.

B. The project Geotechnical Report refers to the “Calaroga Sanitary Sewer Pump Station Replacement report no. 00-223529-1 prepared by Northwest Geotech, Inc.” These data represent the subsurface information available; however, variations may exist in the subsurface conditions between the exploratory boring and probe locations. Anticipate potential groundwater seepage and/or perched water flowing into the probe holes.

C. All work shall be performed in accordance with all City, State, and Federal safety and environmental regulations, permits, and other environmental control requirements specified in the Contract documents for the project.

1.02 REFERENCES

A. The publications listed below form a part of this Section to the extent referenced. The commercial standards are referred to in the text by their basic designations only. The current requirements of the referenced standards and publications shall apply to this Section.

B. Abbreviations:
   1. API - American Petroleum Institute.
   2. ASME - American Society of Mechanical Engineers.
   3. ASTM - American Society for Testing and Materials.

C. Commercial Standards:
   1. API RP 13B-1 - Recommended Practice for Field Testing Water-based Drilling Fluids, 4th Edition.
   2. ASME B16.3 - Malleable Iron Threaded Fittings, Classes 150 and 300.
   3. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded at Seamless.

4. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
5. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
6. ASTM C109/C109M - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
7. ASTM C150/C150M - Standard Specification for Portland Cement.
8. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
9. ASTM C937 - Grout Fluidifier for Preplaced-Aggregate Concrete.
10. ASTM E329 - Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.

D. Standard Specifications:
   1. Oregon Department of Transportation, Standard Specifications for Construction.

1.03 SUBMITTALS

A. The following submittals listed below shall be submitted no later than sixty (60) calendar days after the Notice to Proceed and at least sixty (60) calendar days prior to mobilization of foundation excavation and related construction equipment, whichever comes first.

B. Submit the name and qualifications of the Contractor-retained QC Specialist responsible to inspect, observe, and document the following work activities: drilling and cleaning of probe holes; grout preparation; backfilling; and any other related work activities as required throughout construction. Submit sufficient information in writing to demonstrate compliance with the project qualification requirements of Article 1.04 of this Section.

C. Probe and Grout Work Plan:
   1. Submit a detailed work plan describing the proposed drilling and grouting methods and equipment to be used including at a minimum the following:
      a. Drilling and grouting methods and procedures.
      b. Description of drilling and grouting equipment, including manufacturer's literature describing capabilities.
      c. Log template to be used by the QC Specialist to document grouting of probe holes.
      d. Name and qualification of the independent testing agency.
      e. Grout Mix Design(s).
      f. Spoil control and disposal, including all necessary precautions to control and prevent discharge of grouting spoils and drill cuttings onto adjacent landscaped areas or properties.
      g. Restoration plan.

D. Reports and Records:
   1. The Contractor's retained QC Specialist shall keep records of drilling and grouting operations, to include at a minimum: Individual logs of each grouted holes, probe depths and probe penetration and withdrawal rate per each foot interval during drilling and grouting, geologic characteristics of drill cuttings return, the time of each change of grouting operation, the pressure and rate of pumping, grout mix(es) used onsite for each probe hole, grout returns, volume of grout pumped into each drilled hole, and other data as deemed by the QC Specialist to be necessary. Furnish all records to the Engineer in a report signed and stamped by the Contractor's retained QC specialist who shall certify the successful completion of the foundation drilling and grouting program.

1.04 QUALITY ASSURANCE

A. QC Specialist shall be a Civil Engineer licensed in the State of Oregon who has worked on a minimum of 3 successfully completed projects performing inspection of foundation probing and grouting work.

B. Foundation drilling and grouting activities shall be performed will full-time on-site observation under the supervision of the QC Specialist. The QC Specialist is responsible for ensuring the probe holes be drilled and grouted based on accepted work plans and shop drawings, updating the work plan as construction progresses with additional probe holes as needed, and submitting an updated plan if necessary.

C. Grout Testing shall be performed by an independent testing agency or laboratory that can certify compliance with requirement of ASTM E329, or as accepted by the Engineer. The laboratory shall demonstrate experience performing the laboratory tests of grout mix(es) required herein.

PART 2 PRODUCTS

2.01 MATERIALS AND MIX DESIGN

A. Deliver all necessary ingredients for grouting in undamaged, unopened containers bearing manufacturer’s original label. Store and handle grout materials in accordance with manufacturer’s recommendations.

B. Grouting Materials: Provide grout composed of a mixture of Portland cement, water, and sand thoroughly mixed together with fluidifier and/or admixture(s), if necessary, into a uniform and balanced mixture. The grout mix(es) shall have a consistency that is fluid and pumpable. Provide non-shrink, non-metallic, non-gaseous cement grout with a minimum compressive strength of 1,000 psi at 28 calendar days.

C. Cement: Portland cement, ASTM C150, Type I or II.

D. Fluidifier: Fluidifier shall be a compound capable of increasing the flowability of the mixture, by assisting in dispersal of the cement grains and neutralizing the setting shrinkage of the grout. The property and performance of the fluidifier shall meet the requirements specified in ASTM C937.

E. Admixtures: Admixtures shall meet the requirements specified in ASTM C494. If 2 or more admixtures and/or fluidifier are used, all shall be compatible into a uniform and balanced mixture.

F. Water: Potable water shall be used.

2.02 EQUIPMENT

A. Drilling Equipment:
   1. Standard drilling equipment of the rotary or percussion type capable of completing the work shall be used to perform the drilling. Use air and/or water for removing cuttings from the probe holes during drilling operations. Supplies shall include all bits, drill rods, tools, casing, piping, pumps, water, and power to accomplish the required drilling. All drilling rigs and pumps shall be equipped with pressure gauges.

B. Grouting Equipment:
   1. The grouting equipment shall be capable of accepting, mixing, and stirring the grout ingredients and additives into a uniform and balanced grout mixture, and shall also be capable of pumping the grout mixture into the probe holes to the specified depths and to the satisfaction of the Engineer.
      a. Pipes and Fittings: pipes and fittings required for placing grout and providing drainage shall be furnished, cut, threaded, and fabricated by the Contractor.
         1) Pipes: Pipes shall be made of black steel with the specified minimum diameters and used in the locations as indicated on the drawings. The pipes shall conform to ASTM A53/A53M.
         2) Fittings: Fittings shall be made of black, malleable iron in conformance with ASME B16.3.

C. Recording Equipment:
   1. Provide automatic recording equipment with a meter to measure the volume of grout injected into each probe hole. The meter shall be calibrated in cubic feet to the nearest one-tenth of a cubic foot.

D. Spare parts and/or tools/equipment shall be available on-site to maintain drilling and grouting equipment in satisfactory operating conditions at all times during execution of the drilling and grouting work. Any probe hole lost or damaged as a result of mechanical failure of equipment; inadequate grout supplies; or improper drilling or grouting procedures shall be replaced and re-grouted with another hole, as approved by the Engineer, at no additional cost to the Owner.

PART 3 EXECUTION

3.01 GENERAL DRILLING AND GROUTING PROCEDURE

A. Notify the Engineer at least 15 days before beginning foundation probe drilling and grouting.

B. Drilling:
   1. At a minimum, drill probe holes where indicated on the Contract Drawings, plus any additional probe holes as directed by the Engineer. However, base bid price on the number of probe holes and quantities indicated in the Probe Hole Schedule provided herein. Probe holes shall be minimum 3 inches in diameter and drilled to the depths below the foundation subgrade elevations specified in the probe hole schedule provided herein and on the contract drawings. Do not drill deeper than the specified "drilled depth below foundation" unless directed by the Engineer.
   2. If cavities, voids, and/or very soft/loose zones are detected below slabs on grade or foundations, additional probe holes shall be drilled to delineate their lateral extents as directed by the Engineer or the onsite designated representative of the Engineer.

Foundation Probe Hole Schedule

Building/Facility/ Location	Bottom of Probe Hole Elevation (ft)(1)	Number of Probe Holes to Drill(2)	Estimated Injected Grout Quantity (10x Theoretical Volume of a Drilled Probe Hole) (CY)(3)
Calaroga Pump Station	4	40	25
Total Sum of the Estimated Grout Quantities			25

Notes:
(1) Depth (in feet) below the bottom of excavation elevation.
(2) Refer to Plans for drilled probe hole locations.
(3) Based on 3-inch diameter drilled probe holes. Refer to Article 3.01 Paragraph C.1.d for drilled probe hole diameters larger than 3 inches selected by the Contractor.

C. Grouting:
   1. All grouting operations shall be performed under the supervision of the Contractor's retained QC Specialist and in the presence of the Engineer or an onsite designated representative of the Engineer. The Contractor shall notify the Engineer at least 1 week prior to starting or resuming probing and grouting at each site.
      a. Grouting Injection:
         1) Grout each probe hole through a minimum 1.5-inch or suitable larger diameter pipe inserted to the bottom of the probe hole.
         2) At a minimum, the volume of grout to be pumped successively into each probe hole shall be equal to at least the theoretical volume of the probe hole.
         3) The grouting of any probe hole shall not be considered complete until that hole refuses to take any more grout with grout overflowing top of the hole.

4) The estimated grout quantities provided in the Foundation Probe Hole Schedule is generally based on 10 times the theoretical volume of a 3-inch diameter drilled probe hole and the minimum drilled depth below foundation. Additional grout quantities that are installed due to the difference in size between the minimum 3-inch diameter drilled probe hole and the Contractor's selected drilled probe hole diameter, will not be measured and paid for by the Owner.
5) If it is found impracticable to complete grouting after pumping up to 1 cubic yard, pumping shall be stopped temporarily and, as directed by the Engineer or the onsite designated representative of the Engineer, intermittent grouting shall be performed into the hole, allowing sufficient time between grout injections for the grout to stiffen. If the desired result is not obtained, grouting shall be discontinued at the probe hole when directed. In such an event, the hole shall be cleaned, the grout allowed to set, and additional probing of minimum 3-inch diameter probe hole and grouting shall then be performed in the partially grouted holes or in the adjacent areas as directed, until the desired grout intake at each hole is achieved, to the satisfaction of the Engineer.
6) Grout that cannot be placed, for any reason, into a probe hole within 2 hours after mixing, or a shorter time as specified by the grout manufacturer, shall be properly disposed and is not considered as part of the measured grout for payment.

b. Equipment Capability and Operation:
1) The grouting equipment and system shall be capable of providing a continuous circulation of grout throughout the system and permitting accurate pressure control by operation of a valve on the grout return line, regardless of how small the grout intake may be. The equipment and lines shall be prevented from becoming fouled by constant circulation of grout and periodic flushing out of the system with water. Flushing shall be done with the grout intake valve closed, the water supply valve opened, and the pump running at full speed.

c. When authorized by the Engineer, the Contractor shall backfill encountered cavities and/or voids as directed by the Engineer or the onsite designated representative of the Engineer. The Contractor shall perform the work in accordance with accepted submittals. The Contractor shall provide all necessary labor, equipment, and materials to fill the encountered cavities and/or voids. Excavations or boreholes shall be properly supported with suitable shoring provisions to avoid loss of ground and ground movements that could damage adjacent utilities, structures, or improvements, in accordance with Section 02300 - Earthwork. Backfill materials to fill cavities and/or voids, when authorized by the Engineer, shall consist of self-compacting sands and/or gravels, controlled low strength material (CLSM), and/or concrete. Any damage caused by excavation and backfill to fill cavities and/or voids shall be immediately repaired at no additional cost to the Owner.

D. Protection of Work and Cleanup:
   1. The Contractor shall furnish pumps and other equipment as necessary to care for and properly dispose of drill spoils, and waste grout from all drilling, grouting, and related operations. Upon completion of these operations, clean up all wastes resulting from the operations that are unsightly or would interfere with foundation construction. Discharge of all wastes shall be performed in accordance with all applicable government requirements.
   2. Roadways shall be cleaned by the Contractor as required to prevent excessive dusting or dirt accumulation, at a minimum, on a daily basis. Vehicles shall be washed prior to exiting the project site and the disposal or stockpiling sites and entering public roadways, as required. The Contractor is responsible to immediately contain and remove all washing or cleaning water from the sites, and discharge or dispose of them properly in accordance with all applicable government requirements.

3.02 QUALITY CONTROL

A. All quality control (QC) testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Owner.

B. Grout Mix:
   1. During the execution of the foundation probing and grouting, the unit weight or specific gravity shall be measured on liquid samples of grout taken from the grout return line, to verify grout mix uniformity.
   2. Testing shall be performed in accordance with API RP 13B-1 test method. Testing frequency shall be at least 1 test for every two (2) hours that grout is mixed and pumped. Complete and accurate records shall be kept to verify that grout mix is as accepted.

C. Grout Samples:
   1. For every 10 probe holes, 2 sets of 4 samples (8 samples total) of the cement grout used for grouting the probe holes shall be collected and fabricated in accordance with ASTM C31/C31M or C109/C109M.
   2. Each of these samples shall be stored in a damp environment at constant temperature in accordance with applicable ASTM procedures.
   3. After the samples have cured sufficiently, they shall be taken to an independent qualified laboratory, accepted by the Engineer, for testing.
   4. Two grout samples shall be subjected to compressive strength tests at 7 days in accordance with ASTM C39/C39M or C109/C109M. The remaining samples shall be subjected to compressive strength test at 28 days following the same ASTM testing procedures.

END OF SECTION

SECTION 02260

EXCAVATION SUPPORT AND PROTECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for designing, providing, maintaining, and removing excavation support and protection.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. Guidelines of Engineering Practice for Braced and Tied-Back Excavations.

B. Department of the Navy Naval Facilities Engineering Command (NAVFAC):
   1. Design Manual 7.2 - Foundations and Earth Structures.
   2. Design Manual 7.3 - Soil Dynamics and Special Design Aspects.

C. United States Steel Corporation (USS):
   1. Steel Sheet Piling Design Manual.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. General Engineering Design Practice: General engineering design practice in area of the Project, performed in accordance with recent engineering literature on subject of shoring and stability of excavations.
   2. Shoring: A temporary structural system designed to support vertical faces, or nearly vertical faces, of soil or rock for purposes of excavation. Shoring includes pre-engineered internally braced shoring system, or caisson system. Sloping of the soil is not shoring.
   3. Support Levels: Level of tiebacks, wales, rakers, bottom of excavation, and other types of support.

1.04 SUBMITTALS

A. Shop Drawings and calculations:
   1. Calculations for different load, support, and other conditions that occur during the sequence of installation of shoring, construction of facilities protected by shoring, and sequence of removal of shoring.
   2. Sketches showing the condition at various stages of installation and removal of shoring.
   3. Show on plan shoring, structures, pipelines, and other improvements located near shoring.

4. When utilities penetrate shoring, show location of penetrations on elevation of sides of shoring.
5. Show details for ground support and sealing around utility penetrations.
6. Indicate method used for installing driven shoring.
    a. Drilling is the only acceptable method.

B. Control points and schedule of measurements:
1. Submit location and details of control points and method and schedule of measurements.
2. Survey data.

C. Detailed sequence of installation and removal of shoring:
1. Consider effects of ground settlement in sequence of installation and removal of shoring.
2. Provide sketches showing conditions at various stages in sequence of installation and removal of shoring.

D. Vibrator monitoring:
1. Vibration monitoring program.
2. Manufacturer's literature on vibration monitoring instrumentation.
3. Vibration monitoring data.

E. Settlement monitoring:
1. Proposed product for survey benchmark for settlement monitoring.

F. Furnish Submittals for excavation support and protection as complete package and include items required in this Section:
1. Incomplete Submittals will not be reviewed and will be returned for resubmittal as complete package.

G. Furnish dewatering Submittals as specified in Section 02241 - Dewatering with Submittals for excavation support and protection.

1.05 SEQUENCING

A. Do not begin construction of any shoring or excavation operations until:
1. Submittals for shoring and dewatering have been accepted.
2. Control points as specified in this Section and on existing structures and other improvements as indicated on the Drawings have been established and surveyed to document initial elevations and locations.
3. Materials necessary for installation are on site.

B. Furnish Submittals a minimum of 60 days prior to scheduled date to begin excavation work.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Where general engineering design practice is specified, provide Drawings and calculations that are performed and signed by civil or structural engineer registered in State where Project is located:
   1. Clearly disclose assumptions made, criteria followed, and stress values used for materials being used in design calculations.
   2. Submit list of references acceptable to the Engineer that substantiating appropriateness of design assumptions, criteria, and stress values.

B. Design requirements:
   1. General:
      a. For trench excavations 5 feet or more in depth and for trenches less than 5 feet in depth when there is potential for cave-in.
         1) Perform design pursuant to general engineering design practice.
      b. Dewatering:
         1) Dewater soil inside shoring as specified in Section 02241 - Dewatering and 02256 – Subgrade Probing and Grouting.
         2) Do not lower groundwater outside of shoring more than 1 foot.
         3) Recharge groundwater outside shoring to limit groundwater draw down outside of shoring to amount specified above.
      c. When electing to design with material stresses for temporary construction higher than allowable stresses prescribed in building code as specified in Section 01410 - Regulatory Requirements, increase in such stresses shall not exceed 10 percent of value of prescribed stresses.
      d. Minimum safety factor used for design shall not be less than 1.5.
      e. The calculated minimum depth of penetration of shoring below bottom of excavation shall be increased not less than 30 percent if full value of allowable passive pressure is used in design.
      f. Maximum height of cantilever shoring above bottom of excavation shall not exceed 15 feet. Use braced shoring when height of shoring above bottom of excavation exceeds 15 feet.
      g. The location of point of fixity for shoring shall not be less than half calculated minimum embedment depth below bottom of excavation.
      h. Generally acceptable references for design of shoring and excavations are as follows:
         1) ASCE Guidelines of Engineering Practice for Braced and Tied-Back Excavations.
         2) NAVFAC Design Manual 7.2.
         3) NAVFAC Design Manual 7.3.
         4) USS Steel Sheet Piling Design Manual.
      i. Maximum total deflection of shoring at any point on shoring shall not be more than 1/2 inch.
      j. Shoring design shall be performed by a registered professional engineer regularly engaged in the design of excavation support systems. Include cost for shoring design in bid.
         1) Provide geotechnical report for shoring design.

k. Shoring engineering firm shall obtain errors and omissions insurance for Project for an amount of not less than 1,000,000 dollars.
l. Shoring geotechnical firm shall obtain errors and omission insurance for Project for an amount of not less than 1,000,000 dollars.

2. Soil anchors, rock anchors, and deadman anchors:
   a. Not allowed due to proximity to property lines.

C. Performance requirements:
1. General:
   a. Support faces of excavations and protect structures and improvements in vicinity of excavations from damage and loss of function due to settlement or movement of soils, alterations in ground water level caused by such excavations, and related operations.
   b. Specified provisions:
      1) Complement, but do not substitute or diminish, obligations of Contractor for furnishing of safe place of work pursuant to provisions of the Occupational Safety and Health Act of 1970 and its subsequent amendments and regulations and for protection of Work, structures, and other improvements.
      2) Represent minimum requirement for:
         a) Number and types of means needed to maintain soil stability.
         b) Strength of such required means.
         c) Methods and frequency of maintenance and observation of means used for maintaining soil stability.
2. Provide safe and stable excavations by means of sheeting, shoring, bracing, sloping, and other means and procedures, such as draining and recharging groundwater and routing and disposing of surface runoff, required to maintain stability of soils and rock.
3. Provide support for trench excavations for protection of workers from hazard of caving ground.
4. Provide shoring:
   a. Where, as result of excavation work and analysis performed pursuant to general engineering design practice, as defined in this Section:
      1) Excavated face or surrounding soil mass may be subject to slides, caving, or other types of failures.
      2) Stability and integrity of structures and other improvements may be compromised by settlement or movement of soils, or changes in soil load on structures and other improvements.
   b. For trenches 5 feet and deeper.
   c. For trenches less than 5 feet in depth, when there is potential for cave-in.
   d. Where indicated on the Drawings.
5. For safe and stable excavations, use appropriate design, construction, and maintenance procedures to minimize settlement of supported ground and to prevent damage to structures and other improvements, including:
   a. Using stiff shoring systems.
   b. Following appropriate construction sequence.
   c. Using shoring system that is tight enough to prevent soil loss through the shoring.
   d. Using shoring system that extends far enough below bottom of excavation to prevent piping, heave, or flow of soil under shoring.
   e. Design for safety factor of not less than 1.50.

f. Providing surface runoff routing and discharge away from excavations.
g. Shoring used for existing wet well modifications and new wet well installation must be Caisson-type only.
h. Shoring for trench excavation(s) may be soldier pile (drilled in and lagged) and/or internally braced boxes.
i. Where dewatering inside shoring is necessary, recharge groundwater outside shoring as necessary to prevent settlement in area surrounding shored excavation.
j. Not applying shoring loads to existing structures and other improvements.
k. Not changing existing soil loading on existing structures and other improvements.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Installation of shoring:
1. Install means for providing safe and stable excavations as indicated in Submittals.

B. Removal of shoring:
1. Except for caisson-style and similar shoring systems, remove shoring by completion of Work.
2. Select shoring system and method of removal, which will minimize soil that sticks to shoring from creating voids and causing settlement.
3. To prevent settlement caused by pulling shoring, fill voids with pressure injected grout:
   a. Inject grout starting at bottom of void and progressively fill void to grade.
   b. Minimize length of shoring removed ahead of grouting operation and limit time void is left ungrouted to prevent void from closing up before being grouted.
4. Pressure preservative treated wood lagging may be left in place if acceptable to the Engineer.

C. Control points:
1. Establish control points on shoring and on structures and other improvements in vicinity of excavation for measurement of horizontal and vertical movement:
   a. Set control points on shoring support system:
      1) Set points at distances not exceeding 25 feet at each support level.
2. Promptly upon completion of construction of control points survey control points. Submit copy of field notes with measurement.
3. Perform horizontal and vertical survey and measurement of control points at least once every week.
   a. Field notes shall show current measurement and change in measurement from first measurement taken.
4. Set control points on corners of existing structures and on curbs, manholes, and other improvements at the locations indicated on the Drawings.
5. Provide plumb bobs with horizontal targets indicating original position of plumb bobs in relation to shoring at control points.

D. Vibration monitoring:
   1. Measure vibration due to installation and removal of shoring.
   2. Do not exceed 0.2 inches per second at distance of 25 feet from shoring for installation and removal of shoring.
   3. Perform vibration monitoring continuously during installation and removal of shoring.
   4. Submit vibration monitoring program including information on vibration monitoring instrumentation.
   5. Submit vibration monitoring data daily.

E. Settlement monitoring:
   1. Install at least 3 permanent benchmarks (PK nails or equivalent) for settlement monitoring for edge of excavation.
   2. Contractor to install benchmarks in driveway of 3891 Calaroga Drive where indicated by Engineer. Benchmarks shall be located at least 1 foot from driveway edge.

F. Maintenance:
   1. Where loss of soil occurs, plug gap in shoring and replace lost soil with fill material acceptable to the Engineer.
   2. Where measurements and observations indicate possibility of failure or excessive movement of excavation support, determined in accordance with general engineering design practice, take appropriate action immediately.

END OF SECTION

SECTION 02300

EARTHWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loosening, excavating, filling, grading, borrow, hauling, preparing subgrade, compacting in final location, wetting and drying, and operations pertaining to site grading for buildings, basins, reservoirs, boxes, roads, and other facilities.
   2. Backfilling and compacting under and around structures.
   3. Backfilling and compacting above buried structures.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. ASTM International (ASTM):
   1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
   2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 DEFINITIONS

A. Backfill Above Concrete Structure: Backfill within volume bounded by the top surface of the structure.

B. Backfill Adjacent to Structure: Backfill within volume bounded by the exterior surfaces of structure, the surface of undisturbed soil in the excavation around structure, and finish grade around structure.

C. Embankments: Dikes, levees, berms, and similar facilities.

D. Excavation: Consists of loosening, removing, loading, transporting, depositing, and compacting in final location, wet and dry materials, necessary to be removed for purposes of construction of structures, ditches, grading, roads, and such other purposes as are indicated on the Drawings.

1.04 SUBMITTALS

A. Copy of Property Owner’s Agreement allowing placement of surplus soil material on their property.

1.05 QUALITY ASSURANCE

A. Initial compaction demonstration:
   1. Adequacy of compaction equipment and procedures: Demonstrate adequacy of compaction equipment and procedures before exceeding any of following amounts of earthwork quantities:
      a. 50 cubic yards of backfill adjacent to structures.
      b. 100 cubic yards of embankment work.
      c. 100 cubic yards of fill.
      d. 50 cubic yards of roadway base material.
      e. 100 cubic yards of road fill.
   2. Compaction sequence requirements: Until specified degree of compaction on previously specified amounts of earthwork is achieved, do not perform additional earthwork of the same kind.
   3. After satisfactory conclusion of initial compaction demonstration and at any time during construction, provide confirmation tests as specified under "FIELD QUALITY CONTROL."

B. Contractor shall perform work related to this Section in accordance with the approved Stormwater Pollution Prevention Plan (SWPPP).

1.06 SEQUENCING AND SCHEDULING

A. Schedule earthwork operations to meet requirements specified in this Section for excavation and uses of excavated material.

B. If necessary, stockpile excavated material in order to use it at specified locations.

C. Excavation, backfilling, and filling: Perform excavation, backfilling, and filling during construction in manner and sequence that provides drainage at all times.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Where mud or other soft or unstable material is encountered, remove such material and refill space with stabilization material. Wrap stabilization material with stabilization fabric.
   2. Obtain acceptable import material from other sources if surplus obtained within Project site does not conform to specified requirements or are not sufficient in quantity.
   3. No extra compensation will be made for hauling of fill materials nor for water required for compaction.

2.02 MATERIALS

A. Water for compacting: Use water from source acceptable to Engineer.

B. Soil and rock materials:
   1. General:
      a. Provide aggregate base course, drain rock, native material, sand, where specified or indicated on the Drawings.
      b. If suitable surplus materials are available, obtain native material and select material from cut sections or excavations or imported materials.
   2. Aggregate base course materials: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   3. Drain rock: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   4. Native material: As specified in Section 02050 - Soils and Aggregates for Earthwork.
   5. Sand: As specified in Section 02050 - Soils and Aggregates for Earthwork.

C. Controlled low-strength material: As specified in Section 00442 - Controlled Low Strength Materials of Standard Specifications.

D. Geotextile fabrics:
   1. Filter fabric: As specified in Section 02620 - Filter Fabric.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
   1. Character and quantity of material:
      a. Verify character and quantity of rock, gravel, sand, silt, water, and other inorganic or organic materials to be encountered in work to be performed.
      b. Determine gradation, shrinkage, and swelling of soil, and suitability of material for use intended in work to be performed.
      c. Determine quantity of material, and cost thereof, required for construction of backfills, cuts, embankments, excavations, fills, and roadway fills, whether from onsite excavations or imported materials. Include in cost of work to be performed.
      d. Include wasting of excess material, if required, in cost of work to be performed.

3.02 PREPARATION

A. Backfills:
   1. After clearing and excavation are completed, scarify entire areas that underlie backfills or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
   2. Recompact scarified areas to density specified before placing backfill material or concrete.

3. Do not place backfill against walls until:
    a. Walls have been cast full height of structure and concrete has reached the specified strength.
    b. Connecting slabs and beams have been cast, and concrete has reached the specified strength.
4. Do not place backfill on top of buried structures until:
    a. Concrete has reached full strength.
5. Prior to backfilling:
    a. Remove forms.
    b. Clean trash and debris from the excavation site.
6. After inspection of foundation, walls, and pipes, place backfill symmetrically around structures to prevent eccentric loading of structures.
7. Place material on top of structure to prevent excessive point loading that exceeds the loading capacity of the structure.
    a. Contractor is responsible for damage to structures due to improper backfilling and compaction.

B. Embankments:
1. After clearing is completed, scarify entire areas that underlie embankments to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for embankments before placing of embankment material.

C. Fills:
1. After clearing is completed, scarify entire areas that underlie fill sections or structures to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for compacted fills before placing of fill material or concrete.

D. Roadway fills:
1. After clearing is completed, scarify entire areas that underlie roadway fills to a depth of 6 inches and until surface is free of ruts, hummocks, and other features that would prevent uniform compaction by equipment to be used.
2. Recompact scarified areas to density specified for roadway fills before placing of roadway fill material.

E. Sloped surfaces for fill or foundations:
1. Foundations for fill having slopes in excess of 1 vertical to 4 horizontal:
    a. Bench or terrace to adequately key existing ground and fill built thereon.
2. Slopes of original hillsides and old fills: Bench minimum of 10 feet horizontally as fill is placed.
3. Provision of new benches:
    a. Start new bench wherever vertical cut of next lower bench intersects existing grade.
    b. Recompact material thus cut out along with new embankment material at no additional cost to the Owner.

3.03 INSTALLATION

A. General:
   1. Dispose of excavated materials that are not required or are unsuitable for fill and backfill in lawful manner.
   2. Dispose of surplus material on private property only when written permission agreement is furnished by owner of property. Submit copies of such agreements.
   3. Rocks, broken concrete, or other solid materials larger than 4 inches in greatest dimension: Remove from project site at no additional cost to the Owner.
   4. Stabilization of subgrade: Provide materials used, or perform work required, to stabilize subgrade so it can withstand loads that may be placed upon it by Contractor's equipment.

B. Borrow area: There is no borrow area on Project site.
   1. Where material is required, import material from source located off Project site selected by the Contractor and subject to acceptance by the Engineer.
   2. There will be no additional cost to the Owner for use of imported material.

C. Compaction:
   1. Provide specified compaction for backfills, cuts, embankments, fills, roadway fills, and other earthwork.
   2. Perform confirmation tests to verify and confirm that work has complied, and is complying at all times, with compaction requirements specified in this Section for initial compaction demonstration and field quality control testing.
   3. In-place density of compacted backfills, cuts, embankments, fills, and roadway fills determined in accordance with ASTM D6938.
   4. Maximum density, laboratory compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.
   5. To prevent damage to structures due to backfilling operations, place backfill with equipment that does not exceed AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading, within a distance from the face of the structure of not less than 1/2 the depth of backfill. The depth of backfill is the distance between the level being compacted and the bottom of the excavation. Outside this distance, heavier compaction equipment may be used.
   6. Compact to percentage of maximum density as follows:
      a. Backfill adjacent to structures: 92 percent.
      b. Backfilling voids:
         1) Non-structural areas: 85 percent.
         2) Structural areas: 92 percent.
      c. Trenches: 90 percent.
      d. Embankments:
         1) Non-structural areas: 85 percent.
         2) Structural areas: 92 percent.
      e. Loose fill:
         1) No compaction other than by hauling vehicles will be required.
         2) Uniformly distribute travel of vehicles over fill area as required to provide uniformly compacted surface.
      f. Under present and future structures: 92 percent.

g. Under roadways, parking and storage areas, curbs, and sidewalks: 92 percent.
h. Upper 6 inches of cuts: 92 percent.
i. Fills:
1) Non-structural areas: 85 percent.
2) Structural areas: 92 percent.

D. Dewatering: As specified in Section 02241 - Dewatering.

E. Excavation:
1. Blasting: Not permitted.
2. Excavations for trenching: As specified in Section 02318 - Trenching.
3. Excavations for structures:
a. Provide excavations conforming to dimensions and elevations indicated on the Drawings for each structure.
b. After clearing is complete, excavate for the structure, down to the elevation indicated on the Drawings. Unless directed by Engineer, do not carry excavations below elevation indicated on the Drawings.
c. Where soil is encountered having unsuitable bearing value, Engineer may direct in writing that excavation be carried to elevations below those indicated on the Drawings.
d. Where excavations are made below elevations indicated on the Drawings, adjust elevations of excavations in accordance with the following requirements:
1) Under slabs: Restore to proper elevation in accordance with procedure specified for backfill in this Section.
2) Under footings: Restore to the proper elevation using one of the following:
a) Aggregate base course.
e. Excavation width:
1) Extend excavations at least 2 feet clear from walls and foundations of structures to allow for placing and removal of forms, installation of services, and inspection.
2) Do not undercut slopes.
f. Difficulty of excavation: No extra compensation will be made for removal of rock or any other material due to difficulty of excavation.
4. Excavation of lined channels:
a. Excavations in open cut for lined channels may be made so as to place concrete directly against excavated surfaces providing faces of excavations are:
1) Firm and unyielding.
2) Will stand or can be made to stand without sloughing.
b. Excavations to provide subgrade for lined channel or subdrainage material: Excavate to lines and grades indicated on the Drawings.
5. Excavation of unlined channels and basins:
a. Excavate to lines and grades indicated on the Drawings.
b. Perform excavation and grading so that finish surfaces are in uniform planes with no abrupt breaks in surface.
6. Excavation of ditches and gutters:
a. Cut ditches and gutters accurately to cross sections and grades indicated on the Drawings.

b. Take care not to excavate ditches and gutters below grades indicated on the Drawings.
c. Backfill excessive ditch and gutter excavations to grade with suitable material acceptable to the Engineer.
d. Do not deposit any material within 3 feet of edge of ditch unless otherwise indicated on the Drawings.

7. Necessary over excavation:
   a. Where it becomes necessary to excavate beyond normal lines of excavation in order to remove boulders or other interfering objects, backfill voids remaining after removal as specified in backfilling of voids below, or as acceptable to the Engineer.
   b. Backfill voids with material acceptable to the Engineer:
      1) With acceptance of the Engineer, backfill with one of the following:
         a) Aggregate base course.
         b) Controlled low-strength material.

F. Materials for backfills, embankments, fills, and roadway fills:
   1. General:
      a. Obtain import material from other sources if surplus materials from cuts and excavations obtained from within Project site do not conform to specified requirements or are not sufficient in quantity for construction of Project.
   2. Backfills:
      a. Backfill adjacent to structures, slabs, or walls: Aggregate base course material, unless otherwise specified or indicated on the Drawings. Backfill material under concrete structures: Aggregate base course material, except in areas where controlled low-strength material or concrete encasement are indicated on the Drawings.
      b. Extend backfill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
      c. Aggregate base course material, unless otherwise specified or indicated on the Drawings.
   3. Fills:
      a. Aggregate base course material, unless otherwise specified or indicated on the Drawings.
      b. Extend fill in any area under concrete structures from undisturbed soil or rock to the bottom aggregate base course material layer.
   4. Roadway fills: One of the following, unless otherwise specified or indicated on the Drawings:
      a. Aggregate base course material.
   5. Top soil fill: top soil to be placed on top 6-inches of site in non-structural areas to provide positive drainage away from structures and replenish top soil.
      a. Native soil-select or imported topsoil.

G. Placement:
   1. General:
      a. Lines and grades:
         1) Construct backfills, embankments, fills, and road fills, at locations and to lines and grades indicated on the Drawings.
         2) Overbuild permanent fill slopes by at least 1 foot and then cut to final grade to provide adequate compaction of the remaining fill.

2. Backfills:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    c. Defective compacted backfills: Remove and recompact.
3. Fills:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    c. Defective compacted fills: Remove and recompact.
4. Embankments:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    c. Defective compacted embankments: Remove and recompact.
5. Roadway fills:
    a. Place loose material in successive layers that do not exceed 8 inches in depth after compaction.
    b. Bring each layer to a moisture content between optimum moisture content and 3 percent above optimum moisture content before compacting.
    c. Defective compacted roadway fills: Remove and recompact.

3.04 FIELD QUALITY CONTROL

A. Confirmation tests:
    1. Contractor's responsibilities:
        a. Adequacy of compaction equipment and procedures:
            1) Demonstrate adequacy of compaction equipment and procedures.
            2) At each test location include tests for each type or class of backfill from bedding to finish grade.
        b. Compaction sequence requirements:
            1) Do not perform additional earthwork of the same kind until specified degree of compaction has been demonstrated.
        c. Cost of confirmation tests: Paid for by the Contractor.
        d. Qualifications of Contractor's testing laboratory: Acceptable to Engineer.
        e. Copies of confirmation test reports: Submit promptly to the Engineer.
    2. Frequency of confirmation testing:
        a. Maximum dry density versus moisture: every 100 cubic yards.

B. Tolerances:
    1. Finish grading of backfills, cuts, embankments, fills, and roadway fills:
        a. Perform fine grading under concrete structures such that finish surfaces are never above the grade or cross section indicated on the Drawings and are never more than 0.10 feet below.
        b. Provide finish surface for areas outside of structures that are within 0.10 feet of grade or cross section indicated on the Drawings.

2. Unlined channels and basins:
    a. In both cut and fill, and levee and access road side slopes in cut: Vertical tolerance of none above and 3 inches below grade indicated on the Drawings on bottom and side slopes.
    b. On top surface of levee and access road in both cut and fill, and levee and access road side slopes in fill: Vertical tolerance of none below and 3 inches above grade indicated on the Drawings.
3. Areas which are not under structures, concrete, asphalt, roads, pavements, sidewalks, dikes, and similar facilities:
    a. Provide finish graded surfaces of either undisturbed soil, or cohesive material not less than 6 inches deep.
    b. Intent of proceeding is to avoid sandy or gravelly areas.
4. Finish grading of surfaces:
    a. Reasonably smooth, compacted, and free from irregular surface changes.
    b. Provide degree of finish that is ordinarily obtainable from blade grader operations, except as otherwise specified.
    c. Uniformly grade areas that are not under concrete.
    d. Finish ditches and gutters so that they drain readily.

C. Compliance tests:
1. Frequency of testing: Periodic compliance tests will be made by the Engineer to verify that compaction is meeting requirements previously specified.

3.05 ADJUSTING

A. Finish grades of excavations, backfills, and fills:
1. Repair and reestablish grades to required elevations and slopes due to any settlement or erosion that may occur from action of the elements or any other cause prior to final acceptance.

3.06 PROTECTION

A. Finish grades of backfills, cuts, excavations, and fills:
1. Protect newly graded areas from erosion and deterioration by action of the elements.

B. Ditches and gutters:
1. Maintain ditches and gutters free from detrimental quantities of debris that might inhibit drainage until final acceptance.

END OF SECTION

SECTION 02318

TRENCHING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Trench excavation and trench backfill for pipelines, manholes, vaults, and appurtenances.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
   2. D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.03 DEFINITIONS

A. Backfill: Material placed in trench above the pipe embedment zone.

B. Bedding: Material placed under, around, and over pipes or ducts in trenches.

C. Fine Grading: bedding material placed directly below pipes or ducts to provide support at the bottom of the trench and to bring those elements to required grades and elevations.

D. Flexible Pipe: Includes steel, ductile iron, thermoplastics such as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), thermosetting plastics such as fiberglass-reinforced polymer (FRP), bar-wrapped concrete cylinder pipe, and corrugated steel pipes.

E. Haunch Zone: Material placed below and beside the pipe up to the pipe springline.

F. Lift: A layer of soil or aggregate material, measured before compaction.

G. Maximum Density, Field Compaction: Soil density and water content when tested in accordance with ASTM D6938.

H. Maximum Density, Laboratory Compaction: Soil maximum density and optimum water content when tested in accordance with ASTM D1557.

I. Pavement Section: Includes pavement plus underlying courses such as base course and subgrade.

J. Pipe Embedment Zone: Includes bedding, fine grading, and haunch zone.

K. Pipe Foundation: Material placed at the bottom of trench to provide support.

L. Pipe Foundation: Stabilization material placed at the bottom of trench to provide support when the trench bottom is not firm, dry or uniform.

M. Pipe Springline: A horizontal reference line located at mid-height, or halfway point, of a circular conduit, pipe, or tunnel. It is the maximum horizontal dimension or diameter of a circular conduit, pipe, or tunnel.

N. Rigid Pipe: Includes reinforced non-cylinder concrete, reinforced concrete cylinder, prestressed concrete cylinder, vitrified clay, polymer concrete, cast iron, asbestos cement and cast-in-place pipes.

1.04 SUBMITTALS

A. As specified in Section 01330 - Submittal Procedures.

B. Product data on soils and aggregates.
   1. Material source.
   2. Gradation.
   3. Test data to demonstrate compliance with requirements as specified in this Section.

C. Samples:
   1. Provide 50-pound sample of materials when requested by the Engineer.

D. Confirmation testing:
   1. Certification of Contractor's testing laboratory.
   2. Record copy report for tests performed by Contractor's testing laboratory.

PART 2 PRODUCTS

2.01 MATERIALS

A. As specified in Section 02050 - Soils and Aggregates for Earthwork.

B. Class C concrete: As specified in Section 03300 - Cast-in-Place Concrete.

C. Controlled low-strength material: As specified in Section 02300 - Earthwork.

PART 3 EXECUTION

3.01 PREPARATION

A. Stabilize excavations as specified in Section 02260 - Excavation Support and Protection.

B. Perform subsurface utility engineering (SUE) for utility locating and verification prior to any excavation work.

3.02 DEWATERING

A. As specified in Section 02241 - Dewatering.

3.03 TRENCH EXCAVATION

A. Excavate bottom of trench to depth indicated on the Drawings.

B. Areas of new fill or embankment:
   1. Prior to laying pipes or electrical service, place fill and compact as specified to not less than 2 feet above top of pipe, conduit, or duct bank.
   2. Excavate through fill for pipe trench.

C. Trench widths as specified in the following table:

Buried Pipe Or Accessory	Minimum Trench Width	Maximum Trench Width
Nominal Pipe Diameter: 4 inch to 24 inch	OD + 18 inches	OD + 24 inches
Nominal Pipe Diameter: Greater than 24 inch	OD + 24 inches	OD + 36 inches
Manholes, vaults, valves, or other accessories	12 inches between outer surface and trench side or shoring	Not applicable

D. Potable water pipe and appurtenances:
   1. Lay in trenches separate from those used for sewers and recycled water.
   2. Unless otherwise specified or indicated on the Drawings, lay in trenches having cover of not less than 3 feet below surface of ground located at distance of not less than 10 feet clear horizontally from any parallel sewer and 1 foot clear vertically above any parallel sewer.

E. At road crossings or existing driveways:
   1. Provide notification, vehicular access, and traffic control as required by permits and special conditions.
   2. Provide temporary asphalt or plating for traffic or access at the end of each work day unless approved in writing by Engineer.
   3. If unexpected utility conflicts or changed site conditions require trenchless technologies or temporary bridges, immediately notify the Engineer in writing. Approval is required before proceeding with construction.
   4. When trench width at top of pipe is increased beyond width specified in this Section because of soil conditions, safety requirements, or other reasons, Engineer approval for remedy is required without additional cost to Owner.
      a. Remedy may include upgrade laying conditions or install stronger pipe designed in accordance with Specifications.

3.04 TRENCH BACKFILL - GENERAL

A. Trench area terminology and locations as indicated on the Drawings.

B. Place material, except CLSM and concrete, in maximum 6 inch lifts, measured before compaction.

C. Backfilling of manhole excavation: Conform to backfilling requirements for trenches as specified in this Section.

3.05 PIPE FOUNDATION

A. Provide trench bottom with firm, dry, uniform bearing surface at the grade indicated on the Drawings.

B. Excess excavation below elevation indicated on the Drawings will require installation of pipe foundation material to bring the trench bottom back to the elevation indicated on the Drawings at no additional cost to Owner.

C. If bottom of trench excavation consists of soil:
   1. Scarify bottom of trench to a depth of 6 inches below the grade indicated on the Drawings.
   2. Materials and placement:
      a. Recompact scarified material to 95 percent of maximum density.

D. If bottom of trench excavation consists of rock or any material that, by reason of its hardness, cannot be excavated to provide uniform bearing surface:
   1. Remove such rock or other material to a depth of not less than 4 inches below pipe embedment zone.
   2. Materials:
      a. CLSM.
      b. Class C concrete.

E. If bottom of trench excavation consists of mud or other soft unstable material:
   1. Remove such unacceptable material to a depth of not less than 18 inches below pipe embedment zone.
   2. Material and placement:

3.06 PIPE EMBEDMENT ZONE

A. Pipe displacement:
   1. Take necessary precautions in placement and compaction of bedding material to prevent displacement of piping.
   2. In event there is movement or floating of the piping, re-excavate, re-lay, and backfill the pipe.

B. Fine grading:
   1. Place 6-inches of approved haunch zone bedding material from the trench bottom to the bottom of the pipe or duct to provide support at the bottom of the trench and to bring those elements to required line and grade.

C. Depressions for joints or couplings:
   1. Excavate holes in the fine grading material at the bottom of the trench.
   2. Provide holes of sufficient width to provide ample room for grouting, banding, or welding as necessary for making joints and to ensure that pipe rests upon prepared trench bottom and not supported by any portion of the joint.

D. Rigid pipe:
   1. Pipe embedment zone: Below pipe springline:
      a. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.
   2. Pipe embedment zone: Above pipe springline:
      a. Compacted to a depth above pipe: 12-inch minimum.
      b. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.

E. Flexible pipe:
   1. Pipe embedment zone:
      a. Compacted to a depth above pipe: 12-inch minimum.
      b. Materials and placement:
         1) Aggregate base course compacted to 95 percent maximum dry density.

3.07 BACKFILL

A. Trenches:
   1. Materials and placement:
      a. Aggregate base course compacted to 90 percent maximum dry density.

B. Trenches in rock:
   1. Backfill to top of rock.
      a. Materials and placement:
         1) CLSM.
         2) Class C concrete.
   2. Backfill from top of rock to grade, if applicable:
      a. Materials and placement:
         1) Aggregate base course compacted to 90 percent of maximum density.

C. Trenches below or within 10 feet of the outside perimeter of structures:
   1. Backfill to underside of structural fill below structure, as specified in Section 02300 - Earthwork.
   2. Materials and placement:
      a. Aggregate base course compacted to 92 percent of maximum density.
      b. CLSM.

D. Trenches in roadways and paved areas:
   1. Backfill trench to underside of pavement.
   2. Materials and placement:
      a. Aggregate base course compacted to 92 percent of maximum density.
      b. CLSM.

E. Trenches in areas outside the improved section of roadways or in open country:
   1. Backfill to finished grade.
   2. Materials and placement:
      a. Aggregate base course compacted to 90 percent of maximum density.

F. Trenches under existing intersecting pipes, duct banks, or conduits larger than 3 inches in diameter:
   1. Backfill from above top of new pipe embedment zone to springline of intersecting pipe or conduit.
      a. Extend backfill at least 2 feet on either side of intersecting pipe or conduit to ensure backfill material remains in place while other backfill is being placed.
      b. Materials and placement:
         1) CLSM, unless otherwise indicated on the Drawings.
   2. Backfill remainder of trench:
      a. Materials and placement:
         1) CLSM.
         2) Class C concrete.

3.08 EXCESS MATERIAL

A. Remove excess excavated material from the Project site as specified in Section 02300 - Earthwork.

3.09 FIELD QUALITY CONTROL

A. Provide field quality control for the Work as specified in Section 01450 - Quality Control.

B. Confirmation tests: As specified in Section 02300 - Earthwork.
   1. Minimum frequency of confirmation testing:
      a. At each test location include tests for each type or class of backfill from bedding to finished grade.
      b. For trenches: 1 location every 200 linear feet.
      c. In open fields: 2 locations every 1,000 linear feet or 1 location every 200 cubic yards.
      d. Along dirt or gravel road or off traveled right-of-way: 1 location at every 500 linear feet.
      e. Crossing paved roads: 1 location at each crossing.
      f. Under pavement cuts or within 2 feet of pavement edges: 1 location every 400 linear feet.

C. Compliance tests:
   1. Make periodic compliance tests to verify that compaction is meeting requirements as specified in this Section.
   2. Perform remedial work if compaction test fails to meet specified requirements using one of the following methods:
      a. Remove and replace backfill at the proper density.
      b. Other means acceptable to the Engineer.
   3. Retesting:
      a. Costs of retesting: Contractor is responsible for the costs of retesting required to confirm and verify that remedial work has brought compaction within specified requirements.
      b. Contractor's confirmation tests during performance of remedial work:
         1) Performance: Perform tests in manner acceptable to the Engineer.
         2) Frequency: Double amount specified for initial confirmation tests.

END OF SECTION

SECTION 02337

GABION BASKET RETAINING WALLS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Gabion basket retaining walls.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   3. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   4. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
   5. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   6. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   7. C42 - Standard Methods of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   8. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   9. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   10. C150 - Standard Specification for Portland Cement.
   11. D512 - Standard Test Method for Chloride Ion in Water.
   12. D516 - Standard Test Method for Sulfate Ion in Water.
   13. D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort.
   14. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
   15. D3080 - Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.
   16. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soil.
   17. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
   18. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

19. G51 - Standard Test Method for measuring pH of Soil in Corrosion Testing.
20. G57 - Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method.

B. Oregon Department of Transportation (ODOT):
1. Oregon Standard Specifications for Construction (Standard Specifications).

1.03 SUBMITTALS

A. Shop drawings:
1. Submit a copy of the design calculations and 3 sets of design drawings:
a. Include in the design drawings details, dimensions, quantities, and cross sections necessary to construct the wall and shall include but shall not be limited to the following:
1) An elevation sheet or sheets for each wall.
2) An elevation view of the wall which shall include the elevation at the top of the wall at horizontal and vertical break points and at least every 50 feet along the face of the wall, steps in the foundation and an indication of the final ground line and maximum calculated bearing pressures.
3) A typical cross section or cross sections showing the elevation relationship between ground conditions and proposed grades.
4) General notes pertaining to design criteria and wall construction.
5) A listing of the summary of quantities on the elevation sheet for each wall.
b. Clearly indicated details for construction of walls around drainage facilities.
c. The details for diverting soil reinforcements around obstructions such as piles, catch basins, and other utilities.
2. Calculations: Submit engineering structural design calculations for walls, sealed and signed by a Professional Engineer licensed in the state of Oregon regularly engaged in the design of gabion retaining walls.

B. Quality control submittals:
1. Certificates of Compliance: Submit a Certificate of Compliance certifying that the applicable materials comply with the specifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
1. Handle, storage, and shipping:
a. Handle, store, and ship units in such a manner as to minimize the danger of chipping, cracks, fractures, and excessive bending stresses.
b. Store and ship gabion baskets in stacks with adequate support to prevent permanent distortion.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements: Consider gabion basket walls as gravity retaining walls. Analyze the stability of the wall mass and intermediate levels for the following items:
   1. Forces acting on the walls based on design criteria indicated on the drawings.
   2. Maximum base pressure shall not exceed allowable bearing pressure indicated on the drawings.
   3. Account for external loads which affect the internal stability such as those applied through piling, bridge footings, traffic, slope surcharge, hydrostatic and seismic loads, in the design.
   4. Hydrostatic forces:
      a. Design high-water surface is flood elevation indicated on the Drawings at the face of the wall, the design stresses calculated from that elevation to the bottom of wall must include a 3 foot minimum differential head of saturated backfill. Use the buoyant weight of saturated soil in the calculation of pullout resistance.
   5. Backfill:
      a. Assume the friction angle of the select backfill used in the reinforced fill zone for the internal stability design of the wall to be 34 degrees unless otherwise indicated on the Drawings, determined by the standard direct shear test, ASTM D3080, utilizing a sample of the material compacted to 95 percent maximum density in accordance with ASTM D1557, at optimum moisture content. Before construction begins, the borrow selected shall be submitted to acceptance to show conformance with this frictional requirement.
      b. Compliance with the test requirements shall be the responsibility of the Contractor. The wall supplier shall be furnished a copy of the test results for the backfill prior to construction.
      c. Assume the friction angle of the foundation soils and random backfill to be 30 degrees unless otherwise indicated on the Drawings.
   6. Safety factors:
      a. The minimum factors of safety follow:
         1) 1.5 for sliding.
         2) 2.0 for overturning.
   7. Connections:
      a. All connections shall be positive, structural connections indicated on the Drawings.

2.02 MATERIALS

A. The Contractor shall make his own arrangements to purchase the materials covered by this Section of the specifications, including wire mesh, tie wire, and rings and necessary incidentals from the wall system suppliers. Materials not conforming to this Section of the specifications shall not be used without the written consent of the Engineer.

2.03 GABIONS

A. Materials:
   1. Wire mesh and diaphragms: must meet requirements of Standard Specifications 02340.10.
      a. Thickness: Minimum U.S. Steel Wire Gauge No. 9.
      b. Galvanizing: 0.80-ounce per square foot of uncoated wire surface in accordance with ASTM A641 and A90.
      c. Tensile strength: 60,000 psi minimum including galvanizing.
      d. Conform to ASTM A185.
   2. Tie or connecting wire: must meet requirements of Standard Specifications 02340.10.
      a. Thickness: Same as wire mesh wire, minimum 9 gauge.
      b. Spiral binders, spring steel clip, and clamp-on ring type may be used as substitutions per Standard Specification 02340.10.
      c. Quantity: As required for securely fastening edges of gabions and diaphragms and providing internal connections.
   3. Rings: Hog rings minimum gauge, galvanized.
   4. Stones: Gabion Basket Fill per Specification Section 02050 - Soils and Aggregate for Earthwork.
   5. Panels: Welded wire mesh gabion basket panels must meet requirements of Standard Specifications 02340.20 and as indicated on the Drawings.
   6. Openings: nominal 3-inch by 3-inch grid pattern conforming with ASTM A185.
   7. Wall foundation/leveling pad: Material shall consist of compacted sand or aggregate base course per Specification Section 02050 - Soils and Aggregate for Earthwork. Pea gravel shall not be used.

B. Fabrication of gabion wire baskets: must meet requirements of Standard Specifications 00596B.44(c)(2) and 02340.40 and FHWA Detail 253-1.
   1. Fabricate non-raveling mesh with maximum 4-1/2-inch dimension across maximum 8 square inch openings.
   2. Securely selvage mesh perimeter edges so that joints formed by tying selvedges have the same or greater strength as mesh body.
   3. Weave baskets base lid, ends, and sides into single unit, or connect so that strength and flexibility at connections equals or exceeds strength and flexibility of mesh.
   4. Fabricate baskets so that sides, ends, lids, and diaphragms can be assembled at project site into rectangular baskets of specified sizes.
   5. Secure diaphragms in proper position on base so that no additional tying at junctures will be necessary.
   6. Fabricate with uniform minimum 36-inch horizontal widths.
   7. Fabricate with lengths of 2, 3, or 4 multiples of, and heights of 1, 1-1/2, or 1-1/3 fractions of horizontal width.
   8. When length exceeds horizontal width, equally divide baskets by diaphragms so cell lengths do not exceed horizontal width.
   9. Height, length, and width tolerance: Within 3 percent of manufacturer's stated dimensions.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Wall excavation:
      a. Unclassified excavation shall be in accordance with the requirements of the general specifications and in reasonably close conformity with the limits shown on the plans.
   2. Foundation preparation:
      a. Grade the foundation for the structure level for a width equal to or exceeding the length of the wall base, or as indicated on the Drawings. Prior to wall construction, compact the foundation. Remove and replace any foundation soils found to be unsuitable.

3.02 GABIONS

A. Place, fill, and perform field repairs of the wall per Standard Specifications 00596B.44(c)(3), (4) and (5).

B. Set empty wire basket units to line and grade as indicated on the Drawings.

C. Assemble each wire basket for gabions unit by binding together vertical edges with wire ties at approximately 6 inches on center, or by stitching around vertical edges with continuous connecting wire about every 4 inches.

D. Uniformly space internal tie wires or hog rings at maximum 6-inch intervals in each outside cell of structure and fasten securely.

E. Use standard fence stretcher, chain fall, or iron rod to stretch wire basket units and hold alignment.

F. Fill wire baskets with stone carefully placed by hand or machine. Ensure alignment and avoid bulges and voids.

G. After wire baskets have been filled, bend lid over until it meets sides and edges.

H. Secure lid to sides, ends, and diaphragms with wire continuous ties at 6 inches on center or stitching connecting wire at 4 inches on center.

I. Cut and seal gabions, where gabions abut structures at angle, to meet structures flush.

J. Tolerances: Contractor must meet the following tolerances per Standard Specification 00596B.44(c)(6) or designer's tolerances, whichever is more conservative:
   1. First course of gabion basket facing: within 1/4-inch of design horizontal alignment.
   2. Final out of plane concavity or convexity: within 2-inches in 10 feet.
   3. Final deviation from the design batter: within 1 inch for each 10 feet of wall height.

4. Outward leaning batter: none.
5. Out of plane offset between consecutive rows: within 1-inch from the planned offset.
6. Finished top of wall elevation: within 1-inch of design elevation.

K. Leveling pad: Compacted aggregate base course per Specification Section 02050 - Soils and Aggregates for Earthwork.

L. Backfill placement:
1. Backfill placement shall closely follow erection of each wall layer.
    a. Place backfill in such a manner as to avoid any damage or disturbance to the wall materials or misalignment of the gabions.
    b. Remove and replace any wall materials which become damaged or disturbed during backfill placement.
    c. Remove and replace any backfill material placed which does not meet the requirements of this specification.
2. Compact backfill to 92 percent of the maximum density in accordance with ASTM D1557.
3. The moisture content of the backfill material prior to and during compaction shall be uniform throughout each layer.
    a. Remove backfill material with a placement moisture content less than optimum moisture content.
    b. Remove backfill material with a placement moisture content in excess of the optimum moisture content and rework until the moisture content is uniform and acceptable throughout the entire lift.
    c. Determine the optimum moisture content in accordance with ASTM D1557.
4. The frequency of sampling of select granular backfill material, necessary to ensure gradation control throughout construction, shall be as determined by the Engineer.
5. Do not exceed the maximum lift thickness after compaction of 10 inches, regardless of the vertical spacing between layers of soil reinforcements. Decrease this lift thickness, if necessary, to obtain the specified density.
6. Compact within 3 feet of the back face of the gabions by at least 3 passes of a lightweight mechanical tamper, roller, or vibratory system.
    a. Adjust specified lift thickness as warranted by the type of compaction equipment actually used, but no soil density tests need be taken within this area.
    b. Exercise care in the compaction process to avoid misalignment of the panels or damage to the attachment devices.
    c. Do not use heavy compaction equipment to compact backfill within 3 feet of the wall face.
7. At the end of each day's operation, slope the last level of backfill away from the wall facing to direct runoff of rainwater away from the wall face. In addition, do not allow surface runoff from adjacent areas to enter the wall construction site.

END OF SECTION

SECTION 02552

TEMPORARY BYPASS PUMPING

PART 1 GENERAL

1.01 SUMMARY

A. This Section describes the requirements for temporary bypass pumping of wastewater flows as needed to complete the Work.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C110 - Ductile-Iron and Gray-Iron Fittings.
   2. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
   3. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

B. ASTM International (ASTM):
   1. B241 - Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube.
   2. D3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Material.

C. National Fire Protection Association (NFPA):
   1. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

1.03 REQUIREMENTS

A. Provide all services related to, but not limited to, mobilization, setup, around-the-clock operations and maintenance, demobilization, traffic control, permits, and all other materials, labor, and equipment to install, maintain, and operate a complete continuous pumping and transport system for wastewater 24 hours per day, 7 days per week, until the portion(s) of the Work have been completed to the satisfaction of the Engineer.

B. The means and methods of accomplishing and maintaining the temporary bypass pumping and associated facilities is the sole responsibility of Contractor.

C. The temporary bypass pumping system shall be installed as a complete standalone system.
   1. Provide power, fuel, and/or backup pumps for operation of the system.

D. The temporary bypass pumping operation shall be limited to the months or seasons indicated in the Work, unless approved in writing by the Engineer.

E. The temporary bypass pumping shall be continuously monitored.

F. Contractor shall be responsible for bypassing wastewater in a way that ensures that no wastewater is allowed to leak outside of the sanitary sewer system or the bypass pipelines.
   1. Bypass pumping shall be done in such a manner as not to damage private or public property, or create a nuisance or public menace.
   2. The pumped wastewater shall be in an enclosed pipe that is adequately protected from traffic, and shall be redirected into sanitary sewer system.

G. No bypassing to the ground surface, receiving waters, storm drains, or bypassing that results in soil or groundwater contamination or any potential health hazards shall be permitted.
   1. Contractor shall adhere to all agency restrictions regarding the transport and conveyance of wastewater.

H. Contractor shall be liable for all cleanup, damages, and resultant fines in the event of spills, leaks, or backups associated with bypass pumping activities, which includes commissioning, operation, and decommissioning of bypass pumping facilities.

I. No interruption of wastewater flow shall be permitted throughout the duration of the project. Contractor is responsible for all sanitary sewer overflows during construction of this Work and bypass operations.

J. Coordinate the placement of the bypass piping and pumping equipment with Engineer.

K. Where bypass pipelines are required to cross traffic lanes, and will be in place for more than 3 days, the piping and fittings shall be buried a minimum of 4 inches below the pavement surface and backfilled with temporary asphalt concrete surfacing or use an approved flow-through drivable apparatus approved by Engineer.
   1. At no time shall traffic lanes be blocked or closed, unless specifically allowed in writing by Owner.

L. For purposes of bypass pumping lateral flows, right of entry onto private property is not permitted without right-of-entry/right-of-access agreement, as specified in Section 01140 - Work Restrictions.
   1. Laterals indicated on the Drawings are from the best-available records from Owner or provided by property owners.
   2. Not all laterals are indicated on the Drawings.

M. Contractor is responsible to identify additional laterals not indicated on the Drawings that may require bypass pumping.

N. After the Work is completed, flow shall be returned to the rehabilitated sewer and all temporary equipment removed.

1.04 SUBMITTALS

A. Contractor shall submit a temporary bypass pumping plan as required to complete the Work to Engineer and Owner, 30 days prior to bypass pipe installation, for review as specified in Section 01330 - Submittal Procedures.

B. The temporary bypass pumping plan submittal shall be satisfactory to Engineer and Owner prior to Contractor commencing the bypass pumping operation.
   1. Contractor shall notify Engineer and Owner 24 hours prior to commencing the bypass pumping operation.

C. The temporary bypass pumping plan must provide for accessibility to pedestrians and vehicular traffic in accordance with Owner requirements.

D. The temporary bypass pumping plan shall include the following at a minimum:
   1. Number, type, capacity, and size of pumps, standby equipment, pipe material, pipe layout with pressure relief, and air/vacuum valves locations, and power requirements, if applicable.
   2. Design calculations of the system and selected equipment, including flow, total dynamic head (TDH) with static head including all friction and minor losses, and pump curves showing operating range of flow and TDH.
   3. Standby power generator size and location for electrically driven bypass pumps.
   4. Downstream Discharge Plan.
   5. Pipe thrust and restraint block sizes and locations.
   6. Temporary pipe supports and anchoring required.
      a. The bypass corridor lies within a flood zone, therefore buoyancy restraint is required.
      b. Buoyancy calculations are required.
   7. Schedule that shows duration of temporary bypass pumping including milestones for installation, maintenance, and removal of equipment and accessories.
   8. Means and methods of installing, operating, monitoring, and maintaining the temporary bypass pumping shall be provided.
   9. Plan indicating bypass pumping line locations.
      a. Plan shall include details showing methods used to protect and identify the bypass pumping lines through the length of the bypass corridor.
   10. Plans for access to bypass pumping locations.
   11. Detailed plans of a redundant backup system.
   12. Address access for pedestrians and vehicular traffic.
   13. Mechanical plan showing equipment, valves, pipe sizes and locations, pipe materials, dimensions, vehicle access (where applicable), pedestrian access (where applicable).
   14. Proposed type, catalog cutsheets, and location of piping plugs.
   15. Emergency Response Plan.
   16. Staffing Plan.
   17. Spill prevention and cleanup plan.
   18. Method of noise control.
   19. Health and Safety Plan.
   20. Catalog cutsheets for all pumping equipment including pump performance curves, all pipe and fittings, all valves, noise reduction system, and health and safety plan.

1.05 QUALITY ASSURANCE

A. Contractor's qualifications:
   1. Minimum 5 years of experience in performing substantially similar temporary bypass pumping operations.
   2. Submit list of at least 5 separate construction projects completed within the last 10 years that include the satisfactory setup, operation, and maintenance of a pumping and piping system used to bypass wastewater during construction similar to the specified Work.

B. Fulfillment of the specified experience requirements shall be a condition of acceptance.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Contractor shall collect flow data or request flow data from Owner to determine the appropriate range of design flows and design TDH. The following criteria shall be determined at a minimum:
   1. Peak Flow and TDH: 125 gallons per minute at 55 feet.
      a. Note: the head condition may need to be modified to account for suction/discharge pressure requirements based on placement of the temporary bypass system and suction/discharge piping diameter. Provided head is for approximate sizing purposes.

2.02 CAPACITY

A. Pumps, piping, and accessories shall be of adequate capacity and size to handle the range of wastewater flows from Minimum Flow to Peak Flow.

B. All piping, fittings, and all accessories shall withstand 2.0 times the maximum pressure.

C. Contractor shall maintain on site sufficient equipment and materials to ensure continuous and successful operation of the bypass system.
   1. Contractor shall have standby pump(s) incorporated into the system that provide 100-percent redundancy of the bypass system design Peak Flow.
      a. The redundant pump(s) shall be plumbed, fueled, and available for operation in 10 minutes upon emergency backup.
   2. Contractor shall maintain on site a sufficient number of valves, tees, elbows, connections, tools, pipe plugs, piping, and other parts or system hardware to ensure immediate repair or modification of any part of the bypass system as necessary.

2.03 BYPASS PUMPS

A. A minimum of 2 pumps shall be provided, each capable of transporting 100 percent of the peak flow.

B. Pump capacity shall be sufficient to pump the anticipated peak hour flow with the largest pump out of service.

C. Pumps shall be a packaged unit with a skid base or 2-wheel trailer.

D. Pumps shall be fully automatic, self-priming, close-coupled centrifugal units that do not require use of foot valves or vacuum pumps for priming.

E. Pumps shall utilize oil-lubricated mechanical seal.

F. Pump materials shall be as follows:
   1. Volute: Cast iron.
   2. Impeller: Cast iron or Chromium steel.
   3. Pump shaft: Type 431 stainless steel.
   4. Mechanical seal faces: Silicon carbide.

G. Pumps shall be capable of passing 3-inch diameter solids, rags, rocks, hair, and other debris encountered in municipal wastewater.

H. Pumps shall be operated by diesel engine or 480-volt electric engine as described below and include the following:
   1. Primary pump may be electrically powered (if suitable temporary power is established) or diesel powered; backup pump shall be power by a diesel engine system.
   2. Minimum 24-hour capacity diesel fuel tank as defined by fuel consumption during peak pumping rate.
   3. Fuel gauge with red warning light when tank approaches empty.

I. Pumps shall be capable of dry operation for up to 5 hours to accommodate large fluctuations in flow.

J. Maximum pump speed shall not exceed 2,200 revolutions per minute.

K. The system shall include the following features:
   1. START/STOP operation.
   2. Instrumentation and controls for operation and monitoring for each pump.

L. All electrical equipment, instrumentation, and accessories shall be suitable for Class 1 Division 1 service in accordance with NFPA 820.

2.04 BYPASS PIPING

A. Contractor shall use HDPE, ductile iron, or aluminum piping for the temporary bypass pumping system.

B. All piping shall have no leakage and shall include spill containment vessels or "spill guards" in areas indicated on the Drawings.

C. HDPE Piping shall be as follows:
   1. In accordance with ASTM D3350.
   2. Minimum SDR of 17.
   3. Joints shall be butt-fusion welded.

D. Ductile Iron Piping shall be as follows:
   1. In accordance with AWWA C151.
   2. Fittings in accordance with AWWA C110.
   3. Joints shall be rubber gasketed push-on in accordance with AWWA C111.

E. Aluminum piping:
   1. In accordance with ASTM B241 or approved by Engineer.
   2. Fittings: Standard pipe fittings made of aluminum alloy suitable for 30 percent above maximum shutoff pressure.
   3. Joints shall be rubber.

2.05 PIPE PLUGS

A. Pipe diameters 24 inches and smaller shall use mechanical plugs with rubber gaskets.

2.06 NOISE CONTROL

A. Pump equipment shall be equipped with devices or enclosures for noise attenuation, which includes, but is not limited to, mufflers and/or plywood/Styrofoam noise panels.

B. The noise level shall be at or below 75 dBA at 50 feet from the pumping equipment for the duration of the Work.

PART 3 EXECUTION

3.01 GENERAL

A. Contractor shall notify Owner a minimum of 30 days prior to the Work requiring temporary bypass pumping and notify Engineer at least 72 hours prior to bypassing or diverting flow in any of the pipelines or laterals or structures.

B. All pumps, generators, and other equipment shall be placed on a plastic tarp to protect against spills of petroleum products used by the equipment.

C. Before taking interceptor out of service, Contractor shall verify that bypass system is fully operational and acceptable to Engineer.

D. Traffic control as specified in Section 01550 - Traffic Control.

E. Flow in the existing sewers shall not be restricted or dammed for any period of time without the approval of Engineer.

F. All wastewater facilities, including laterals, shall remain in continuous and full operation during construction.

3.02 PROTECTION

A. All pumps and piping shall be sized to adequately convey the flows anticipated at each bypass application.
   1. The bypass system shall be watertight; no leakage will be allowed.

B. Contractor shall be responsible for all bypass flows.
   1. Contractor shall inspect the entire bypass pumping and piping system for leaks or spills at a frequency of not less than: 1 time per day.
   2. The temporary bypass system shall not be shut down between shifts, on holidays or weekends, or during work stoppages without written permission from Engineer.

C. The temporary bypass system will have trained and qualified attendants available 24 hours per day 7 days per week whose only duty is to maintain the bypass system until the bypassing of the system is no longer required. The attendants shall:
   1. Be capable of performing pump and piping maintenance required.
   2. Have a cellular phone for communication with Contractor and Engineer in the event of emergencies.

D. In the event of any wastewater spill, Contractor shall be responsible for the prompt cleanup and disinfecting of the spill as called for in the temporary bypass pumping plan.
   1. Contractor shall compensate Owner for the cost of any fines levied as the result of a spill or unauthorized discharge.

E. Contractor shall implement measures to prevent interference between the public and the bypass pumping equipment, pipelines, and wastewater.

F. Contractor shall take precautions to protect all bypass lines from damage.
   1. Any aboveground portions of the bypass lines shall be clearly identified by flashers, fencing, or other means to warn the public of their presence.

3.03 FIELD QUALITY CONTROL

A. Hydrostatic Pressure Test:
   1. Prior to operation, test each section of discharge piping with maximum pressure equal to 2.0 times the maximum operating pressure.
   2. The test shall run for a duration of 4 hours.
   3. Contractor shall fill the line with water.
   4. The line shall be sealed on the discharge end.
   5. The line may be put in service if, after the specified test duration, the pressure has been maintained and there are no observable leaks.
   6. Notify Engineer at least 48 hours prior to testing.

B. Inspection:
   1. An attendant/operator shall inspect temporary bypass piping system at a minimum of every hour, 8 hours per day.

2. An attendant/operator shall be present to monitor the operation of the bypass pumps at all times, 24 hours per day.
    a. Attendant/operator may monitor alarms and condition remotely during non-regular work hours and days (e.g., after 5 p.m. and on weekends/holidays).
3. Inspection Log: Keep at each pumping location.

3.04 CLEAN-UP

A. The temporary bypass pumping system shall be cleaned and drained prior to being dismantled.

B. Contractor shall alternate pigging and purging of the system to remove all loose material.
    1. After Contractor has cleaned the pipe, and prior to dismantling of the piping for removal from the project site, Contractor shall disinfect the pipe with 10-percent chlorine solution.

C. Disturbed Areas:
    1. Upon completion of bypass pumping operation, clean disturbed areas, restoring to original condition, including pavement restoration, at least equal to that which existed prior to start of Work.
    2. As specified in Section 02952 - Pavement Restoration and Rehabilitation.

3.05 SCHEDULING

A. The temporary bypass pumping system shall not be shut down between shifts, on holidays or weekends, or during work stoppages.

B. The bypass system shall have trained and qualified attendants 24 hours per day, 7 days per week whose only duty is to maintain the bypass system from the start of bypass until the bypassing of the system is no longer required.

END OF SECTION

SECTION 02581

PRECAST ELECTRICAL HANDHOLES AND ELECTRICAL MANHOLES

PART 1 GENERAL

1.01 SUMMARY

A. Design, fabricate, and install precast electrical handholes and precast electrical manholes of the size and type indicated on the Drawings and specified.
   1. Construction of cast-in-place concrete electrical structures, including handholes and manholes, are specified in other sections.

B. Section includes:
   1. Precast portland cement concrete handholes and accessories.

C. Alternates:
   1. Contractor may propose to construct cast-in-place structures in lieu of the precast structures specified.
      a. Obtain Engineer's acceptance of this alternative before submitting, providing, or installing.
      b. Submit full information on design and detailing of proposed alternatives including design details and drawings of the same types required by this Section for precast structures.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

C. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. C857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   3. C858 - Standard Specification for Underground Precast Concrete Utility Structures.
   4. C891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures.
   5. C1028 - Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method.
   6. C1037 - Standard Practice for Inspection of Underground Precast Concrete Utility Structures.

D. Code of Federal Regulations (CFR):
   1. Title 29, Chapter XVII, Part 1910 - Occupational Safety and Health Standards (OSHA).

E. National Fire Protection Association (NFPA):
   1. National Electrical Code (NEC).

F. National Precast Concrete Association (NPCA).

G. Society of Cable Telecommunications Engineers (SCTE):
   1. 77 - Specification for Underground Enclosure Integrity.

H. Underwriters Laboratories (UL).

1.03 DEFINITIONS

A. Handhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to reach into, but not enter, the enclosure to install, operate, or maintain equipment or wiring or both. (Reference: NEC, Article 100):
   1. As used in this Section, “handhole” will refer to a precast electrical handhole.

B. Manhole: An enclosure for use in underground systems that has been sized and detailed to allow personnel to enter the enclosure to install, operate, or maintain equipment or wiring or both.
   1. As used in this Section, “manhole” will refer to a precast electrical manhole.

C. Portland Cement Concrete: A composite material consisting of a portland cement binder, water, admixtures, and a combination of fine and coarse mineral aggregates.
   1. Abbreviated “PCC” as in “PCC HANDHOLE” or “PCC MANHOLE.”

D. Precast Concrete: A concrete fabrication designed by a qualified engineer and subsequently fabricated at a qualified fabrication site, which is usually located some distance from the site where the fabrication will be installed.

1.04 SUBMITTALS

A. Product data: Manufacturer’s catalog data, details, and warranties for the following items.
   1. Portland cement concrete handholes and manholes:
      a. Materials of construction.
      b. Joint details and joint-sealing materials.
      c. Data for hatches or covers and rings.
      d. Preformed channels and accessories for cable racking.
      e. Drain and sump details, including removable covers.
      f. Pulling iron details.

B. Shop drawings:
   1. Portland cement concrete handholes and manholes:

a. Shop drawings for each structure shall bear the seal and signature of a professional engineer licensed in the state where the structures will be installed.
b. Dimensioned and “to-scale” plans, sections, and details for each structure including:
    1) Layout plan for that structure.
    2) Sizes, locations, and vertical positions of duct bank windows and knockout panels.
    3) Locations and details for access openings, pulling irons, embedded cable supports and racks, and sumps.
    4) Details of structural reinforcement showing bar size and spacing; true position of reinforcement in structural members with clear concrete cover at both inside and outside faces; location, bar size, and spacing of added reinforcement around openings; and other details relevant to design and fabrication of the structure.
    5) Details of joints between adjacent precast sections, including provisions for overlap and for placement of sealants.

C. Design data:
1. Portland cement concrete handholes and manholes:
    a. Structural calculations:
        1) Submit complete structural calculations for each structure.
        2) Provide calculations bearing the seal and signature of a professional engineer licensed in the state where the structures will be installed.
        3) Calculations will be filed for record. Review comments will not be returned.
    b. Manufacturer’s statement of materials used for fabrication and construction, in accordance with ASTM C858, for record. Include the following:
        1) Concrete mix design: For each concrete mix design to be used for the structures, include data describing:
            a) Source and type of cement.
            b) Sources, grading, and specific gravities of aggregates.
            c) Aggregate reactivity data.
            d) Concrete mix proportions and design strength.
            e) Type, name, and dosage of admixtures included in the concrete mix.
        2) Reinforcing steel: Mill certificates.

D. Test reports:
1. Polymer concrete handholes:
    a. Independent laboratory test reports bearing the seal of a licensed professional engineer and demonstrating compliance with the requirements of SCTE 77 for the loading conditions specified.
2. Portland cement concrete handholes and manholes:
    a. Fabricator’s tests for compressive strength of concrete used in structures, made in accordance with recommendations of ASTM C858.

E. Certificates:
   1. Polymer concrete handholes:
      a. Manufacturer's certification that polymer concrete handholes are in accordance with the requirements of SCTE 77.
   2. Portland cement concrete handholes and manholes:
      a. Manufacturer's current plant certification under NPCA for the structures to be supplied.
         1) Certification shall be current and in-effect at the time structures are manufactured.
      b. Manufacturer's certification that handholes and manholes are in accordance with the requirements of ASTM C858.

F. Manufacturer's instructions:
   1. Instructions for handling and setting structures in place.
   2. Portland cement concrete handholes and manholes:
      a. Instructions for operation and maintenance of hatches.

G. Manufacturer's field reports:
   1. Portland cement concrete handholes and manholes:
      a. Manufacturer's inspection reports in accordance with ASTM C1037.

H. Closeout documents:
   1. Project record documents:
      a. Portland cement concrete handholes and manholes:
         1) Final, revised plans and details of as-constructed precast handholes and manholes if requested for record by the Engineer.
   2. Warranties:
      a. Manufacturer's standard warranty for:
         1) Polymer concrete handholes.
         2) Portland concrete handholes and manholes and accessories.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Designer:
      a. Portland cement concrete handholes and manholes:
         1) Professional engineer qualified in the design of concrete structures and holding a current license in the state where the structures will be installed.
   2. Manufacturer:
      a. Portland cement concrete handholes and manholes:
         1) Holding current NPCA plant certification for the products produced.
         2) Demonstrating at least 5 years of experience in the design, production, and installation of products of the type required for this Work.
         3) Capable of providing structural designs prepared by a professional engineer licensed in the state where the structures will be installed.
         4) Providing inspection during fabrication and handling in accordance with the requirements of ASTM C1037.

3. Installer:
    a. Capable of providing equipment of adequate capacity and mobility to handle and set units with proper bearing on the subgrade and without damage to the unit.

B. Packing, shipping, handling, and unloading:
    1. Package and brace structures to avoid damage during shipping and handling.
    2. Furnish crane or forklift for unloading and setting of portland cement concrete handholes and manholes.

C. Acceptance at site:
    1. Structures delivered to the site with cracks, damage, and damaged or missing accessories shall be removed from the site and replaced at no additional cost to the Owner.

D. Storage and protection:
    1. Store handholes and manholes and their appurtenances in areas protected from damage due to weather and site operations.

1.06 SEQUENCING

A. Coordinate installation of precast electrical handholes and manholes with conduits and duct banks.

1.07 WARRANTY

A. Provide manufacturer's standard warranty for precast handhole and manhole structures and accessories.

1.08 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS - PORTLAND CEMENT CONCRETE HANDHOLES AND MANHOLES

A. General:
    1. Provide portland cement concrete handholes and manholes configured and designed as indicated on the Drawings and specified.
    2. In accordance with ASTM C858 unless otherwise noted.
        a. Concrete: Provide units with minimum specified compressive strength (f'c) of 4,500 pounds per square inch and using Type A cement.

B. Manufacturers: One of the following, or equal:
    1. Oldcastle Precast.
    2. Jensen Precast.

C. Components:
   1. Floor:
      a. Construct floors as a monolith.
      b. Where sump or low-point drain is included, slope floor to that point.
   2. Roof, walls, and base:
      a. Designed and rated to support vehicle and pedestrian loads at the spans indicated.
      b. See the Electrical Handhole and Manhole Schedule indicated on the Drawings for required load rating by structure location.
   3. Access covers:
      a. Handholes: Aluminum plate hinged Heavy Duty Off-Street Floor Access Doors (hatch) as specified in Section 08320 - Floor Access Doors.
         1) Minimum access door size not less than 36 inches square, unless otherwise indicated on the Drawings.
         2) Provide bearing surface with pre-installed continuous elastomeric gasket to minimize water infiltration at lid.
         3) Provide skid-resistant lid with cast-in or machined-in grid pattern and the word “ELECTRICAL” in block letters at least 1.5 inches high.

D. Accessories:
   1. Provide accessories as indicated on the Drawings and specified.
   2. Materials at duct bank penetrations:
      a. Joint filler.
      b. Backer rod and sealant as specified in Section 07900 - Joint Sealants.
   3. Pulling irons:
      a. Provide non-corroding cable pulling irons located for use with each current duct bank location and additional irons for use with duct banks that may be installed through future knockout panels.
      b. Pulling irons may not be located on the floor.
      c. Where pulling irons are installed on the wall, any pockets surrounding the irons shall have bottom surfaces sloped to drain.
      d. Secure pulling eyes to structure reinforcement.
   4. Cable racks and racking hardware:
      a. Materials: Stainless steel.
      b. Embedded slots: Maximum depth of 1.5 inches.
   5. Sumps and drains:
      a. Fiberglass or HDPE fabrications including removable lids to prevent tripping hazards.
   6. Exterior dampproofing:
      a. As specified in Section 07110 - Dampproofing.
      b. Field applied to wall and roof surfaces exposed to soil.

E. Fabrication:
   1. Embeds:
      a. Install embedded items with provisions for drainage to remove dripping or standing water, and to minimize corrosion.
         1) Pulling irons may not be placed on the floor or in pockets that will collect water.
         2) Detail bottom of cable rack channels to provide a downward sloping “sill” at the bottom of each vertical channel, so that the channel slot drains toward the floor.

b. Concrete cover:
    1) Provide minimum 0.75-inch clear concrete cover between embeds and surrounding reinforcement.
    2) Provide minimum 1.25-inch clear concrete cover between embed and exterior face of wall.

F. Tests and inspections:
    1. Test and inspect structures in accordance with ASTM C858 and ASTM C1037.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General requirements for handholes and manholes:
    1. As specified in Section 16050 - Common Work Results for Electrical for general requirements for electrical work.
    2. Provide structures of the sizes and shapes indicated on the Drawings, with layouts, dimensions, and details as indicated on the Drawings and as specified.
    3. Conform to the requirements of:
        a. NEC.
        b. Project regulatory requirements as specified in Section 01410 - Regulatory Requirements.

B. Portland cement concrete handholes and manholes:
    1. Load resistance of boxes and covers.
    2. Design requirements: Loads on structures:
        a. In accordance with ASTM C857, except as modified in this Section.
        b. Loads at the ground surface:
            1) See “Electrical Handhole and Manhole Schedule” indicated on the Drawings for minimum surface loading requirements at each structure. Loads are designated as “sidewalk,” or ”roadway”.
            2) The vehicle and pedestrian loadings in the following paragraphs need not be additive; however, structures designated for “roadway” loading shall also support “sidewalk” loads.
            3) Vault must be rated for “Roadway” loads.
            4) “Sidewalk”: Load from regular pedestrian traffic with considerations for occasional non-deliberate vehicular traffic:
                a) Designation "A-0.3" in ASTM C857 Table 1 (300-psf uniform load).
            5) ”Roadway”: Load from heavy, frequently repeated vehicle traffic:
                a) Designation "A-16" in ASTM C857 Table 1 (AASHTO HS20-44).
        c. Lateral earth pressure loads:
            1) Determine in accordance with the following requirements. Include effects of groundwater and seismic accelerations on lateral earth pressures.
                a) Equivalent lateral pressure: 60 pounds per square foot per foot of depth (triangular distribution).
                b) Surface surcharge load:
                    (1) In accordance with ASTM C857 Vehicle Load Designation "A-16" for "Roadway" or "A-0.3" for "Sidewalk" where such surcharge exceeds backfill loads described in the preceding paragraph.

c) Groundwater effects:
(1) Include effects from groundwater and soils saturated by flooding to site finished grade elevation.
(2) Use equivalent lateral pressure of 90 pounds per square foot per foot of depth (triangular distribution) for soil below the design groundwater elevation.
d) Seismic design:
(1) As specified in Section 01850 - Design Criteria.
(2) On opposite sides of the structure that are perpendicular to the direction of acceleration, include equivalent lateral pressure (inverted fluid pressure distribution), beginning with a pressure of 0 at the base of the structure, and increasing at a rate of 37.5 pounds per square foot per foot of rise toward the ground surface.
(3) Apply seismic effects as additive force on side where the soil mass is being accelerated toward the structure, and as subtractive force on the opposite side where the soil mass is being accelerated away from the structure.

d. Groundwater and flood loads - buoyancy effects:
1) Design for site groundwater elevation taken at the level of finished grade around the structure.
2) Buoyancy: For groundwater and flood conditions, provide factor of safety against flotation of at least 1.20.
a) If the weight of soil overlying footing projections on the structure is considered to resist flotation, use a buoyant unit weight of soil equal to not more than 40 pounds per cubic foot.
b) Concrete fill may be provided in the bottom section of precast portland cement concrete structures to add weight. Submit proposed details.

e. Soil-bearing pressure at base:
1) Maximum 1,500 pounds per square foot total pressure on prepared subgrade soils.

f. Lifting and handling loads:
1) Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or erection.

g. Load combinations:
1) Design structures to sustain the specified loads individually or in combination.

3. Design requirements: Structural analysis, design, and detailing:
a. General:
1) Analyze and design structures including the effects of 2-way action (“plate action”) and of load transfer around current and future openings.
2) Where structures include panels designed for future removal (“knockout panels”), design structures for loads and stresses with any combination of any or all such panels in place or removed.

b. Precast polymer concrete handholes:
1) Design to resist loads with cover in place or removed.
2) Detail cover support and top edges to maintain cover in place over walls and to prevent soil from sloughing into the handhole when cover is removed.

c. Precast portland cement concrete handholes and manholes:
    1) Design structures in accordance with the requirements of ACI 318 and this Section.
    2) Provide reinforcement at areas subject to tensile stress when loaded with the specified loads and combinations thereof.
    3) Provide temperature and shrinkage reinforcement to equal or exceed ACI 318 requirements in concrete sections.
    4) Provide minimum clear concrete cover over reinforcement at both interior and exterior faces of members in accordance with the following:
        a) Handholes: 1.25 inches.
    5) Reinforcement details:
        a) Walls: For structures with wall thickness of 8 inches or less, locate a single mat of reinforcement at the center of the wall.
        b) Slabs: For structures with slab thickness of 7 inches or less, locate a single mat of reinforcement at the center of the slab.
        c) Structures with wall or slab thicknesses exceeding these limits shall have a reinforcement at each face of the member.
    6) Joints:
        a) Provide structures with watertight joints between sections and detailed to minimize water infiltration at duct bank and conduit penetrations.
        b) Provide structures with non-skid, shiplap or tongue and groove joints between sections.

4. Design requirements: Materials:
    a. Portland cement concrete handholes and manholes:
        1) In accordance with ASTM C858.

2.03 MATERIALS

A. Cast-in-place concrete for fill at base sections of portland cement concrete manholes with deep sumps or ballast to resist buoyancy shall be “Class A” concrete as specified in Section 03300 - Cast-in-Place Concrete.

2.04 SOURCE QUALITY CONTROL

A. Portland cement concrete handholes and manholes.
    1. Per Specification Section 01450 – Quality Control.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish and install precast electrical handholes and manholes as indicated on the Drawings and specified.

B. Install additional handholes and manholes required so installation procedures will conform to cable manufacturer’s pulling tension requirements.
    1. Include proposed locations and details of such additional handholes and manholes with the submittals under this Section.

3.02 PREPARATION

A. Design:
   1. Prepare detailed and scalable layouts for each manhole structure showing locations of conduit or duct bank penetrations, clearances, locations, and sizes of access openings and major accessories.

B. Protection:
   1. Where handhole and manhole structures are installed adjacent to existing site structures or utilities, provide excavation support or other protection as required to maintain those facilities in service and to prevent damage to both existing and new facilities.

C. Site preparation:
   1. Excavate and prepare exposed subgrade as indicated on the Drawings and as specified.
   2. Install and compact foundation layer as indicated on the Drawings and specified.
   3. Level foundation materials so that structures will be set plumb, and duct banks will be at proper grade and alignment.
      a. Install with uniform bearing on foundation materials.
      b. Wedging or blocking of base sections for leveling over the foundation materials will not be permitted.

3.03 INSTALLATION

A. General:
   1. Protect handholes and manholes from displacement, flooding, or flotation.

B. Portland cement concrete handholes and manholes:
   1. Install structures in accordance with ASTM C891 and the provisions of this Section.
      a. In the event of conflicts, the more restrictive provisions shall apply.
   2. Clean and prime joints between adjacent precast sections.
      a. Install sealing compound between sections and provide watertight joints.
   3. Set covers and hatches at elevations indicated on the Drawings.
      a. Securely attach frames to top of precast structures and grade adjustment rings.
   4. Penetrations:
      a. Holes for duct banks and other penetrations may not be cut into precast handholes and manholes unless they are located at designated locations shown on the shop drawings or at knockout panels cast into the structure during manufacturing.
      b. Carefully remove concrete from knockout panel areas with saws.
         1) Ensure that break-back does not extend beyond the designated limits of the knockout panel.
      c. Coat any reinforcement cut or exposed during removal of knockout panel sections with minimum 2 coats of high solids epoxy as specified in Section 09960 - High-Performance Coatings.
         1) Apply epoxy coating applied over and at least 1-inch past the perimeter of the reinforcement.

5. Install duct banks and conduit penetrations in accordance with the penetration details indicated on the Drawings.
    a. Place joint fillers, caulks, and sealants before coating exterior concrete surface with bituminous dampproofing.
6. Fill holes that were provided for handling or other temporary purposes with non-shrink cement grout using procedures as specified in Section 03300 - Cast-in-Place Concrete unless otherwise detailed by the manufacturer.
7. After structures are set and before backfilling, coat exterior below-grade surfaces (around the sidewalls, over the top slab, and around any vertical risers to grade) with 2 heavy coats of bituminous dampproofing as specified in Section 07110 - Dampproofing.
    a. Apply dampproofing in accordance with the coating manufacturer's instructions and at a rate of 40 to 60 square feet per gallon per coat.
    b. Mask over at least 1 inch back from joint caulks or sealants and prevent dampproofing from coming in contact with those materials.
8. Backfill handholes and manholes as specified in Section 02300 - Earthwork.

C. Site tolerances:
1. Set electrical handholes and manholes plumb and true at locations indicated on the Drawings.
2. Tolerances on placing:
    a. Horizontal location: Plus or minus 1 inch.
    b. Vertical elevation: Plus or minus 1/2 inch.
    c. Plumb: Plus or minus 1/8 inch over 10 feet.

3.04 REPAIR/RESTORATION

A. Repair cracks or blemishes in concrete as described in Section 03300 - Cast-in-Place Concrete.

3.05 FIELD QUALITY CONTROL

A. Site test and inspection:
1. Per Specification Section 01450 – Quality Control.

B. Manufacturer's field service.

C. Per Specification Section 01450 - Quality Control Special inspections.

3.06 PER SPECIFICATION SECTION 01450 - QUALITY CONTROL ADJUSTING

A. After final grading is complete, adjust access covers to grade.

3.07 CLEANING

A. Before installation of cables in any duct banks and handholes or manholes, remove concrete spoil, forms, debris, silt, dust, and other foreign material.

3.08 PROTECTION

A. Per Specifications Section 01500 - Traffic Control.

3.09 SCHEDULES

A. See Drawings for Electrical Handhole and Electrical Manhole Schedule.

END OF SECTION

SECTION 02600

CONCRETE MANHOLESGENERAL

1.01 SUMMARY

A. Section includes:
   1. Manhole frames and covers.
   2. Manhole grade rings.
   3. Manholes cones and risers.
   4. Manhole bases.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. C33 - Standard Specification for Concrete Aggregates.
   3. C150 - Standard Specification for Portland Cement.
   4. C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
   5. C478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.
   6. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint.
   7. C923 - Standard Gide for In-Plant Performance Evaluation of Automatic Pedestrian SNM Monitors.
   8. C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.

C. International Organization of Standardization (ISO):
   1. 9001 - Quality Management Standard.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. Manufacturer’s catalog data and details of following items for approval:
      a. Frame and covers.
      b. Grade rings.
      c. Manhole cones and risers.
      d. Manhole bases, if precast.
   2. Manhole construction details, jointing methods, connection details, materials, and dimensions.
   3. Repair procedures and details.

C. Calculations and criteria used in manhole design including material properties, loadings, load combinations, and dimensions assumed.

D. Test methods and results including certification that the manhole riser exceeds the minimum requirements in accordance with ASTM C478.

E. Sealed drawings and design calculations by a registered Professional Engineer licensed in the State where the project is located.

F. Certificates
   1. ISO 9001 certificate by a third party confirming that ASTM test reports are valid and up to date at the time of the bid and during construction period.
   2. Manufacturer's Certificate of Source Testing.

1.04 PRODUCT REQUIREMENTS

A. As specified in Section 01601 - Product Requirements.

B. Provide suitable quantities of lifting equipment to handle the manholes/risers and castings.
   1. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it will be subjected, or which will damage or gouge the manhole components.
   2. Dragging or dropping the manhole components shall not be allowed.

C. Source testing.
   1. Perform pre-production and post-production tests by manufacturer staff with a minimum of 5 years of experience in quality control, inspection, and testing of manholes.
      a. In lieu of this experience, witness of tests by up to 3 full-time Owner representatives.
   2. Examine each completed manhole section for dimensional requirements, strength, and workmanship.
   3. Complete required testing in accordance with ASTM C478.
   4. Provide the Manufacturer's Certificate of Source Testing.

1.05 DESIGN CRITERIA

A. Manholes shall not include steps.

B. Manhole lids: Locking type.

C. Manhole bases:
   1. Constructed as part of the pipe installation or using tee risers.

D. Manhole riser:
   1. Made of the same pipe material selected for the project, providing a sealed connection between the pipe base and riser as indicated on the Drawings.
   2. Manufactured specifically for this project and no materials shall be furnished from stock unless approved by the Engineer.

E. Manhole provider shall coordinate with the pipe manufacturer for dimensions and connections.

F. Manhole systems:
   1. Provided by a single manufacturer.

G. Frames and covers:
   1. Provided by a single manufacturer unless approved by the Engineer.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manhole grade rings, cones, and risers: One of the following or equal.
   1. Old Castle Precast.

B. Manhole frames and covers: Manufacturers: One of the following or equal.
   1. Alhambra Foundry Company.
   2. Neenah Foundry Company.

2.02 BASIS OF DESIGN

A. Design in accordance with local jurisdiction requirements, including but not limited to the following:
   1. Manhole frames and covers.
   2. Manhole diameter tolerance.
   3. Manhole length.
   4. Manhole cover bolting.
   5. Manhole backfill.

A. Design requirements: Loads on structures:
   1. In accordance with ASTM C857, except as modified in this Section.
   2. Loads at the ground surface:
      a. ”Roadway”: Load from heavy, frequently repeated vehicle traffic:
         1) ASTM C857, Table 1, Designation A-16 (AASHTO HS20-44).
   3. Loads against walls. Include effects of groundwater and seismic accelerations on earth pressures.
      a. Equivalent lateral pressure:
         1) Triangular distribution: 60 pounds per square foot per foot of depth (triangular distribution).
         2) Rectangular distribution backfill-induced live load surcharge: 240 pounds per square foot.
      b. Surface surcharge load: In accordance with ASTM C857 A-16 wheel load if such surcharge exceeds backfill loads described in the preceding paragraph.

c. Groundwater effects: Include groundwater effects on lateral earth pressure loads using final grade elevation.
    1) Use equivalent lateral pressure of 90 pounds per square foot per foot of depth (triangular distribution) for soil below the design groundwater elevation.
d. Seismic acceleration effects:
    1) As indicated on the Drawings.
    2) On opposite sides of the structure, uniform equivalent lateral leave in pressure type distribution, with a pressure of 37.5 in pounds per square foot where it is the depth of structure.
    3) Adding lateral force for soil accelerating toward structure:
        a) Direct uniform pressure distribution toward the wall, effectively increasing the static lateral soil pressure.
    4) Reducing lateral force for soil accelerating away from structure:
        a) Direct inverted pressure distribution away from the wall, effectively reducing the static lateral soil pressure.

4. Groundwater and flood loads, and buoyancy effects:
    a. As specified in Geotechnical Report for design groundwater and design flood elevations.
        1) Depths will be as indicated on the Drawings.
        2) Buoyancy resistance calculations should assume groundwater is at finish grade.
    b. Lateral pressure effects: Determine based on groundwater and flood elevations specified.
5. Buoyancy: For groundwater and flood conditions, provide factor of safety against flotation of at least 1.20.
    a. Design with sufficient bottom anchorage and side friction to resist buoyancy.
    b. Anti-flotation flange:
        1) Exterior of manhole riser shall incorporate a 3-inch wide flange at its base.
        2) Upon joining of manhole riser to pipe tee, place sufficient concrete around tee and manhole riser to prevent buoyancy.
        3) Encase anti-flotation flange in a minimum of 6 inches of concrete.
    c. Concrete ballast:
        1) Pour sufficient concrete around manhole riser base to prevent buoyancy as indicated on the Drawings.
        2) If the weight of soil overlying footing projections on the structure is considered to resist flotation, use a buoyant unit weight of soil equal to not more than 40 pounds per cubic foot.
        3) Concrete fill may be provided in the bottom section of precast portland cement concrete structures to add weight. Submit proposed details.
6. Soil bearing pressure at base:
    a. Maximum 1,500 pounds per square foot total pressure on prepared subgrade soils.
7. Lifting and handling loads:
    a. Make provision in the design for the effects of loads or stresses that may be imposed on structures during fabrication, transportation, or erection.

8. Load combinations:
    a. Design structures to sustain the specified loads individually or in combination.

B. Manholes, grade rings, risers, and bases:
1. Manhole:
    a. Nominal sizes as indicated on the Drawings.
2. Grade rings:
    a. At least 1 but not more than 2 grade rings shall be used.
    b. Maximum total distance from top of cone section to final grade: 18 inches.
3. Cone and riser sections:
    a. As specified in this Section and as indicated on the Drawings.
    b. Cone sections shall be concentric or eccentric as indicated on the Drawings.
4. Manhole bases:
    a. As specified in this Section and as indicated on the Drawings.
        1) Consider existing wet well as manhole base for cone design.
    b. Provide corrosion protection system on unlined concrete.

C. Threaded lifting inserts:
1. Design inserts to be fully threaded:
    a. Do not fully penetrate through entire manhole wall.
2. Provide lifting device compatible with spreader bar and chains, hooks and slings.
3. Design with minimum safety factor of 4.0.
4. Do not use reinforcing steel bars.

2.03 MATERIALS

A. Cast iron manhole frames and covers.
1. In accordance with ASTM A48.
2. Covers: Bolted as specified.
3. Concrete collars: As indicated on the Drawings.

B. Manhole bases, risers, and grade rings:
1. Cement: Type II portland cement in accordance with ASTM C150.
2. Concrete aggregates: In accordance with ASTM C33, gradation as specified in approved mix design.
3. Sections: Steel reinforced.
4. Precast concrete sections: Manufactured by a process that will produce a dense, homogeneous concrete ring.
5. Top and bottom of sections: Parallel.

C. Joint sealant:
1. Preformed, cold applied flexible joint sealant in accordance with ASTM C990 and ASTM C443.
2. Manufacturers: One of the following or equal.
    a. Henry Corp., Ram-Nek.
    b. Kent Seal - Hamilton Kent Corp.

2.04 COMPONENTS

A. Pipe stubs:
   1. Provide pipe stubs at manhole locations and in accordance with details indicated on the Drawings and as specified.
   2. Plugging stubs:
      a. Plug stubs with vitrified clay stopper, brick plug, or other materials as indicated on the Drawings.
      b. Unless otherwise indicated on the Drawings, comply with following:
         1) Stubs up to and including 21 inches: Vitrified clay stoppers.
         2) Stubs greater than 21 inches: Brick plugs.

B. Resilient pipe connectors:
   1. Unless otherwise indicated on the Drawings or specified, provide a flexible compression type connector between manhole and pipes entering and leaving the manhole in accordance with ASTM C923.
   2. Resilient pipe connectors:
      a. Manufacturers: The following or equal:
         1) A-LOK Premium.

C. Threaded lifting inserts.

2.05 IDENTIFICATION MARKINGS

A. Identification marks on the exterior of bases, risers, grade rings, and include the following information:
   1. Date of manufacture of the item.
   2. Name or trademark of the manufacturer.
   3. Internal diameter in inches.
   4. Number of the manhole as indicated on the Drawings.

2.06 QUALITY CONTROL

A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as specified by this Section.

B. Material testing, inspection procedures, and manufacturing process are subject to inspection by the Owner or Owner's representative.

C. Perform manufacturer's tests and inspections in accordance with the referenced standards and as specified in this Section including the following:
   1. Provide the Manufacturer's Certificate of Source Testing as specified in Section 01601 - Product Requirements.
   2. Manufacturer shall make available services of representative throughout the project duration when deemed necessary by the Engineer.
   3. Calibrate within last 12 months for equipment such as scales, measuring devices and calibration tools used in the manufacturing of pipe.
      a. Each device used in the manufacture of manholes is required to have a tag recording date of last calibration.
      b. Devices are subject to inspection by Engineer.

D. Furnish labor necessary to assist the Engineer in inspecting manholes upon delivery.

E. Remove rejected manholes immediately.

PART 3 EXECUTION

3.01 MANHOLE INSTALLATION

A. Excavate and backfill as specified in Section 02318 - Trenching and as indicated on the Drawings.

B. Maintain identification markings on installed pieces throughout installation.

C. Do not use sections with chips or cracks in the joint.

D. Engineer may inspect manhole sections, prior to installation.

E. Repair of manhole sections damaged during installation in accordance with manufacturer's repair procedures; with the concurrence of the Engineer.

F. Install joint sealant material in accordance with manufacturer's instructions:
   1. Completed manhole: Rigid and watertight.

G. Fill threaded lifting inserts with grout.

H. Lay grade rings on joint sealant with sides plumb and tops level.

I. Set frame and covers as specified and as indicated on the Drawings.

J. Apply damproofing as specified in Section 07110 - Dampproofing and as indicated on the Drawings.
   1. Apply material in accordance with manufacturer recommendations over the entire exterior surface of the completed manhole, including base section, riser sections, cone section, and grade rings prior to backfilling the manhole.
   2. Allow waterproofing material to dry sufficiently before backfilling.

3.02 CLEANING

A. After completing each manhole, remove debris, construction materials, and equipment from the site of the work, grade, and smooth over the surface and leave the entire right-of-way in a clean, neat, and serviceable condition.

B. After completing each manhole, remove construction material debris from inside the manhole.

3.03 FUNCTIONAL TESTING

A. Provide materials for grouting and patching recommended by the manufacturer or an approved equal.

B. Vacuum testing in accordance with ASTM C1244.
   1. Install the vacuum test head on top of the manhole.
      a. Install and brace sealing devices on influent and effluent pipes.
   2. Draw a vacuum of 10 inches of mercury with a vacuum pump, deactivate the pump, and measure the actual elapsed time for the vacuum to drop to 9 inches of mercury.
   3. Compare test results with the minimum time requirements stated in the table below.
      a. If the actual elapsed time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

Minimum Elapsed Time, Minutes: Seconds				
Manhole Depth, ft.	**Manhole Diameter, inches**			
	36	48	60	72
8	0:14	0:20	0:26	0:33
10	0:18	0:25	0:33	0:41
12	0:21	0:30	0:39	0:49
14	0:25	0:35	0:46	0:57
16	0:28	0:40	0:52	1:07
18	0:32	0:45	0:59	1:13
20	0:35	0:50	1:05	1:21
22	0:38	0:55	1:12	1:29
24	0:42	0:59	1:18	1:37
26	0:46	1:04	1:25	1:45
28	0:49	1:09	1:31	1:53
30	0:53	1:14	1:38	2:01

END OF SECTION

SECTION 02620

FILTER FABRICGENERAL

1.01 SUMMARY

A. Section includes: Nonwoven filter fabric.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
   2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   6. D5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
   7. D6241 - Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.

1.03 DEFINITIONS

A. Filter Fabric: Nonwoven geotextile fabric manufactured from polypropylene fibers.

1.04 SUBMITTALS

A. Product data.

B. Samples.

C. Quality control submittals:
   1. Certificates of Compliance.
   2. Manufacturer's Instructions.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection:
   1. Furnish filter fabric in protective covers capable of protecting the fabric from ultraviolet rays, abrasion, and water.

1.06 PROJECT CONDITIONS

A. Take field measurements to determine the lengths and dimensions of the surfaces to receive the fabric.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Propex, Geotex 401.
   2. Ten Cate Geosynthetics, Mirafi 140N.

2.02 MATERIAL REQUIREMENTS

A. Physical properties: Meet the following minimum requirements:

Property[(1)]	Test Method	Unit	Requirements[(1)]
Minimum Weight	ASTM D5261	oz	4.0
Grab Tensile Strength	ASTM D4632	lbs	100
Grab Elongation	ASTM D4632	%	50
Trapezoid Tear Strength	ASTM D4533	lbs	50
CBR Puncture Resistance	ASTM D6241	lbs	300
UV Resistance (strength retained at 500 hrs)	ASTM D4355	%	70
Apparent Opening Size (AOS)	ASTM D4751	US sieve	70
Permittivity	ASTM D4491	sec^{-1}	1.7
Flow Rate	ASTM D4491	gpm/ft^2	130
Notes: 1. Minimum average roll values.			

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions: Verify that conditions are satisfactory for the installation of filter fabric.

3.02 PREPARATION

A. Surface preparation:
   1. During grading operations, take care not to disturb the subgrade.
   2. This may require use of lightweight dozers for low strength soils such as saturated, cohesionless, or low cohesion soils.

B. Prior to placement of fabric: Prepare surface to smooth condition free of debris, depressions, or obstructions that may damage the fabric.

3.03 INSTALLATION

A. Follow manufacturer's installation instructions and as complimented in this Section.

B. Place the filter fabric smoothly without folds or wrinkles.

C. Use special care when placing the filter in contact with the soil so that no void spaces occur between the filter and the prepared surface.

D. Overlap the parallel rolls and ends of rolls a minimum of 24 inches and not less than manufacturer's instructions.

E. Do not drag filter fabric across subgrade.

F. Make overlaps at ends of rolls in the direction of the aggregate placement with the previous roll on top.

G. Use lightweight dozers if necessary. Do not allow equipment directly on filter fabric.

3.04 FIELD QUALITY CONTROL

A. Inspection:
   1. Before covering, the condition of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric.
   2. Repair all holes and rips by placing a new layer of fabric extending beyond the defect in all directions a distance equal to the minimum overlap required for adjacent rolls.

END OF SECTION

SECTION 02742

ASPHALTIC CONCRETE PAVING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Asphalt concrete pavement on prepared subgrade or aggregate base course, and on existing pavement, to lines, grades, compacted thicknesses, and cross sections indicated on the Drawings.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Transportation Materials and Methods of Sampling and Testing:
      a. MP1: Specification for Performance Graded Asphalt Binder.

B. ASTM International (ASTM):
   1. C117 - Standard Test Method for Material Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
   2. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   3. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   4. D977 - Standard Specification for Emulsified Asphalt.
   5. D2041 - Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
   6. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

C. Oregon Department of Transportation (ODOT):
   1. Oregon Standard Specifications for Construction (Standard Specifications).

1.03 DEFINITIONS

A. Bituminous Prime Coat: Consist of application of hot bituminous material on previously prepared base course.

1.04 SUBMITTALS

A. Proposed mix design and gradation of materials.

B. Quality control submittals:
   1. Certificate of Compliance.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Asphalt concrete delivery:
   1. Transport the mixture from the mixing plant to the point of use in vehicles having tight bodies previously cleaned of foreign materials.
   2. Treat bodies as necessary to prevent material from sticking to the bodies.
   3. Cover each load with canvas or other suitable material of sufficient size and thickness to protect the asphalt mixture from the weather.

B. Comply with Standard Specifications storage requirements, if applicable.

1.06 PROJECT CONDITIONS

A. Environmental requirements:
   1. Asphalt concrete:
      a. Place asphalt concrete only when surface is dry, and when atmospheric temperature in the shade is 40 degrees Fahrenheit and rising, or above 50 degrees Fahrenheit if falling.
      b. Do not place asphalt concrete when weather is foggy or rainy or when base on which material is to be placed is in wet or frozen condition.
   2. Prime coat:
      a. Do not apply prime coat when atmospheric temperature is below 60 degrees Fahrenheit.
      b. Apply prime coat only when base course is dry or contains moisture not in excess of that which will permit uniform distribution and desired penetration.

1.07 SEQUENCING AND SCHEDULING

A. Prime coat:
   1. Prior to requesting Engineer's acceptance for application, inspect area to be coated to determine its fitness to receive bituminous priming material.
   2. Do not begin application before area to be coated has been accepted for application by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Compact the asphalt concrete to at least 95 percent of the density of the theoretical maximum density in accordance with ASTM D2041.

2.02 MATERIALS

A. Subgrade material: Stabilization material as specified in Section 02050 - Soils and Aggregates for Earthwork.
   1. Thickness: As indicated on the Drawings.
   2. Maximum lift thickness: 4 inches.
   3. Compaction: Minimum 98 percent of the AASHTO T-180 maximum dry density.

B. Base material: Aggregate base course material as specified in Section 02050 - Soils and Aggregates for Earthwork.
   1. Thickness: As indicated on the Drawings.
      a. Maximum lift thickness: 2 inches.
   2. Compaction: Minimum 98 percent of the AASHTO T-180 maximum dry density.

C. Prime coat:
   1. Use bituminous material for prime coat in accordance with Standard Specifications.
   2. Apply at temperature of 105 to 175 degrees Fahrenheit at rate of 0.3 to 0.6 gallons per square yard by use of bituminous distributor.

D. Sand: Acceptable to the Engineer.

E. Tack coat: Use bituminous material in accordance with Standard Specifications.

F. Asphalt concrete materials:
   1. Asphalt cement: Conform to requirements for asphalt cement, PG 64-16 AASHTO MP1.
   2. Mineral aggregate:
      a. Consist of coarse aggregate of crushed stone or gravel composed of hard, durable particles, sand, and filler as follows:
         1) Coarse aggregate: Portion of material retained on Number 8 sieve. Fine aggregate: That portion passing Number 8 sieve.
      b. Provide composite material that is uniformly graded from coarse to fine and that complies with requirements of one of following gradings when tested in accordance with ASTM C136.
      c. Asphalt concrete: As indicated on the Drawings, 2-course plant mix for asphalt concrete having an overall thickness of 2 1/2 inches or more if not indicated. If less than 2-1/2 inches of asphalt concrete, use single-course plant mix.

Plant Mix, Two Course				**Plant Mix, Single Course**	
Seal, 3/4 inch Thick Minimum		**Base, 1-3/4 inch Thick Minimum**		**1-1/2 inch Thick Minimum**	
Sieve Size	**Percent Passing**	**Sieve Size**	**Percent Passing**	**Sieve Size**	**Percent Passing**
1/2"	100	1-1/4"	100	3/4"	100
3/8"	95 - 100	1"	87 - 100	1/2"	75 - 95
No. 4	50 - 70	3/4"	75 - 90	3/8"	65 - 85
No. 8	35 - 55	3/8"	55 - 72	No. 4	50 - 65
No. 30	15 - 30	No. 4	40 - 60	No. 8	35 - 50
No. 100	5 - 15	No. 8	30 - 50	No. 30	15 - 30
No. 200	3 - 8	No. 30	15 - 30	No. 100	5 - 15
		No. 100	5 - 15	No. 200	3 - 8
		No. 200	3 - 8		

3. Coarse aggregate:
    a. Consist of at least 70 percent by weight of each size aggregate and consist of particles that have at least 1 rough, angular surface produced by crushing:
        1) Have percentage of wear of not more than 50 at 500 revolutions, in accordance with ASTM C131.
    b. Aggregate plasticity index: Not more than 2 in accordance with ASTM D4318.
    c. Sand may be added to crusher or pit-run product to supply any deficiency in Number 8 sieve and filler may be added to supply any deficiency in Number 200 sieve material. If aggregate contains an excess of sand, wasting will be required.
    d. Filler:
        1) Use finely powdered limestone, portland cement, or other artificially or naturally powdered mineral dust acceptable to the Engineer.
        2) Weigh filler and add separately to each batch at time of proportioning.
        3) Use filler that is free from deleterious matter of any kind.
        4) Fineness that meet the following requirements:
            a) Passing Number 50 sieve: 100 percent.
            b) Passing Number 200 sieve: At least 75 percent.
        5) Determine amount of material passing the Number 200 sieve in accordance with ASTM C117.
    e. Provide composite aggregate that is free from vegetable matter, lumps or balls of clay, adherent films of clay, or other matter which would prevent thorough coating of asphalt cement.
    f. Materials derived from processing demolished, or removed asphalt concrete, are not acceptable.

G. Fog sealing: Asphalt emulsion, Grade SS-1h.

2.03 EQUIPMENT

A. Bituminous distributor: Designed and equipped so as to distribute bituminous material uniformly at even heat on variable widths of surface at readily determined and controlled rate with pressure range of 25 to 75 pounds per square inch.

B. Liquid asphalt distributor:
1. Designed and operated to distribute asphaltic material in uniform spray without atomization.
2. Equipped with bitumeter having dial registering feet of travel per minute.
    a. Locate dial so that it is visible to truck driver so that he can maintain constant speed required for application at specified rate.
3. Equip pump with tachometer having dial registering gallons per minute passing through nozzles.
    a. Locate dial so that it is readily visible to operator.
4. Provide means for accurately indicating temperature of asphaltic material in distributor at all times.
    a. Locate thermometer well so that it is not in contact with, or close to, heating tube.

5. Have spray bar having normal width of application of not less than 12 feet and capable of providing for application of lesser width when necessary.
6. Provided with hose and spray nozzle attachment for applying asphaltic material to patches and areas inaccessible to spray bar.
7. Equipped with heating attachments and capable of circulating asphaltic material through spray bar during entire heating process.

C. Asphalt concrete mixing plants:
   1. Equipment:
      a. Use screen and storage bins at plant of sufficient capacity to furnish the necessary amount of aggregates, when operating at the maximum capacity of the plant, with no periods of undue waiting for material.
         1) Use bins consisting of at least 2 compartments, so proportioned as to ensure adequate storage of appropriate fractions of the aggregate.
         2) Provide each compartment with an overflow pipe of such size and at such location as to prevent any backing up of material into other compartments.
      b. Dryer:
         1) Designed to heat and dry the aggregate to Specification requirements and to agitate it continuously during the heating.
         2) Capable of preparing aggregates at a rate equal to the full-rated capacity of the plant.
      c. Dust collector:
         1) So constructed as to waste or return uniformly to the hot elevator all or any part of the material collected.
      d. Mixer:
         1) Adequate capacity, with twin shafts.
      e. Thermometers:
         1) Furnished for determining the temperature of the mix.
      f. Weighing and measuring equipment:
         1) Weighing or volumetric measuring equipment of sufficient capacity.
         2) Devices to permit easy readjustment of any working part needing readjustment, so that the equipment will function properly and accurately.
         3) Attach scales for weighing to the bucket.
         4) Test and seal weighing equipment by a representative of the Inspector of Weights and Measures having jurisdiction, as often as the Engineer may deem necessary to ensure accuracy.
      g. Tanks for storage of bituminous material:
         1) Capable of heating the material under effective and positive control at all times to temperatures within the range stipulated.
   2. Asphalt concrete plant operation:
      a. Mineral aggregate:
         1) Dry and heat mineral and then screen into at least 2 fractions and conveyed into separate compartments ready for proportioning and mixing.
         2) When combined with asphalt cement:

b. Aggregate:
    1) Contain not more than 2 percent moisture by weight.
    2) Be at a temperature within the range of that specified for the asphalt cement but not more than 25 degrees Fahrenheit above the temperature of the asphalt cement.
c. Combine dry aggregate in the plant in the proportionate amounts of each fraction of aggregate required to meet the specified grading.
    1) Introduce the asphalt cement into the mixer in the amount and at the temperature for the particular material being used.
    2) Continue mixing for at least 30 seconds, and for such longer period as may be necessary to coat the particles.
d. When a continuous mixer is used, determine the mixing time by weight method using the following formula:
    1) Mixing time in seconds = Pugmill dead capacity in pounds.
    2) Pugmill output in pounds per second.

D. Asphalt-concrete-placing equipment:
1. Use equipment for placing, spreading, shaping, and finishing asphalt concrete consisting of a self-contained power machine operating in such manner that no supplemental spreading, shaping, or finishing is required to provide surface that complies with requirements for smoothness contained in this Section.
    a. In areas inaccessible to the machine, hand spreading may be permitted.
2. Furnish 1 self-propelled, pneumatic-tired roller, and one 8-ton (minimum), smooth-wheel tandem roller.
    a. When spreading is in excess of 100 tons per hour, furnish 1 additional roller of either type for each additional 100 tons, or fraction thereof, spread per hour.

2.04 MIXES

A. Asphalt cement:
1. Do not mix at temperatures lower than 275 degrees Fahrenheit or higher than 325 degrees Fahrenheit.
2. Usual amount of asphalt cement, by weight, to be added to aggregate be 5.4 to 5.8 percent of weight of mixture.

B. Asphalt concrete:
1. Before being delivered to the site, mix aggregate with asphalt cement at the central mixing plant.
2. Use mixing plants that are in good working order with no excessively worn parts and so equipped that:
    a. Temperatures of aggregates leaving dryer, of asphalt cement entering mixer, and of mix leaving mixer can be readily determined and positively controlled within Specification limits at all times.
    b. Weights of different sizes of aggregates and of asphalt cement as set by the Engineer can be consistently introduced into the mixer.
    c. Asphalt cement can be uniformly distributed throughout the mixture with aggregate completely coated.
    d. Mixing time can be positively controlled to minimum specified.
    e. Bin samples of aggregate can be readily obtained.
    f. Provide means of calibrating weighing devices.

PART 3 EXECUTION

3.01 PREPARATION

A. Protection
   1. Prime-coated surfaces:
      a. Maintain surfaces until succeeding layer of pavement has been placed.
      b. During this interval, protect primed surfaces against damage and repair any broken spots.

B. Surface preparation:
   1. Prime coat:
      a. Where portions of base course prepared for immediate treatment are excessively dry, sprinkle such portions lightly with water immediately in advance of prime coat application.
      b. Immediately following preparation of base course, apply bituminous material by means of bituminous distributor at the temperature previously specified.
      c. Apply priming material in manner that results in uniform distribution being obtained at all points of surface to be primed.
      d. Following the application of prime material, allow the surface to dry for a period of not less than 48 hours without being disturbed, or for such additional period of time as may be necessary to obtain penetration into the base course and drying out or evaporation of the volatiles from prime material.
      e. Spread sufficient sand on areas that show an excess of bituminous material to effectively blot up and cure the excess.
   2. Base courses:
      a. Thoroughly clean base and apply prime coat before placing asphalt concrete.
      b. Thoroughly clean any existing base, surfacing, or pavement prior to placing plant-mixed surfacing.
      c. Where existing pavement is being widened or extended, cut to straight vertical face and treat with asphalt paint binder prior to paving operations.
      d. When asphalt concrete is to be applied over existing pavement and local irregularities in existing surface would result in course of more than specified thickness, bring surface of existing pavement to uniform contour by patching with asphalt concrete thoroughly tamped or rolled until it conforms with surrounding surface, and then apply tack coat.

3.02 APPLICATION

A. At existing asphalt to be paved over: Apply tack coat at minimum rate of 0.10 gallons per square yard.

B. Placing and compacting asphalt concrete:
   1. Placing and compacting asphalt mixture: Progress in sections generally not more than 750 linear feet in length.
   2. Spreading of mixture:
      a. Spread, shape, and finish by specified equipment.
      b. Spread each successive strip adjacent to previously spread strip.

c. Do not compact minimum 6-inch width of each strip adjacent to new strip until after new strip has been placed.
d. Spread as nearly continuous as possible.
e. Laying against vertical surfaces such as gutters: Roughen and clean face of vertical surfaces as required for proper bonding and then paint with light coating of asphalt cement or emulsified asphalt.
f. At terminations of new surface courses: Feather asphalt mixture into existing surface over such distance as may be required to produce smooth riding transition.
g. Base-course and single-course construction: Joined by vertical butt joints, finished and rolled to smooth surface.
h. Rolling:
1) Perform initial or "breakdown" rolling with tandem power roller and follow spreading operation when mixture has reached temperature where it does not "pick up" on rolls.
2) Keep rolls properly moistened but do not use surplus of water.
3) Follow initial rolling with pneumatic roller when mixture is in proper condition and when rolling does not cause undue displacement, cracking, or shoving.
4) Begin rolling at sides and progress gradually to center, lapping each preceding track until entire surface has been rolled.
5) Terminate alternate trips of roller in stops at least three feet distant from any preceding stop.
6) At any place not accessible to roller, thoroughly compact mixture with tampers and finish, if necessary, with hot iron to provide uniform layer over entire width being paved.

3. Provide finish surface having uniform texture.

C. Fog sealing:
1. Fog seal asphalt pavement after compaction with fog sealing material applied at rate of 0.05 gallons per square yard at the following locations:
a. All asphalt pavement.

D. Full-depth asphalt pavement:
1. Contractor's option:
a. Install either asphalt and aggregate base material or full-depth asphalt pavement in areas where paving is indicated on the Drawings or specified to be 2 inches of asphalt concrete over aggregate base course.
b. If option is selected to install full-depth asphalt pavement, prepare subgrade as previously specified in this Section.
c. Substitute asphalt concrete for aggregate base at ratio of 1 inch of asphalt concrete to 2-1/2 inches of aggregate base material. Use full-depth asphalt pavement not less than 4 inches in thickness after compaction.
d. Place asphalt concrete in courses of not more than 4 inches.
e. Use compaction equipment in accordance with following course thicknesses:
1) 1- to 2-inch thickness: Minimum 8-ton roller.
2) 2- to 3-inch thickness: Minimum 10-ton roller.
3) 3- to 4-inch thickness: Minimum 12-ton roller.
2. Pneumatic rollers used for initial or secondary rolling: Use 12 to 15 tons with tires capable of 90-pounds-per-square-inch inflation pressure.

3. Asphalt concrete for full-depth asphalt pavement:
    a. Asphalt concrete as previously specified in this Section.
    b. Apply bituminous prime coats where full-depth asphalt pavement is installed.
    c. Contractor's option: If Contractor elects to use full-depth asphalt pavement, at road shoulders reduce aggregate base course to minimum aggregate thickness of 4 inches.
4. Except for asphalt thickness, aggregate base course thickness, and prime coating, full-depth asphalt pavement shall comply with requirements of this Section.

3.03 FIELD QUALITY CONTROL

A. Base course density tests:
    1. Density tests shall be taken at locations suitable to confirm compliance with compaction requirements.
    2. Take a minimum of 1 test per 1,000 square yards, for each lift.

B. Placement:
    1. Place the mixture on the roads, pavements, or walks at a temperature not less than 225 degrees Fahrenheit.

C. Curing time:
    1. Allow asphalt concrete to cure for the following time periods:
        a. Minimum 24 hours before foot traffic is allowed.
        b. Minimum 5 days before vehicle traffic is allowed.
        c. Minimum 10 days before overnight parking is allowed.
        d. Minimum 20 days before heavy construction vehicle traffic is allowed.
    2. Contractor shall provide barricades and signs as required to enforce curing time.

D. Asphalt tests:
    1. Provide sampling and control testing for the asphalt concrete.
        a. Location, type, and size of the samples: Suitable to determine conformance with stability, density, thickness, compaction, and other specified requirements.
        b. Use an approved power saw or core drill for cutting samples.
        c. Furnish tools, labor, and materials for cutting samples, testing, and replacing the pavement where samples were removed.
        d. Take a minimum of 1 sample per 200 tons of asphalt concrete placed.

E. Inspection:
    1. Asphalt concrete:
        a. Test with a 10-foot straightedge laid on the surface parallel with the centerline of the road. Variation of the surface from the testing edge of the straightedge not to exceed 1/4 inch.
        b. Test each course with running water applied on the surface of the pavement. Water shall flow in the direction indicated on the Drawings. After stopping the water, the pavement surface shall have no areas with standing water.

END OF SECTION

SECTION 02836

INTERLOCKING BLOCK RETAINING WALL

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete modular interlocking block retaining wall.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C90 - Standard Specification for Loadbearing Masonry Units.
   2. C140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.

1.03 SUBMITTALS

A. General: Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Latest edition of manufacturer's specifications for proposed materials, method of installation, and list of material proposed for use.

C. Shop drawings and calculations:
   1. Shop drawings including design calculations prepared by the manufacturer of the modular units.
   2. Calculations: Submit engineering structural design calculations for retaining walls, sealed and signed by a licensed registered Professional Engineer licensed in the state where the project is located.

D. Samples:
   1. Samples of products specified in this Section.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Prevent excessive mud, wet cement, epoxy, and similar materials which may affix themselves from coming in contact with the modular units.

B. Protect the materials from damage:
   1. Damaged materials shall not be incorporated into the retaining wall structure.
   2. Damaged materials shall be removed from the jobsite upon discovery.

1.05 SEQUENCING AND SCHEDULING

A. Order units well before start of installation to ensure adequate time for manufacturing and curing before start of installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Keystone Retaining Wall Systems, Standard.
   2. Anchor Wall Systems, Anchor Diamond Unit.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Design and install concrete modular retaining wall in accordance with manufacturer's suggested design procedure.
   2. Design retaining walls in accordance with the building codes specified in Section 01410 - Regulatory Requirements.
   3. Seismic lateral force:
      a. In accordance with seismic design criteria as specified in Section 01850 - Design Criteria.

2.03 CONCRETE UNITS

A. Concrete units: In accordance with ASTM C90 and ASTM C140.

B. Compressive strength:
   1. Concrete units shall have a minimum compressive strength of 3,000 pounds per square inch at 28 days.
   2. The concrete shall have a maximum moisture absorption of 8 percent.

C. Exterior dimensions may vary in accordance with ASTM C90.

D. Units shall have angled sides capable of concave and convex alignment curves with a minimum radius of 3.5 feet. Where applicable for straight walls, use non-angled straight side cap units.

E. Standard unit: 8 inches high by 18 inches wide, unless otherwise indicated on the Drawings, or other sizes as needed to minimize cutting.

F. Cap units: 4 inches high. Provide straight-sided or beveled as required and indicated on the Drawings for curved walls and angles.

G. Color: Integral natural concrete gray. Ensure exposed-to-view finish surfaces of concrete block units are uniform in color and appearance.

2.04 BASE LEVELING PAD MATERIAL

A. Material shall consist of compacted sand, gravel, or aggregate base course.
   1. Pea gravel shall not be used.

2.05 UNIT FILL

A. Fill for units shall drain rock, Class 2 permeable or aggregate base course as specified in Section 02300 - Earthwork.
   1. Gradation of the fill shall be approved by the Engineer.

B. Place recommended fill behind the retaining wall units.
   1. Pea gravel shall not be used.

2.06 BACKFILL

A. Do not use unsuitable soils for backfill or in the reinforced soil mass.
   1. Use backfill as specified in Section 02300 - Earthwork.

2.07 GEOGRID

A. Geogrid shall have a minimum ultimate strength of 2,600 pounds per foot, machine direction, and 1,300 pound per foot, cross direction in accordance with ASTM D4595.

B. Geogrid shall weigh a minimum of 5.5 ounces per square yard in accordance with ASTM D3776.

C. Geogrid products shall be high-density polyethylene expanded sheet or polyester woven fiber materials, specifically fabricated for use as soil reinforcement.

D. Manufacturers
   1. One of the following or equal:
      a. TC Mirafi, Miragrid 5T.
      b. Propex, Stragrid SG350.

2.08 MISCELLANEOUS

A. Materials such as adhesives and pins shall be in accordance with manufacturer's recommendations.

PART 3 EXECUTION

3.01 EXCAVATION

A. Excavate to the lines and grades indicated on the Drawings. Take care to not disturb embankment materials beyond lines indicated on the Drawings.

3.02 FOUNDATION SOIL PREPARATION

A. Excavate foundation soil as required for leveling pad dimensions recommended by manufacturer.

B. Foundation soil shall be approved by the Engineer to confirm that the actual soil conditions meet or exceed assumed design strength.
   1. Soils not meeting required strength shall be removed and replaced with acceptable material.

C. Fill over-excavated areas with compacted backfill material.

3.03 BASE LEVELING PAD

A. Place leveling pad materials to a minimum thickness of 6 inches.

B. Material shall be compacted so as to provide a level surface on which to place the first course of units.
   1. Compaction shall be to 95 percent of Standard Proctor for sand or gravel type materials.
   2. For crushed rock, material shall be densely compacted.

C. Prepare leveling pad to ensure complete contact of retaining wall units with base. Gaps shall not be allowed.

3.04 UNIT INSTALLATION

A. Erect units in accordance with manufacturer's printed instructions and as specified.

B. First course of concrete wall units shall be placed on the prepared base material.
   1. Units shall be checked for level and alignment.
   2. The top of units shall be at the same elevation.

C. Ensure that the units are in full contact with base.

D. Place units side by side for full length of wall alignment. Alignment may be done using a string line or offset of wall line.

E. Fill voids at units with fill material.

F. Sweep excess material from top of units and install next course.
   1. Ensure each course is completely filled, backfilled, and compacted prior to proceeding to next course.

G. A minimum of 12 inches of free-draining backfill shall be placed behind the units.

H. As appropriate where wall changes elevation, units can be stepped with grade or turned into the embankment with a convex return end.
   1. Provide appropriate buried units on compacted leveling pad in area of convex return end.

3.05 CAP UNIT INSTALLATION

A. Apply construction adhesive to the top surface of the unit below and place the cap unit into desired position.

B. Backfill and compact to finish grade.

3.06 GEOSYNTHETIC REINFORCEMENT

A. The geogrid soil reinforcement shall be laid horizontally on compacted backfill and connected to the concrete wall units in accordance with the manufacturer's recommendations.
   1. Pull geogrid taut and anchor before backfill is placed on it.

B. Remove slack in the geogrid at the wall unit connections.

C. Lay geogrid at the proper elevation and orientation as recommended by manufacturer.

D. Verify correct orientation (roll direction) of the geogrid.

E. Pull pinned geogrid taut to eliminate loose folds. Stake or secure back edge of geogrid prior to and during backfill and compaction.

F. Follow manufacturer's recommendation for overlap requirements of uniaxial and biaxial geogrids.

3.07 FILL PLACEMENT

A. Backfill material shall be placed in 6 to 8-inch lifts and compacted to 95 percent of maximum density.

B. Place, spread, and compact backfill in such a manner that minimizes the development of slack or loss of pretension of the geogrid.

C. Use only hand-operated compaction equipment within 3 feet of the back surface of the units.

D. Place backfill from the wall back into the embankment to ensure that the geogrid remains taut.

E. Do not operate tracked construction equipment directly on the geogrid.
   1. A minimum backfill thickness of 6 inches is required prior to operation of tracked vehicles over the geogrid.
   2. Keep turning of tracked vehicles to a minimum to prevent tracks from displacing the fill and damaging the geogrid.

F. Rubber-tired equipment may pass over the geogrid reinforcement at slow speeds of less than 10 miles per hour. Avoid sudden braking and sharp turning.

3.08 ADJUSTING AND CLEANING

A. Replace damaged units with new units during construction.

B. Remove debris caused by this construction and leave adjacent areas broom clean.

END OF SECTION

SECTION 02952

PAVEMENT RESTORATION AND REHABILITATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Resurfacing roads and paved surfaces in which surface is removed or damaged by installation of new work.

1.02 SUBMITTALS

A. Mix designs:
   1. Prior to placement of asphalt concrete, submit full details, including design and calculations for the asphalt concrete mix proposed.
   2. Submit gradation of aggregate base.
   3. Submit proposed mix design of portland cement concrete.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Limiting dimensions:
      a. Determine the exact lengths and dimensions of such roads, pavements, parking areas, and walks that will require removal and replacement for new work.
      b. Join existing surfaces to terminals of new surfacing in smooth juncture.

2.02 MATERIALS

A. Aggregate base course: As specified in Section 02050 - Soil and for Earthwork.

B. Asphalt pavement: As specified in Section 02742 - Asphaltic Concrete Paving.

C. Portland cement concrete replacement material: Class A concrete as specified in Section 03300 - Cast-in-Place Concrete.

2.03 EQUIPMENT

A. Roads, pavements, parking areas, and walks:
   1. Equipment requirements: Good condition, capable of performing work intended in satisfactory manner.

2.04 ACCESSORIES

A. Material for painting asphalt concrete pavement: Tack coat as specified in Section 02742 - Asphaltic Concrete Paving.

PART 3 EXECUTION

3.01 INSTALLATION

A. Aggregate surface removal replacement:
   1. When trench cut is in aggregate surfaced areas, replace aggregate base course material with material matching existing material compacted to 95 percent of its maximum density.

B. Pavement removal and temporary asphalt replacement:
   1. Install temporary asphalt pavement or first course of permanent pavement replacement immediately following backfilling and compaction of trenches that have been cut through existing pavement.
   2. Except as otherwise provided, maintain this temporary pavement in safe and reasonably smooth condition until required permanent pavement is installed.
   3. Remove and dispose of temporary paving from project site.
   4. Where longitudinal trench is partly in pavement, replace pavement to original pavement edge, on a straight line, parallel to centerline of roadway.
   5. Where no part of longitudinal trench is in pavement, surfacing replacement shall only be required where existing surfacing materials have been removed.

C. Asphalt pavement replacement:
   1. Replace asphalt pavement to same thickness as adjacent pavement and match as nearly as possible adjacent pavement in texture, unless otherwise indicated on the Drawings.
   2. Cut existing asphalt pavements to be removed for trenches or other underground construction by wheel cutter, clay spade, or other device capable of making neat, reasonably straight and smooth cut without damaging adjacent pavement. Cutting device operation shall be subject to acceptance of Engineer.
   3. Cut and trim existing pavement after placement of required aggregate base course and just prior to placement of asphalt concrete for pavement replacement, and paint trimmed edges with material for painting asphalt concrete pavement immediately prior to constructing new abutting asphalt pavements. No extra payment will be made for these items, and costs incurred in performing this work shall be incidental to pipe laying or pavement replacement.
   4. Conform replacement of asphalt pavement to contour of original pavement.

D. Portland cement concrete pavement replacement:
   1. Where trenches lie within portland cement concrete section of streets, alleys, sidewalks, and similar concrete construction, saw cut such concrete (to a depth of not less than 1-1/2 inches) to neat, vertical, true lines in such manner adjoining surfaces are not damaged.

2. Place portland cement concrete replacement material to dimension as indicated on the Drawings.
3. Provide expansion joints that match existing.
4. Before placing replacement concrete, thoroughly clean edges of existing pavement and wash with neat cement and water.
5. Surface finish: Wood float finish.

E. Curb, gutter, and sidewalk replacement:
1. Where any concrete curb, gutter, or sidewalk has been removed or displaced, replace to nearest construction joints with new Class A curb, gutter, or sidewalk to same dimensions and finish as original construction that was removed:
a. Provide expansion joints of same spacing and thickness as original construction.

3.02 FIELD QUALITY CONTROL

A. Tests:
1. Asphalt concrete as specified in Section 02742 - Asphaltic Concrete Paving.
2. Concrete as specified in Section 03300 - Cast-in-Place Concrete.

B. Inspection:
1. Asphalt concrete:
a. Lay 10-foot straightedge parallel to centerline of trench when the trenches run parallel to street, and across pavement replacement when trench crosses street at angle.
b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.
2. Portland cement concrete replacement pavement:
a. Lay 10-foot straightedge either across pavement replacement or longitudinal with centerline of gutter or ditch.
b. Remove and correct any deviation in cut pavement replacement greater than 1/4 inch in 10 feet.

END OF SECTION

SECTION 03055

ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bonding reinforcing bars and all thread rods in concrete using adhesives.

1.02 REFERENCES

A. American Concrete Institute (ACI).
   1. 355.4 - Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary.

B. American National Standards Institute (ANSI):
   1. Standard B212.15 - Carbide Tipped Masonry Drills and Blanks for Carbide Tipped Masonry Drills.

C. ASTM international (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

D. Concrete Reinforcing Steel Institute (CRSI).

E. ICC Evaluation Service, Inc. (ICC-ES):
   1. AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.

F. Society for Protective Coatings (SSPC):
   1. SP-1 - Solvent Cleaning.

1.03 DEFINITIONS

A. Evaluation Service Report (ESR): Report prepared by ICC-ES, or other testing agency acceptable to Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and to document its acceptance for use under the Building Code specified in Section 01410 - Regulatory Requirements.

1.04 SUBMITTALS

A. Product data: Technical data for adhesives, including:
   1. Manufacturer's printed installation instructions (MPII).

2. Independent laboratory test results indicating allowable loads in tension and shear for concrete of the types included in this Work, with load modification factors for temperature, spacing, edge distance, and other installation variables.
3. Handling and storage instructions.

B. Quality control submittals:
1. Special inspection: Detailed step-by-step instructions for the special inspection procedures required by the building code specified in Section 01410 - Regulatory Requirements.
2. For each adhesive to be used, Evaluation Report confirming that the product complies with the requirements of AC308 for both un-cracked and cracked concrete and for use in Seismic Design Categories A through F.
3. Installer qualifications:
   a. Submit evidence of successful completion of adhesive manufacturer's installation training program.
   b. Submit evidence of current certification for installation of inclined and overhead anchors under sustained tension loading.

C. Inspection and testing reports:
1. Inspections: Field quality control: Reports of inspections and tests.
   a. Inspections: Field quality assurance: Reports of special inspections and tests.

1.05 QUALITY ASSURANCE

A. Qualifications:
1. Installation requirements:
   a. Have available at the site, and install anchors in accordance with, the adhesive manufacturer's printed installation instructions.
2. Installer qualifications:
   a. Demonstrating successful completion of adhesive manufacturer's on-site training program for installation of adhesive-bonded anchors.
   b. Holding current certification for installation of adhesive-bonded anchors by a qualified organization acceptable to the Engineer and to the Building Official.
      1) Organizations/certification programs deemed to be qualified are:
         a) ACI-CRSI Adhesive Anchor Installer Certification Program.
         b) Adhesive anchor manufacturer's certification program, subject to acceptance by the Engineer and the Building Official.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products as follows, unless more restrictive requirements are recommended by the manufacturer:
1. Store adhesives and adhesive components on pallets or shelving in a covered-storage area protected from weather.

2. Control temperature to maintain storage within manufacturer's recommended temperature range.
    a. If products have been stored at temperatures outside manufacturer's recommended range, test by methods acceptable to the Engineer to confirm acceptability before installing in the Work.
3. Dispose of products that have passed their expiration date.

1.07 PROJECT CONDITIONS

A. As specified in Section 01850 - Design Criteria.

B. Seismic Design Category (SDC) for structures: SDC = D.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials: Use end products of one manufacturer in order to achieve structural compatibility and singular responsibility.

B. Adhesives shall have a current Evaluation Report documenting testing and compliance with the requirements or ACI 355.4 and of ICC-ES AC308 for use with un-cracked concrete and with cracked concrete in the Seismic Design Category specified.

C. Bond reinforcing bars and all thread rods in concrete using epoxy adhesive unless other adhesives specified are specifically indicated on the Drawings or approved in writing by the Engineer.

2.02 EPOXY ADHESIVE

A. Materials:
1. Meeting the physical requirements of ASTM C881, Type IV, Grade 3, Class B or C depending on site conditions.
2. 2-component, 100 percent solids, insensitive to moisture.
3. Cure temperature, pot life, and workability: Compatible with intended use and environmental conditions.

B. Packaging:
1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle.
    a. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
    b. Provide nozzle extensions as required to allow full-depth insertion and filing from the bottom of the hole.
2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

C. Manufacturers: One of the following or equal:
   1. Hilti, Inc., HIT-RE 500-V3.
   2. Simpson Strong-Tie Co., Inc., SET-XP.

2.03 ACRYLIC AND HYBRID ADHESIVE

A. Materials:
   1. 2-component, high-solids, acrylic-based or hybrid acrylic and epoxy-based adhesive.
   2. Approved by the manufacturer for installation at substrate temperatures of 0 degrees Fahrenheit and above.

B. Packaging:
   1. Disposable, self-contained cartridge system furnished in side-by-side cartridges designed to fit into a manually or pneumatically operated caulking gun, and with resin and hardener components isolated until mixing through manufacturer's static mixing nozzle. Nozzle designed to dispense components in the proper ratio and to thoroughly blend the components for injection from the nozzle directly into prepared hole.
   2. Container markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

C. Manufacturers: One of the following or equal:
   1. Hilti, Inc., HIT-HY-200.
   2. Simpson Strong-Tie Co., Inc., AT-XP.

2.04 ALL THREAD RODS

A. Materials: As specified in Section 05120 - Structural Steel Framing for rods, nuts and washers.

2.05 REINFORCING BARS

A. As specified in Section 03200 - Concrete Reinforcing.

PART 3 EXECUTION

3.01 GENERAL

A. Execution of this work is restricted to installers who have personally completed the adhesive manufacturer's on-site training for the products to be installed, and who are personally certified through a qualified certification program described under Quality Assurance and accepted by the Engineer and the Building Official.
   1. Do not install holes or adhesive until training is complete.

B. Perform work in strict compliance with the accepted MPII and the following instructions. Where the accepted MPII and the instructions conflict, the MPII shall prevail.

C. Install reinforcing bars and all thread rods to embedment depth, and at spacing and locations indicated on the Drawings.
   1. If embedment depth is not indicated, contact Engineer for requirements.
   2. Do not install adhesive-bonded all thread rods or reinforcing bars in upwardly inclined or overhead applications unless accepted in advance by Engineer.

3.02 PREPARATION

A. Do not begin installation of adhesive bonded anchors until:
   1. Concrete has achieved an age of at least 21 days after placement.
   2. On-site training in installation of adhesive bonded anchors by manufacturer's technical representative is complete. Do not drill holes in concrete or install adhesive and embeds in holes.

B. Review manufacturer's printed installation instructions (MPII) and "conditions of use" stipulated in the Evaluation Report before beginning work.
   1. Bring to the attention of the adhesive manufacturer's technical representative any discrepancies between these documents and resolve before proceeding with installation.

C. Install adhesive bonded anchors in full compliance with manufacturer's printed installation instructions using personnel who have successfully completed manufacturer's on-site training for products to be used and who hold certifications specified in this Section.

D. Confirm that adhesive and substrate receiving adhesive are within manufacturer's recommended range for temperature and moisture conditions, and will remain so during the curing time for the product.

3.03 HOLE SIZING AND INSTALLATION

A. Drilling holes:
   1. Determine location of reinforcing bars or other obstructions with a nondestructive indicator device, and mark locations with construction crayon on the surface of the concrete.
   2. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without prior acceptance by Engineer.

B. Hole drilling equipment:
   1. Electric or pneumatic rotary impact type with medium or light impact.
      a. Installation of anchors in cored holes is not permitted.
      b. Set drill to "rotation only" mode, or to "rotation plus hammer" mode in accordance with the manufacturer's installation instructions and the requirements of the Evaluation Report.
      c. Where edge distances are less than 2 inches and "rotation plus hammer" mode is permitted, use lighter impact equipment to prevent micro-cracking and concrete spalling during the drilling process.

2. Drill bits: Carbide-tipped in accordance with ANSI B212-15 unless otherwise recommended by the manufacturer or required as a "condition of use" in the Evaluation Report.
    a. Hollow drill bits with flushing air systems are preferred. Air supplied to hollow drill bits shall be free of oil, water, or other contaminants that will reduce bond.

C. Hole diameter: As recommended in the manufacturer's installation instructions and the Evaluation Report.

D. Hole depth: As recommended in the manufacturer's installation instructions to provide minimum effective embedment indicated on the Drawings.

E. Obstructions in drill path:
    1. If an existing reinforcing bar or other obstruction is hit while drilling a hole, unless otherwise accepted by Engineer, stop drilling. Prepare and fill the hole with dry-pack mortar. Relocate the hole to miss the obstruction and drill another hole to the required depth.
        a. Obtain Engineer's acceptance of distance between abandoned and relocated holes before proceeding with the relocation.
        b. Allow dry-pack mortar to cure to a strength equal to that of the surrounding concrete before resuming drilling in the area.
        c. Epoxy grout may be substituted for dry-pack mortar when accepted by Engineer.
    2. Avoid drilling an excessive number of holes in an area of a structural member, which would excessively weaken the member and endanger the stability of the structure.
    3. When existing reinforcing steel is encountered during drilling and when specifically accepted by Engineer, enlarge the hole by 1/8 inch, core through the existing reinforcing steel at the larger diameter, and resume drilling at original hole diameter using pneumatic rotary impact drill.
    4. Bent bar reinforcing bars: Where edge distances are critical, and interference with existing reinforcing steel is likely, if acceptable to Engineer, drill hole at 10 degree (or less) angle from axis of reinforcing bar or all thread rod being installed.

F. Cleaning holes:
    1. Insert air nozzle to bottom of hole and blow out loose dust.
        a. Use compressed air that is free of oil, water, or other contaminants that will reduce bond.
        b. Provide minimum air pressure of 90 pounds per square inch for not less than 4 seconds.
    2. Using a stiff bristle brush with diameter that provides contact around the full perimeter of the hole, vigorously brush hole to dislodge compacted drilling dust.
        a. Insert brush to the bottom of the hole and withdraw using a simultaneous twisting motion.
        b. Repeat at least 4 times.
    3. Repeat the preceding steps as required to remove drilling dust or other material that will reduce bond, and in the number of cycles required by the MPII and the Evaluation Report.

4. Leave prepared holes clean and dry.
5. Protect prepared and cleaned holes from contamination and moisture until adhesive is installed.
6. Re-clean and dry previously prepared holes if, in the opinion of the Engineer, the hole has become contaminated after initial cleaning.

3.04 INSTALLATION OF ADHESIVE AND INSERTS

A. Clean and prepare inserts reinforcing bars and all thread rods:
   1. Prepare embedded length of reinforcing bars and all thread rods by cleaning to bare metal. Inserts shall be free of oil, grease, paint, dirt, mill scale, rust, or other coatings that will reduce bond.
   2. Solvent clean prepared reinforcing bars and all thread rods over the embedment length in accordance with SSPC SP-1. Provide an oil and grease free surface for bonding of adhesive to steel.

B. Fill holes with adhesive:
   1. Starting at the bottom of the hole, fill hole with adhesive inserting the reinforcing bar or all thread rod.
   2. Fill hole as nozzle is withdrawn without creating air voids.
   3. Unless otherwise indicated on the Drawings, fill hole with sufficient adhesive so that excess adhesive is extruded out of the hole when the reinforcing bar or all thread rod is inserted.
   4. Where necessary, seal hole at surface of concrete to prevent loss of adhesive during curing.

C. Installing reinforcing bars and all thread rods.
   1. Unless otherwise indicated on the Drawings, install bars and rods perpendicular to the concrete surface.
   2. Insert reinforcing bars and all thread rods into adhesive in accordance with manufacturer's recommended procedures.
   3. Confirm that insert has reached the designated embedment in the concrete, and that adhesive completely surrounds the embedded portion.
   4. Securely brace bars and all thread rods in place to prevent displacement while the adhesive cures. Bars and rods displaced during curing will be considered damaged and replacement will be required.
   5. Clean excess adhesive from the mouth of the hole.

D. Curing and loading.
   1. Provide and maintain curing conditions recommended by the adhesive manufacturer for the period required to fully cure the adhesive at the temperature of the concrete.
   2. Do not disturb or load bonded embeds until manufacturer's recommended cure time, based on temperature of the concrete, has elapsed.

3.05 POST-INSTALLATION ACTIVITIES

A. Do not bend bars or all-thread rods after bonding to the concrete, unless accepted in advance by the Engineer.

B. Attachments to all thread rods:
   1. After assemblies to be connected are placed, install nuts and washers for threaded rods as indicated on the Drawings.
   2. Draw nuts down tight, using practices specified for "snug tight" installation of bolts in steel to steel connections.

3.06 FIELD QUALITY CONTROL

A. Provide field quality control over the Work of this Section as specified in Section 01450 - Quality Control.

B. Do not allow work described in this Section to be performed by individuals who do not hold the specified certifications and who have not completed the specified job site training.

C. Manufacturer's services:
   1. Before beginning installation, furnish adhesive manufacturer's technical representative to conduct on-site training in proper storage and handling of adhesive, drilling and cleaning of holes, and preparation and installation of reinforcing bars and all thread rods.
      a. Provide notice of scheduled training to Engineer and to Special Inspector(s) not less than 10 working days before training occurs. Engineer and Special Inspector may attend training sessions.
   2. Submit record, signed by the manufacturer's technical representative, listing Contractor's personnel who completed the training. Only qualified personnel who have completed manufacturer's on-site training shall perform installations.

D. Field inspections and testing:
   1. Hole drilling and preparation.
   2. Results: Submit records of inspections and testing to Engineer by electronic copies within 24 hours after completion.

3.07 FIELD QUALITY ASSURANCE

A. Provide field quality assurance over the Work of this Section as specified in Section 01450 - Quality Control.

B. Special inspections, special tests, and structural observation:
   1. Provide as specified in Section 01455 - Regulatory Quality Assurance.
   2. Frequency of inspections:
      a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Evaluation Report for the product installed.
      b. Provide continuous inspection for the initial installation of each type and size of adhesive bonded reinforcing bar and all thread rod. Subsequent installations of the same anchor may be installed with periodic inspection as defined in subsequent paragraphs.
      c. Provide continuous inspection of all drilling, cleaning and bonding activities for bars and rods installed in horizontal an upwardly inclined positions.

3. Preparation:
    a. Review Drawings and Specifications for the Work to be observed.
    b. Review adhesive manufacturer's MPII and recommended installation procedures.
    c. Review Evaluation Report "Conditions of Use" and "Special Inspection" requirements.
4. Inspection: Periodic:
    a. Initial inspection. Provide an initial inspection for each combination of concrete and reinforcing bar strength or concrete strength and all thread rod material being installed. During initial inspection, observe the following for compliance with the installation requirements.
        1) Concrete: Class (minimum specified compressive strength) and thickness.
        2) Environment: Temperature conditions at work area, and moisture conditions of concrete and drilled hole.
        3) Holes: Locations, spacing, and edge distances; verification of drill bit compliance with requirements; cleaning equipment and procedures; cleanliness of hole. Before adhesive is placed, confirm that depth and preparation of holes conforms to the requirements of the Contract Documents, the MPII, and the "conditions of use" listed in the Evaluation Report.
        4) Adhesive: Product manufacturer and name; lot number and expiration date; temperature of product at installation; installation procedure. Note initial set times observed during installation.
        5) Reinforcing bars and all thread rods: Material diameter and length; steel grade and/or strength; cleaning and preparation; cleanliness at insertion; minimum effective embedment provided.
    b. Subsequent inspections: Subsequent installations of the same reinforcing bars or all thread rods may be performed without the presence of the special inspector, provided that:
        1) There is no change in personnel performing the installation, the general strength and characteristics of the concrete receiving the inserts, or the reinforcing bars and all thread rods being used.
        2) For ongoing installations, the special inspector visits the site at least once per day during each day of installation to observe the work for compliance with material requirements and installation procedures.
5. Inspection: Continuous.
    a. Make observations as described under "Inspection - Periodic, Initial Inspection" during all drilling, cleaning, and bonding activities for all bars and rods installed.
6. Records of inspections:
    a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
    b. Submit electronic copies of inspection reports to Engineer within 24 hours after completion of inspection.

END OF SECTION

SECTION 03071

EPOXIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Epoxy.
   2. Epoxy gel.
   3. Epoxy bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C881 - Standard Specification for Epoxy-Resin-Base Systems for Concrete.
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.

1.03 SUBMITTALS

A. General: Submit as specified in Section 01330 - Submittal Procedures.

B. Product Data: Submit manufacturer's data completely describing epoxy materials:
   1. Submit evidence of conformance to ASTM C881. Include manufacturer’s designations of Type Grade, Class, and Color.
   2. Submit documentation that materials meet or exceed the specified strength and performance characteristics. Indicate test methods and test results.

C. Quality control Submittals:
   1. Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Performance requirements:
   1. Provide epoxy materials that are new.
   2. Store and use products within limitations set forth by manufacturer.
   3. Perform and conduct work of this Section in neat orderly manner.

2.02 MATERIALS

A. General:
   1. Moisture tolerant, water-insensitive, two-component epoxy resin adhesive material containing 100 percent solids, and meeting or exceeding the performance properties specified when tested in accordance with the standards specified.

B. Epoxy: Low viscosity product in accordance with ASTM C881; Types I, II, and IV; Grade 1; Class C, except as modified in this Section.
   1. Manufacturers: One of the following, or equal:
      a. Dayton Superior, Unitex Pro-Poxy 100.
      b. Sika Corporation, Sikadur 35 Hi-Mod LV.
   2. Required properties:

Table 1 - Material Properties - Epoxy

Property	Test Method	Required Results ("neat")
Tensile Strength (7-day)	ASTM D638	7,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	10,000 pounds per square inch, minimum.
Bond Strength (harded concrete to harded concrete after 2-day cure)	ASTM C882	1,000 pounds per square inch, minimum. Concrete failure before failure of epoxy.
Viscosity (mixed)		250 to 550 centipoise

Notes:
1. Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

C. Epoxy gel: Non-sagging product in accordance with ASTM C881, Types I and IV, Grade 3, Class C.
   1. Manufacturers: One of the following, or equal:
      a. Dayton Superior, Sure Anchor J50.
      b. Master Builders Solutions/Sika, MasterEmaco ADH 327.
      c. Sika Corp., Sikadur 31, Hi-Mod Gel.
   2. Required properties:

Table 2 - Material Properties - Epoxy Gel

Property	Test Method	Required Results ("neat")
Tensile Strength (7-day)	ASTM D638	2,000 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,000 pounds per square inch, minimum.
Bond Strength (14-day)	ASTM C882	1,500 pounds per square inch, minimum.

Notes:
1. Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

D. Epoxy bonding agent: Non-sagging product in accordance with ASTM C881, Type II, Grade 2, Class C.
   1. Manufacturers: One of the following, or equal:
      a. Dayton Superior, Sure Bond J58.
      b. Master Builders Solutions/Sika, MasterEmaco ADH 326.
      c. Sika Chemical Corp., Sikadur 32 Hi-Mod LPL.
   2. Required properties:

Table 3 - Material Properties - Epoxy Bonding Agent

Property	Test Method	Required Results
Tensile Strength (7-day)	ASTM D638	3,300 pounds per square inch, minimum.
Compressive Yield Strength (7-day)	ASTM D695	8,300 pounds per square inch, minimum.
Bond Strength (14-days)	ASTM C882	1,800 pounds per square inch, minimum. Concrete failure before failure of epoxy bonding agent.
Pot Life	-	Minimum 60 minutes at 77 degrees Fahrenheit.

Notes:
1. Testing results are for materials installed and cured at a temperature between 72 and 78 degrees Fahrenheit for 7 days, unless otherwise noted.

   3. If increased contact time is required for concrete placement, epoxy resin/Portland cement bonding agent, as specified in Section 03072 - Epoxy Resin/Portland Cement Bonding Agent, may be used instead of epoxy bonding agent.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.

B. Epoxy:
   1. Apply in accordance with manufacturer's installation instructions.

C. Epoxy gel:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Use for vertical or overhead work, or where high viscosity epoxy is required.
   3. Epoxy gel used for vertical or overhead work may be used for horizontal work.

D. Epoxy bonding agent:
   1. Apply in accordance with manufacturer's installation instructions.
   2. Will not be required for filling form tie holes or for normal finishing and patching of similar sized small defects.

END OF SECTION

SECTION 03072

EPOXY RESIN/PORTLAND CEMENT BONDING AGENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Epoxy resin/portland cement bonding agent.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
   2. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   3. C496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   4. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

B. Federal Highway Administration (FHWA):
   1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Sika Corp., Sika Armatec 110.

B. Substitutions: The use of other than the specified product will be considered, providing the Contractor requests its use in writing to the Engineer. This request shall be accompanied by:
   1. A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds specified performance criteria, tested in accordance with the specified test standards.
   2. Documented proof that the proposed substitute product has a 1-year proven record of performance of bonding portland cement mortar/concrete to hardened portland cement mortar/concrete, confirmed by actual field tests and 5 successful installations that the Engineer can investigate.

2.02 MATERIALS

A. Epoxy resin/portland cement adhesive:
   1. Component "A" shall be an epoxy resin/water emulsion containing suitable viscosity control agents. It shall not contain butyl glycidyl ether.

2. Component "B" shall be primarily a water solution of a polyamine.
3. Component "C" shall be a blend of selected portland cements and sands.
4. The material shall not contain asbestos.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Properties of the mixed epoxy resin/portland cement adhesive:
   1. Pot life: 75 to 105 minutes.
   2. Contact time: 24 hours.
   3. Color: Dark gray.

B. Properties of the cured epoxy resin/portland cement adhesive:
   1. Compressive strength in accordance with ASTM C109:
      a. 3 day: 4,500 pounds per square-inch minimum.
      b. 7 days: 6,500 pounds per square-inch minimum.
      c. 28 days: 8,500 pounds per square-inch minimum.
   2. Splitting tensile strength in accordance with ASTM C496:
      a. 28 days: 600 pounds per square-inch minimum.
   3. Flexural strength:
      a. 1,100 pounds per square-inch minimum in accordance with ASTM C348.
   4. Bond strength in accordance with ASTM C882 modified at 14 days:
      a. 0 hours open time: 2,800 pounds per square-inch minimum.
      b. 24 hours open time: 2,600 pounds per square-inch minimum.
   5. The epoxy resin/portland cement adhesive shall not produce a vapor barrier.
   6. Material must be proven to prevent corrosion of reinforcing steel when tested under the procedures as set forth by the FHWA Program Report Number FHWA-RD-86-193. Proof shall be in the form of an independent testing laboratory corrosion report showing prevention of corrosion of the reinforcing steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mixing the epoxy resin: Shake contents of Component "A" and Component "B." Empty all of both components into a clean, dry mixing pail. Mix thoroughly for 30 seconds with a jiffy paddle on a low-speed with 400 to 600 revolutions per minute drill. Slowly add the entire contents of Component "C" while continuing to mix for a minimum of 3 minutes and until uniform with no lumps. Mix only the quantity that can be applied within its pot life.

B. Placement procedure:
   1. Apply to prepared surface with stiff-bristle brush, broom, or "hopper-type" spray equipment:
      a. For hand applications: Place fresh plastic concrete/mortar while the bonding bridge adhesive is wet or dry, up to 24 hours.
      b. For machine applications: Allow the bonding bridge adhesive to dry for 12 hours minimum.

C. Adhere to all limitations and cautions for the epoxy resin/portland cement adhesive in the manufacturer's current printed literature.

3.02 CLEANING

A. Leave finished work and work area in a neat, clean condition without evidence of spillovers onto adjacent areas.

END OF SECTION

SECTION 03102

CONCRETE FORMWORK

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Concrete formwork.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117 - Specifications for Tolerances for Concrete Construction and Materials and Commentary.

B. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

C. Underwriters Laboratories (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Green Concrete: Concrete with less than 100 percent of the minimum specified compressive strength (f'_c).

1.04 SUBMITTALS

A. Information on proposed forming system:
   1. Submit in such detail as the Engineer may require to assure themselves that intent of the Specifications can be complied with by use of proposed system.
   2. Alternate combinations of plywood thickness and stud spacing may be submitted.

B. Form release agent. NSF 61 certification prepared by NSF, Underwriters Laboratories (UL) or other, similar, nationally recognized testing laboratory acceptable to the Engineer.

1.05 QUALITY ASSURANCE

A. Qualifications of formwork manufacturers: Use only forming systems by manufacturers having a minimum of 5 years of experience, except as otherwise specified, or accepted in writing by the Engineer.

B. Regulatory requirements: Install work of this Section in accordance with local, state, and federal regulations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Design of concrete forms, falsework, and shoring in accordance with local, state, and federal regulations.
   2. Design forms and ties to withstand concrete pressures without bulging, spreading, or lifting of forms.

B. Performance requirements:
   1. Construct forms so that finished concrete conforms to shapes, lines, grades, and dimensions indicated on the Drawings.
   2. It is intended that surface of concrete after stripping presents smooth, hard, and dense finish that requires minimum amount of finishing.
   3. Provide sufficient number of forms so that the work may be performed rapidly and present uniform appearance in form patterns and finish.
   4. Use forms that are clean and free from dirt, concrete, and other debris.
      a. Coat with form release agent if required, prior to use or reuse.

2.02 MANUFACTURED UNITS

A. Forms: Built-up plywood:
   1. Built-up plywood forms may be substituted for prefabricated forming system subject to following minimum requirements:
      a. Size and material:
         1) Use full size 4-foot by 8-foot plywood sheets, except where smaller pieces are able to cover entire area.
         2) Sheet construction: 5-ply plywood sheets, 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.
      b. Wales: Minimum 2-inch by 4-inch lumber.
      c. Studding and wales: Contain no loose knots and be free of warps, cups, and bows.

B. Forms: Steel or steel framed:
   1. Steel forms:
      a. Rigidly constructed and capable of being braced for minimum deflection of finish surface.
      b. Capable of providing finish surfaces that are flat without bows, cups, or dents.
   2. Steel framed plywood forms:
      a. Provide forms that are rigidly constructed and capable of being braced.
      b. Plywood paneling: 5-ply, 5/8-inch nominal or 3/4-inch nominal, made with 100 percent waterproof adhesive, and having finish surface that is coated or overlaid with surface which is impervious to water and alkaline calcium and sodium hydroxide of cement.

C. Form release agent.
   1. Effective, non-staining, bond-breaking coating compatible with form surfaces and concrete mixes used.

D. Form ties:
   1. General:
      a. Provide form ties for forming system selected that are manufactured by recognized manufacturer of concrete forming equipment.
      b. Do not use wire ties or wood spreaders of any form.
      c. Provide ties of type that accurately tie, lock, and spread forms.
      d. Provide form ties of such design that when forms are removed, they locate no metal or other material within 1-1/2 inches of the surface of the concrete.
      e. Do not allow holes in forms for ties to allow leakage during placement of concrete.
   2. Cone-snap ties:
      a. Cone-snap ties shall form a cone shaped depression in the concrete with minimum diameter of 1 inch at the surface of the concrete and minimum depth of 1-1/2 inches.
      b. Provide neoprene waterseal washer that is located near the center of the concrete.
   3. Taper ties:
      a. Neoprene plugs for taper tie holes: Size so that after they are driven, plugs are located in center third of wall thickness.

E. Incidentals:
   1. External angles:
      a. Where not otherwise indicated on the Drawings, provide with 3/4-inch bevel, formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, slabs, walls, beams, columns, and openings.
      b. Provide 1/4-inch bevel formed by utilizing true dimensioned wood or solid plastic chamfer strip on walkways, walls, and slabs at expansion, and construction joints.
   2. Keyways: Steel, plastic, or lumber treated with form release agent.

PART 3 EXECUTION

3.01 EXAMINATION

A. Site verification of conditions:
   1. Do not place concrete until forms have been checked for alignment, level, and strength, and mechanical and electrical inserts or other embedded items for correct location.

3.02 INSTALLATION

A. Forms: Built-up plywood:
   1. Studding:
      a. Spaced at 16 inches or 24 inches on center.
      b. Closer spacing may be required depending upon strength requirements of the forms, in order to prevent any bulging surfaces on faces of finished concrete work.
      c. Install studs perpendicular to grain of exterior plys of plywood sheets.
   2. Wales: Form wales of double lumber material with minimum size as specified in this Section.
   3. Number of form reuses: Depends upon durability of surface coating or overlay used, and ability to maintain forms in condition such that they are capable of producing flat, smooth, hard, dense finish on concrete when stripped.

B. Forms: Steel or steel framed:
   1. Steel forms:
      a. Adequately brace forms for minimum deflection of finish surface.
   2. Steel framed plywood forms:
      a. Rigidly construct and brace with joints fitting closely and smoothly.
      b. Number of form reuses: Depends upon durability of surface coating or overlay used.
   3. Built-up plywood forms: As specified in this Section may be used in conjunction with steel forms or steel framed plywood forms for special forming conditions such as corbels and forming around items which will project through forms.

C. Form bracing and alignment:
   1. Line and grade: Limit deviations to tolerances which will permit proper installation of structural embedded items or mechanical and electrical equipment and piping.
   2. Formwork:
      a. Securely brace, support, tie down, or otherwise hold in place to prevent movement.
      b. Make adequate provisions for uplift pressure, lateral pressure on forms, and deflection of forms.
   3. When second lift is placed on hardened concrete: Take special precautions in form work at top of old lift and bottom of new lift to prevent:
      a. Spreading and vertical or horizontal displacement of forms.
      b. Grout "bleeding" on finish concrete surfaces.
   4. Pipe stubs, anchor bolts, and other embedded items: Set in forms where required.
   5. Cracks, openings, or offsets at joints in formwork: Close those that are 1/16-inch or larger by tightening forms or by filling with acceptable crack filler.

D. Forms: Incidentals:
   1. Keyways: Construct as indicated on the Drawings.
   2. Reentrant angles: May be left square.
   3. Level strips: Install at top of wall concrete placements to maintain true line at horizontal construction joints.

4. Inserts:
    a. Encase pipes, anchor bolts, steps, reglets, castings, and other inserts, as indicated on the Drawings or as required, in concrete.
5. Pipe and conduit penetrations:
    a. Install pipe and conduit in structures as indicated on the Drawings, and seal with materials as specified in Section 07900 - Joint Sealants.

E. Form release agent:
1. Apply in accordance with manufacturer's instructions.

F. Form ties:
1. Cone-snap ties: Tie forms together at not more than 2-foot centers vertically and horizontally.

3.03 FORM REMOVAL

A. General:
1. Keep forms in place, as specified in the following paragraphs, to provide curing and to protect concrete surfaces and edges from damage.
1. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

B. Form removal:
1. Do not remove forms from concrete which has been placed when outside ambient air temperature is below 50 degrees Fahrenheit until the following conditions are satisfied:
    a. Concrete has sufficient strength to allow form removal without damage to surfaces.
    a. At least 48 hours have elapsed since the end of concrete placement.
    b. Provisions are in place to maintain moisture for curing concrete, and temperature at or above the required minimum curing temperature specified.
2. Vertical forms:
    a. Retain in place for a minimum of 24 hours after concrete is placed.
    b. If concrete has sufficient strength and hardness to resist surface or other damage after 24 hours, forms may be removed.
3. Other forms supporting concrete, and shoring: Retain in place as follows:
    a. Formed sides of footings: 24 hours minimum.
    c. Formed vertical sides of beams, girders, and similar members: 48 hours minimum.
    b. Forms below slabs, beams, and girders: Until concrete strength reaches specified strength f'c or until shoring is installed.
        1) Shoring for slabs, beams, and girders: Shore until concrete strength reaches minimum specified 28-day compressive strength.

3.04 SURFACE REPAIRS AND FINISHING

A. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified in Section 03300 - Cast-in-Place Concrete.

B. Form ties: Remove form ties from surfaces. Fill tie holes as follows:
   1. Remove form ties from surfaces.
   2. Roughen cone shaped tie holes by heavy sandblasting before repair.
   3. Dry pack cone shaped tie holes with dry-pack mortar as specified in Section 03600 - Grouting.
   4. Taper ties:
      a. After forms and taper ties are removed from wall, plug tie holes with neoprene plug as follows:
         1) Heavy sandblast and then clean tie holes.
         2) After cleaning, drive neoprene plug into each of taper tie holes with steel rod. Final location of neoprene plug shall be in center third of wall thickness. Bond neoprene plug to concrete with epoxy.
         3) Locate steel rod in cylindrical recess and against middle of plug during driving.
            a) At no time are plugs to be driven on flat area outside cylindrical recess.
      b. Dry-pack of taper tie holes:
         1) After installing plugs in tie holes, coat tie hole surface with epoxy bonding agent and fill with dry-pack mortar as specified in Section 03600 - Grouting.
            a) Place dry-pack mortar in holes in layers with thickness not exceeding tie hole diameter and heavily compact each layer.
            b) Dry-pack the outside of the hole no sooner than 7 days after the inside of the hole has been dry packed.
            c) Wall surfaces in area of dry-packed tie holes: On the water side of water containing structures and the outside of below grade walls:
               (1) Cover with minimum of 10 mils of epoxy gel.
               (2) Provide epoxy gel coating on wall surfaces that extend minimum of 2 inches past dry-pack mortar filled tie holes.
               (3) Provide finish surfaces that are free from sand streaks or other voids.

3.05 TOLERANCES

A. Finished concrete shall conform to shapes, lines, grades, and dimensions indicated on the Drawings.

B. Construct work within the tolerances in accordance with ACI 117, except as modified in the following paragraphs or as indicated on the Drawings.
   1. General:
      a. At certain locations in the Work, tolerances required for equipment placement and operation may be more restrictive than the general tolerance requirements of this Section.
      b. Confirm equipment manufacturers' required tolerances for location and operation of equipment that will be installed, and construct concrete to satisfy those requirements.
   2. Slabs:
      a. Slope: Uniformly sloped to drain when slope is indicated on the Drawings.
      b. Slabs indicated to be level: Have maximum vertical deviation of 1/8-inch in 10-foot horizontal length without any apparent changes in grade.
   3. Circular tank walls:
      a. The Contractor may deviate from finish line indicated on the Drawings by use of forms with chord lengths not to exceed 2 feet.
   4. Inserts and embedments:
      a. Set inserts and embedments to tolerances required for proper installation and operation of equipment or systems to which insert pertains.
      b. Maximum tolerances: As follows:

Item	Tolerance
Sleeves and inserts	Plus 1/8 Minus 1/8 inches.
Anchor bolts:	
Projected ends	Plus 1/4 Minus 0.0 inches.
Axial alignment	Not more than 2 degrees off the axis indicated on the Drawings.
Setting location	Plus 1/16 Minus 1/16 inches.
All embedments	Minimum 1 inch clearance from reinforcing steel.

      c. Securing embedded items in formwork by wiring or welding to reinforcement is not permitted.

C. Remove and replace work that does not conform to required tolerances. Procedures and products employed in and resulting from such re-work shall be acceptable to the Engineer.

END OF SECTION

SECTION 03154

HYDROPHILIC RUBBER WATERSTOP

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Hydrophilic rubber waterstop.

1.02 SUBMITTALS

A. General:
   1. Submit the following items for each type, style and size of hydrophilic waterstop to be installed.
   2. Product data:
      a. Manufacturer’s product data sheets.
         1) Include complete physical dimensions, expansion characteristics, and laboratory test reports indicating that average material properties conform to the requirements specified.
         2) Provide data sheets for all materials to be included in the waterstop system.
   3. Samples:
      a. Minimum 6-inch long samples of each type of waterstop to be used if requested by the Engineer.
   4. Manufacturer's installation instructions:
      a. Installation instructions and recommended installation details for the complete waterstop system, and for each component used in that system.

PART 2 PRODUCTS

2.01 HYDROPHILIC RUBBER WATERSTOP

A. General:
   1. System composed of flexible hydrophilic urethane polymer with preformed strips, adhesives, paste, fasteners, and other accessories required for a complete and watertight installation.
      a. To ensure compatibility of materials, a single manufacturer shall provide all products and accessories for the hydrophilic waterstop system.
      b. Products incorporating bentonite are not acceptable under this Section.
      c. Provide waterstop and accessories resistant to degradation under cyclic wetting and drying.

B. Hydrophilic strip waterstop:
   1. Pre-formed strips of flexible hydrophilic rubber designed to undergo controlled expansion when exposed to moisture:
      a. Strips manufactured to limit expansion in directions parallel to the plane of the joint, and to direct expansion against confining material perpendicular to that plane.
   2. Provide normal or low-expansion pressure as scheduled and as indicated on the Drawings.
   3. Manufacturers: One of the following or equal:
      a. Hydrophilic strip:
         1) Adeka Ultra Seal USA, MC-2010MN.
         2) Sika Corp., Hydrotite CJ1020-2K.
      b. Low expansion hydrophilic strip:
         1) Adeka Ultra Seal USA, KBA-1510FP.
         2) Sika Corp., Hydrotite CJ0725-3K.

C. Hydrophilic paste waterstop.
   1. Single-component gun grade paste of hydrophilic rubber designed to undergo controlled expansion when exposed to moisture after initial curing.
   2. Manufacturers: One of the following or equal:
      a. Adeka Ultra Seal USA: P-201.
      b. Sika Corp., Leakmaster LV-Z.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions and recommended details.

B. Prepare concrete joint surfaces:
   1. Use wire brushing or scraping to expose an uncontaminated, solid surface.
   2. Clean prepared surface with high-pressure air or water to remove residue and debris.
   3. Confirm that prepared surfaces conform to manufacturer’s recommendations for surface profile and moisture conditions before installing materials.

C. Provide manufacturer’s recommended lap, splice, and corner details for hydrophilic waterstops.
   1. Use hydrophilic paste at all corner joints and overlap splices of hydrophilic strips.

D. Hydrophilic strip waterstop:
   1. Install primers and adhesives when recommended by the manufacturer before setting hydrophilic strips.
   2. Keep hydrophilic strip taut during the fastening process.
   3. Secure hydrophilic strip in place with concrete nails, screws, or adhesive.

4. Provide installation with no gap between the hydrophilic strip and the concrete to which it is attached. At rough or irregular surfaces, set hydrophilic strip waterstop strip in a bead of hydrophilic paste.
    a. Fill all voids and rough areas under the hydrophilic strip with hydrophilic paste.
    b. Allow hydrophilic paste to cure in accordance with manufacturer's recommendations before encapsulating paste in fresh concrete.

3.02 SCHEDULE

A. At the following joint locations/conditions, use the hydrophilic strip waterstop configuration noted unless otherwise indicated on the Drawings.

B. Concrete construction joints:
    1. Under all of the following conditions, use hydrophilic strip waterstop set in a bed of hydrophilic paste waterstop, and screw strip waterstop to concrete surface:
        a. Slab or wall thickness is greater than 10 inches.
        b. Waterstop is placed between 2 rows of steel reinforcement.
        c. Concrete cover from waterstop to nearest concrete face is at least 4 inches.
    2. Under any one of the following conditions, use low-expansion hydrophilic strip waterstop set in bed of hydrophilic paste waterstop and screw strip to concrete surface:
        a. Waterstop is placed on 1 side of a single row of steel reinforcement.
        b. Concrete cover from waterstop to nearest concrete face is less than 4 inches.

C. Pipe penetrations through concrete:
    1. Pipe diameter less than 4 inches: Not allowed.
    2. Pipe diameter of 4 to 24 inches: Continuous bead of hydrophilic paste waterstop, minimum 1/4-inch high by 1/2-inch wide, encircling pipe.
    3. Pipe diameter greater than 24 inches: Continuous hydrophilic strip waterstop around perimeter of pipe, with hydrophilic paste seal at lapped ends of strip.

END OF SECTION

SECTION 03200

CONCRETE REINFORCING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Reinforcing bars.
      a. Carbon steel.
   2. Thread bars.
   3. Bar supports.
   4. Tie wires.
   5. Welded wire fabric.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.
   2. SP-66 - ACI Detailing Manual.

B. American Iron and Steel Institute (AISI).

C. American Welding Society (AWS):
   1. D1.4 - Structural Welding Code - Reinforcing Steel.

D. ASTM International (ASTM):
   1. A493 - Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging.
   2. A615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
   3. A706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   4. A1064 - Standard Specification of Carbon-Steel wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

E. Concrete Reinforcing Steel Institute (CRSI):
   1. Manual of Standard Practice.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Architectural concrete: Concrete surfaces that will be exposed to view in the finished work.
      a. Additionally, for purposes of this Section, includes:
         1) Concrete surfaces that are designated to receive paints or coatings.
         2) Exposed concrete in open basins, channels, and similar liquid containing structures: Surfaces shall be considered exposed to view if located above a line 2 feet below the normal operating water surface elevation in that structure.
   2. Bars: Reinforcement or reinforcing bars as specified in this Section.
   3. Evaluation Report: Report prepared by ICC-ES, or by other testing agency acceptable to the Engineer and to the Building Official, that documents testing and review of a product to confirm that it complies with the requirements of designated ICC-ES Acceptance Criteria, and its acceptance for use under the Building Code specified in Section 01410 - Regulatory Requirements.
   4. Give away bars: Reinforcing bars that are not required by the Contract Documents but are installed by the Contractor to provide support for the required reinforcing bars.
   5. Wire supports: Metal reinforcing supports constructed of steel wire as specified. Includes individual high chairs, continuous high chairs, bolsters and other similar configurations and shapes.

1.04 SUBMITTALS

A. General:
   1. Submit in accordance with Section 01330 - Submittal Procedures.
   2. Changes to reinforcement in Contract Documents:
      a. Indicate in a separate letter submitted with Shop Drawings any changes to reinforcement indicated on the Drawings or specified.
      b. Such changes will not be acceptable unless the Engineer has accepted them in writing.

B. Product data:
   1. Bar supports:
      a. Wire bar supports:
         1) Schedule of support materials to be provided and locations of use.
      b. Precast concrete bar supports (“dobies”):
         1) Manufacturer's data indicating compression strength of concrete and confirming dimensions and thickness(es).height(s) to be provided for each location where used.

C. Shop Drawings:
   1. Reinforcement Shop Drawings:
      a. Submit Drawings showing bending and placement of reinforcement required by the Contract Documents.
      b. Provide CAD generated Shop Drawings.
      c. Clearly indicate structures or portions of structures covered by each Submittal.

d. Shop Drawings shall conform to the recommendations of the CRSI Manual of Standard Practice and be in accordance with ACI SP-66.
e. Use the same bar identification marks on bending detail Drawings, placement Drawings, and shipping tags.
f. Submittals consisting solely of reinforcing bar schedules, without accompanying placement Drawings, will not be accepted unless accepted under prior written agreement with the Engineer.

2. Reinforcement placement Drawings:
   a. Clearly show placement of each bar listed in the bill of materials, including additional reinforcement at corners and openings, and other reinforcement required by details in the Contract Documents.
   b. Clearly identify locations of reinforcement with coatings (e.g., galvanized or epoxy) and with yield strength other than ASTM A615, Grade 60.
   c. Show anchor bolt locations based on anchor bolt templates for approved equipment.
   d. Show splice locations.
3. Reinforcement fabrication Drawings:
   a. If bend types or nomenclature differs from that recommended in the CRSI Manual of Standard Practice, provide details showing bend types and dimensional designations.
   b. Clearly identify reinforcement with coatings and with yield strength other than ASTM A615, Grade 60.

D. Samples (when requested by the Engineer):
1. Bar supports/wire reinforcement supports: Samples of each type of chair and bolster proposed for use. Submit with letter stating where each type will be used.
2. Precast concrete bar supports: Samples of each type of precast support proposed for use. Submit with letter stating where each will be used.

E. Test reports:
1. Certified copy of mill test for each steel used. Show physical properties and chemical analysis.
   a. Mill test reports may be submitted as record documents at the time the reinforcement from that heat of steel is shipped to the site.
   b. In such cases, submit certificates under the Shop Drawing Submittal number with the letter “R” (for record date) appended to the end (e.g., if the reinforcement was submitted as 03200-002-1, deliver the associated mill certificate as Submittal 03200-002-1R).

F. Manufacturer's instructions.

G. Special procedures:
1. Welding procedures in accordance with AWS D1.4 for reinforcement to be field welded.
   a. Procedures qualification record.

H. Qualifications statements:
1. Welder qualifications.

I. Closeout documents:
   1. Field quality control and inspection reports.
   2. Field quality assurance special inspection and testing reports.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
   1. Deliver bars bundled and tagged with identifying tags.

B. Acceptance at site:
   1. Reinforcing bars: Deliver reinforcing bars lacking grade identification marks with letter containing manufacturer's guarantee of grade.

1.06 SEQUENCING AND SCHEDULING

A. Bar supports:
   1. Do not place concrete until samples and product data for bar supports have been accepted by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Drawings contain notes describing the size and spacing of reinforcement and its placement, details of reinforcement at wall corners and intersections, and details of extra reinforcement around openings in concrete, and other related information.

2.02 MATERIALS

A. Reinforcing bars:
   1. Provide reinforcement of the grades and quality specified, fabricated from new stock, free from excessive rust or scale, and free from unintended bends or other defects affecting its usefulness.
   2. ASTM A615 Grade 60 deformed bars, including the following requirements:
      a. Actual yield strength based on mil tests of reinforcement provided shall not exceed the minimum yield strength specified in this Section by more than 18,000 pounds per square inch.
      b. Ratio of actual ultimate tensile strength to actual tensile yield strength shall not be less than 1.25.
   3. Reinforcing bars designated or required to be welded:
      a. Low-alloy, ASTM A706 Grade 60, deformed bars.

B. Bar supports:
   1. Wire supports:
      a. All stainless steel bar supports:
         1) Conforming to CRSI Manual of Standard Practice recommendations for types and details, but custom fabricated entirely from stainless steel wire in accordance with ASTM A493, AISI Type 316.

b. Stainless steel protected bar supports:
    1) Conforming to CRSI Manual of Standard Practice Class 2, Type B, and consisting of bright basic wire support fabricated from cold-drawn carbon steel wire with stainless steel ends attached at the bottom of each leg.
    2) Stainless steel wire ends shall be in accordance with ASTM A493, AISI Type 316 and shall extend at least 3/4 inch inward from the formed surface of the concrete.
c. Bright basic wire bar supports.
    1) Conforming to CRSI Manual if Standard Practice, Class 3.

2. Plastic supports:
    a. Manufacturers: The following or equal:
        1) Aztec Concrete Accessories.
3. Deformed steel reinforcing bar supports:
    a. Fabricated of materials and to CRSI details recommended for typical reinforcement embedded in concrete and bent to dimensions required to provide specified clearances and concrete cover.
4. Precast concrete bar supports (“dobies”):
    a. Pre-manufactured, precast concrete blocks with cast-in annealed steel wires, 16-gauge or heavier.
    b. Compression strength of concrete: Equal to or exceeding the compression strength of the surrounding concrete.
    c. Block dimensions:
        1) Height to provide specified concrete cover.
        2) Footprint not less than 3 inches by 3 inches, and adequate to support the weight of the reinforcement and maintain specified concrete cover without settling into the underlying surface.

C. Tie wires:
1. General use: Black annealed steel wire, 16-gauge or heavier.

D. Welded wire fabric reinforcement:
1. Material:
    a. Carbon steel in accordance with ASTM A1064.
    b. Stainless steel in accordance with ASTM A1022.
2. Provide welded wire reinforcement in flat sheet form. Rolled wire fabric is not permitted.
3. Fabric may be used in place of reinforcing bars if accepted by the Engineer:
    a. Provide welded wire fabric having cross-sectional area per linear foot not less than the cross-sectional area per linear foot of reinforcing bars indicated on the Drawings.

2.03 FABRICATION

A. Shop fabrication and assembly:
1. Cut and bend bars in accordance with provisions of ACI 318 and the CRSI Manual of Standard Practice.
2. Bend bars cold. Use bending collars to develop the recommended bend radius.

3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.
4. Circumferential and radiused reinforcement: Roll to the radius required for its location in the structure before installation.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:
   1. Reinforcing bars and welded wire reinforcement:
      a. Verify that reinforcement is new stock, free from rust scale, loose mill scale, excessive rust, dirt, oil, and other coatings that will adversely affect bonding capacity when placed in the Work.
   2. Welded wire fabric:
      a. Verify that sheets are not curled or kinked before or after installation.

3.02 PREPARATION

A. Surface preparation:
   1. Reinforcing bars - uncoated:
      a. Clean reinforcement of concrete, dirt, oil and other coatings that will adversely affect bond before embedding bars in subsequent concrete placements.
      b. Thin coating of red rust resulting from short exposure will not be considered objectionable. Thoroughly clean bars having rust scale, loose mill scale, or thick rust coat.
      c. Partially embedded reinforcement: Remove concrete or other deleterious coatings from dowels and other projecting bars by wire brushing or sandblasting before bars are embedded in subsequent concrete placements.

3.03 INSTALLATION

A. Reinforcing bars: General:
   1. Field-cutting of reinforcing bars is not permitted.
   2. Field-bending of reinforcing bars, including straightening and rebending, is not permitted.

Table 1 - Reinforcement Placing Tolerances

Member	Tolerance on Reinforcement Location (1)	Tolerance on Minimum Concrete Cover (1,2)
Slabs, beams, walls and columns except as noted below:		
10 inches thick and less	± 3/8 inch	- 3/8 inch
More than 10 inches thick	± 1/2 inch	- 1/2 inch
Formed soffits	As noted above	- 1/4 inch

Table 1 - Reinforcement Placing Tolerances		
Member	**Tolerance on Reinforcement Location (1)**	**Tolerance on Minimum Concrete Cover (1,2)**
Longitudinal location of bends and ends of reinforcement:		
Conditions not listed below	± 2 inches	- 1/2 inch
At discontinuous ends of brackets and corbels	± 1/2 inch	- 1/4 inch
At discontinuous ends of other members	± 1 inch	- 1/2 inch

Notes:
1. ± indicates “plus or minus;” - indicates “minus;” + indicates “plus.”
2. Tolerance on cover is limited as noted but decrease in cover shall not exceed one third of the minimum cover indicated on the Drawings.

B. Placing reinforcing bars:
   1. Accurately place bars to meet position and cover requirements indicated on the Drawings and specified. Secure bars in position.
   2. Tolerances for placement and minimum concrete cover: As listed in Table 1.
   3. Spacing between bars:
      a. Minimum clear spacing between bars in a layer:
         1) As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
      b. Minimum clear spacing between bars in 2 or more parallel layers:
         1) Place bars in upper layers directly above bars in lower layers.
         2) Minimum spacing between layers: As indicated on the Drawings, but not less than the larger of 1.5 times the bar diameter or 1-1/2 inches.
      c. Limits on minimum clear spacing between bars also applies to the clear spacing between a lap splice and the adjacent bars and/or lap splices.
   4. Lap splices for bars:
      a. Lap splice locations and lap splice lengths: As indicated on the Drawings. Where lap lengths are not indicated, provide in accordance with ACI 318.
      b. Unless otherwise specifically indicated on the Drawings (and noted as “non-contact lap splice”), install bars at lap splices in contact with each other and fasten together with tie wire.
      c. Where bars are to be lap spliced at concrete joints, ensure that bars project from the first concrete placement a length equal to or greater than minimum lap splice length indicated on the Drawings.
      d. Stagger lap splices where indicated on the Drawings.
      e. Where lap splice lengths are not indicated on the Drawings, provide lap splice lengths in accordance with ACI 318.

C. Reinforcing supports:
   1. Provide supports of sufficient numbers, sizes, and locations to maintain concrete cover, to prevent sagging and shifting, and to support loads during construction without displacement and without gouging or indentation into forming surfaces.
      a. Quantities and locations of supports shall not be less than those indicated in ACI SP-66 and the CRSI Manual of Standard Practice.

2. Do not use brick, concrete masonry units, concrete spalls, rocks, wood, or similar materials for supporting reinforcement.
3. Do not use “give away bars” that have less cover than that required by the Contract Documents. Do not adjust the location of reinforcement required by the Contract Documents to provide cover for give away bars.
4. Provide bar supports of height required to maintain the clear concrete cover indicated on the Drawings.
5. Provide bar supports at formed vertical faces to maintain the clear concrete cover indicated on the Drawings.
6. Schedule of reinforcement support materials: Provide bar supports as indicated in Table 2.

Table 2 - Reinforcement Support Materials

Case	Location	Material
a.	Concrete placed over earth and concrete seal slabs (“mud mats”)	Precast concrete bar supports.
b.	Concrete placed against forms and exposed to water or wastewater process liquids (whether or not such concrete received additional linings or coatings)	All stainless steel bar supports.
c.	Concrete placed against forms and exposed to earth, weather, frequent washdown, or groundwater in the finished work	All stainless steel bar supports.
d.	Concrete placed against forms and exposed to interior equipment/piping areas in the finished work	All stainless steel bar supports.
e.	Between mats of reinforcement, and fully embedded within a concrete member	Bright basic wire bars supports, or deformed steel reinforcing bars.

D. Tying of reinforcing:
   1. Fasten reinforcement securely in place with wire ties.
   2. Tie reinforcement at spacings sufficient to prevent shifting.
      a. Provide at least 3 ties in each bar length. (Does not apply to dowel lap splices or to bars shorter than 4 feet, unless necessary for rigidity).
   3. Tie slab bars at every intersection around perimeter of slab.
   4. Tie wall bars and slab bar intersections other than around perimeter at not less than every fourth intersection, but at not more than the spacing indicated in Table 3:

Table 3 - Maximum Spacing of Tie Wires for Reinforcement

Bar Size	Slab Bar Spacing (inches)	Wall Bar Spacing (inches)
Bars Number 5 and Smaller	60	48
Bars Number 6 through Number 9	96	60
Bars Number 10 and Number 11	120	96

5. After tying:
    a. Bend ends of wires inward towards the center of the concrete section. Minimum concrete cover for tie wires shall be the same as cover requirements for reinforcement.
    b. Remove tie wire clippings from inside forms before placing concrete.

E. Welded wire fabric reinforcement:
1. Install only where indicated on the Drawings or accepted in advance by the Engineer.
2. Install necessary tie wires, spacing chairs, and supports to keep welded wire fabric at its designated position in the concrete section while concrete is being placed.
3. Straighten welded wire fabric to make sheets flat in the Work.
4. Do not allow wire fabric to drape between supports unless such a configuration is specifically indicated on the Drawings.
    a. If fabric is displaced during placement of concrete, make provisions to restore it to the designated location using methods acceptable to the Engineer.
5. Bend welded wire fabric as indicated on the Drawings or required to fit Work.
6. Lap splice welded wire fabric as indicated on the Drawings.
    a. If lap splice length is not indicated, splice in accordance with ACI 318, but not less than 1 1/2 courses of fabric or 8 inches minimum. Tie laps at ends and at not more than 12 inches on center.

F. Welding reinforcing bars:
1. Weld only where indicated on the Drawings or where acceptance is received from the Engineer prior to welding.
2. Perform welding in accordance with AWS D1.4 and welding procedures accepted by the Engineer.
    a. Conform to requirements for minimum preheat and interpass temperatures.
3. Submit:
    a. Welding procedures specification.
    b. Procedures qualification record.
    c. Welder qualification test record.
4. Do not tack weld reinforcing bars except where specifically indicated on the Drawings.

3.04 FIELD QUALITY CONTROL

A. Provide quality control for the Work of this Section as specified in Section 01450 - Quality Control.

B. Field inspections and testing:
1. Submit records of inspections and testing to the Engineer in electronic format within 24 hours after completion.

3.05 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01450 - Quality Control.

B. Special inspections and tests:
   1. Provide as specified in Section 01455 - Regulatory Quality Assurance.
   2. Frequency of inspections:
      a. Unless otherwise indicated on the Drawings or in this Section, provide periodic special inspection as required by the Building Code specified in Section 01410 - Regulatory Requirements.
   3. Preparation:
      a. Review Drawings and Specification for the Work to be observed.
      b. Review approved Submittals and Shop Drawings.
   4. Inspections: Special inspection shall include, but is not limited to, the following items:
      a. Reinforcement: General:
         1) Type (material) and location of reinforcement supports.
         2) Bar material/steel grade and bar size.
         3) Location, placement, and spacing of bars.
         4) Clear concrete cover over reinforcement.
         5) Lap splice: Location and lap length. Bars within tolerances for contact (unless non-contact splice is indicated on the Drawings.)
         6) Bar hooks and development lengths embedded within concrete sections as indicated on the Drawings.
         7) Reinforcement tired in position and tie wire legs turned inward toward the center of the concrete section.
      b. Reinforcement: Welding:
         1) Inspector qualification and inspections shall be in accordance with the requirements of AWS D1.4.
         2) Provide periodic inspection for:
            a) Weldability of reinforcement other than ASTM A706.
            b) Single pass fillet welds with thickness less than or equal to 5/16 inch.
         3) Provide continuous inspection for:
            a) Other welds.
            b) Welds at mechanical reinforcing bar couplers and end anchors.
         4) In addition to visual inspection, Owner may inspect reinforcing bar welds by other methods, including radiographic inspection.
   5. Records of inspections:
      a. Provide a written record of each inspection using forms acceptable to the Engineer and to the Building Official.
      b. Submit electronic copies of inspection reports to the Engineer within 24 hours after completion of inspections.

3.06 NON-CONFORMING WORK

A. Before placing concrete, adjust or remove and re-install reinforcement to conform to the requirements of the Contract Documents.

END OF SECTION

SECTION 03300

CAST-IN-PLACE-CONCRETE

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cast-in-place concrete.

B. The requirements of this Section will require advance planning for preparation and testing of trial batches. Review the mix design and testing requirements carefully, and schedule preparations and testing with sufficient time to complete tests, to obtain Engineer's review of mixes and testing results, and to complete revisions and re-testing if required.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.
   2. CODE-350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
   3. PRC-212.3 - Report on Chemical Admixtures for Concrete.
   4. PRC-302.1 - Guide to Concrete Floor and Slab Construction.
   5. PRC-305 - Guide to Hot Weather Concreting.
   6. PRC-306 - Guide to Cold Weather Concreting.

B. ASTM International (ASTM):
   1. C29 - Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate.
   2. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   3. C33 - Standard Specification for Concrete Aggregates.
   4. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   5. C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
   6. C42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   7. C88 - Standard Test Method of Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   8. C94 - Standard Specification for Ready-Mixed Concrete.
   9. C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement.
   10. C117 - Standard Test Method for Materials Finer that 75-m (No. 200) Sieve in Mineral Aggregates by Washing.
   11. C123 - Standard Test Method for Lightweight Particles in Aggregate.
   12. C131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   13. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   14. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

15. C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregate.
16. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
17. C150 - Standard Specification for Portland Cement.
18. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
19. C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
20. C171 - Standard Specifications for Sheet Materials for Curing Concrete.
21. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
22. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
23. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
24. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading).
25. C295 - Standard Guide to Petrographic Examination of Aggregates for Concrete.
26. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
27. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
28. C494 - Standard Specification for Chemical Admixtures for Concrete.
29. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
30. C702 - Standard Practice for Reducing Samples of Aggregate to Testing Size.
31. C856 - Standard Practice for Petrographic Examination of Hardened Concrete.
32. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
33. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
34. C1260 - Standard Test Method of Potential Alkali Reactivity of Aggregates (Mortar Bar Method).
35. C1293 - Standard Test Method for Determination of Length Change of Concrete due to Alkali-Silica Reaction.
36. C1602 - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
37. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
38. D29 - Standard Practice for Determining Volatile and Nonvolatile Content of Cellulosics, Emulsions, Resin Solutions, Shellac, and Varnishes.
39. D75 - Standard Practice for Sampling Aggregates.
40. D2103 - Standard Specification for Polyethylene Film and Sheeting.
41. D3665 - Standard Practice for Random Sampling of Construction Materials.
42. D4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

C. National Ready-Mixed Concrete Association (NRMCA).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Alkali: The sum of sodium oxide and potassium oxide calculated as sodium oxide.
   2. Alkali Load: Amount of alkalies contributed by the Portland cement in a concrete mixture, expressed in pounds per cubic yard (lb/yd^3) and calculated by multiplying the Portland cement content of the concrete in lb/yd^3 by the alkali content of the Portland cement, divided by 100.
   3. Architectural Concrete: Concrete surfaces that will be exposed to view in the finished work.
      a. For purposes of this Section, includes only those surfaces that receive paint or coatings.
      b. Exposed concrete surfaces in open basins, channels, and similar liquid containing structures: Surfaces will be considered exposed to view if located above the water line as defined in Section 03366 - Concrete Finishes.
      c. Exterior concrete surfaces with portions above and below grade: Surface will be considered exposed to view of located above the grade line as defined in Section 03366 - Concrete Finishes.
   4. Average Daily Temperature: Calculated by summing hourly measurements of air temperature in the shade at the face of the concrete and dividing that sum by 24. In calculating the sum of the temperatures recorded, any measurement less than 50 degrees Fahrenheit shall be recorded as 0 degrees Fahrenheit and included in the sum.
   5. Cementitious Materials: Portland cement and supplementary cementitious materials.
   6. Class of Concrete: Refers to a mix with characteristics, proportions, and constituents (including a specific combination of admixtures) as specified in this Section.
      a. Any change in the source or characteristics of constituent materials, in the proportions of materials, or in the admixtures included in a mix shall be considered as creating a new and separate class of concrete.
      b. Any mix to be placed by pumping shall be considered as creating a new and separate class of concrete.
   7. Cold Weather: Includes one or more of the following conditions:
      a. Current air temperature is 45 degrees Fahrenheit and falling.
      b. Air temperature during the first 24 hours after placement is expected to fall into the range of 45 degrees Fahrenheit to 40 degrees Fahrenheit.
      c. A period when, for more than 3 consecutive days, the following conditions exist:
         1) The average daily air temperature drops below 40 degrees Fahrenheit.
         2) The air temperature is not greater than 50 degrees Fahrenheit for more than one-half of any consecutive 24-hour period.
   8. Cold Weather Concreting: Operations for placing, finishing, curing, and protecting concrete during cold weather.
   9. Green Concrete: Concrete that has not yet achieved 100 percent of the minimum specified compressive strength, f'c, for that mix.

10. Hairline Crack: Crack with a crack width of less than 4 thousandths of an inch (0.004 inches).
11. Hot Weather: Any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.2 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and in this Section, Attachment A - Menzel Formula and Nomograph.
12. Hot Weather Concreting: Operations for placing, finishing, curing, and protecting concrete during hot weather.
13. Paste Content: The total concrete volume minus the volume of aggregate, expressed as a percentage of total volume. Paste volume includes volume of cementitious materials, water, air, admixtures materials, and any fibers.
14. Supplemental Cementitious Material: Inorganic material such as fly ash, natural pozzolans, silica fume, or slag cement that reacts pozzolanically or hydraulically.

1.04 DELEGATED DESIGN

A. Provide Delegated Design for the following Work, based on the requirements of this Section.
   1. Concrete mix designs.

1.05 SUBMITTALS

A. General:
   1. Data for concrete mixes and mix constituents supplied to the Work shall be coordinated through a single supplier.
   2. A maximum of 2 mix designs will be reviewed by the Engineer for each class of concrete required.
      a. Review of additional mix designs shall be at the expense of the Contractor.

B. Product data:
   1. Submit data completely describing products and demonstrating compliance with the requirements of this Section.
   2. Data for all products in the mix for each class of concrete shall be submitted concurrently with that mix design.
   3. Where products conforming to NSF-61 are required, submit evidence of testing and listing under NSF-61 for use in direct contact with potable water. Testing and listing shall be by a nationally recognized agency acceptable to the Engineer.
   4. Admixtures:
      a. For each admixture included in concrete mixes, submit manufacturer's product data demonstrating compliance with standards specified.
      b. If air entraining admixture requires test method other than ASTM C173 to accurately determine air content, make special note of requirements in Submittal.
   5. Curing compound: Submit complete data on proposed compound.

C. Design data:
    1. Concrete mix designs:
        a. Submit full details, including mix design calculations and plots, for concrete mixes proposed for use for each class of concrete.
        b. Include mix design calculations of proportions by both weight and volume.
        c. Determine and include the alkali load of the proposed mix.
        d. Include information on correction of batching for varying moisture contents of fine aggregate.
        e. Submit source quality test records with mix design Submittal.
        f. Provide calculations demonstrating that the mixes proposed provide the required average compression strength of concrete (f'cr) based on source quality test records.
        g. For each Class A mix design submitted, plot the mix design Attachment B - Coarseness Factor Chart and submit.
        h. For each Class A mix design submitted, plot the combined aggregate gradation on the chart Attachment C - Combined Aggregate Gradation Chart and submit.

D. Concrete mixes - Trial batches:
    1. Drying shrinkage test results.
        a. Submit results of testing.
    2. Compression strength test results.
        a. Submit results of testing. Provide data for each cylinder tested.
        b. Submit data indicating trial batch mix designator, slump, and specimen number for each test cylinder.
            1) Using indelible marker, clearly label each cylinder with concrete class, trail batch number, and specimen number.
    3. If there is any change in suppliers or in quality of concrete mix constituents, submit new test data.

E. Test reports:
    1. Dated not more than 24 months prior to the date of Submittal.
    2. Aggregate:
        a. Submit certified copies of commercial laboratory tests proposed for use in concrete.
        b. Sieve analyses:
            1) During construction, submit sieve analyses of coarse, fine, and combined aggregates used any time there is a change in supplier, or a significant change in the character and/or grading of materials, and when requested by the Engineer.
        c. Aggregates - coarse:
            1) Physical properties:
                a) Sieve analysis.
                b) Percentage of particles having flat and/or elongated characteristics.
                c) Abrasion loss.
                d) Soundness.
            2) Deleterious substances:
                a) Clay lumps and friable particles content.
                b) Materials finer than 200 sieve (percentage).

c) Shale and chert content.
d) Coal and lignite content.

3) Alkali reactivity.
4) Deleterious substances:
a) Clay lumps and friable particles content.
b) Chert and shale content.
c) Coal and lignite content.
d) Materials finer than No. 200 sieve.
5) Alkali reactivity.

d. Aggregates - Fine:
1) Physical properties:
a) Sieve analysis and fineness modulus.
b) Soundness.
2) Deleterious substances:
a) Clay lumps and friable particles (percentage).
b) Materials finer than No. 200 sieve (percentage).
c) Coal and lignite (percentage).
d) Shale and chert.
e) Organic impurities (“Color” as determined by ASTM C40).
3) Alkali reactivity.

e. Aggregates - Combined:
1) Test combined gradation for the following sieve sizes: 1.5 inches, 1 inch, 3/4 inch, 1/2 inch, 3/8 inch, Number 4, Number 8, Number 16, Number 30, Number 100, Number 200.
2) Bulk density in accordance with ASTM C29.
3) Void content in accordance with ASTM C29.
4) Submit at:
a) Initial mixture design Submittal.
b) Intervals of not more than 4 weeks.
c) Any time there is a change in character or grading of constituent materials.
d) When requested by the Engineer.

3. Cement:
a. Mill tests, including alkali content measured as equivalent alkalies, for each shipment of cement included in the Work.
1) During construction, submit mill certificates for cement being used at intervals of not more than 90 days, any time there is a change in supplier or a significant change in the character of the materials, and when requested by the Engineer.

4. Supplemental cementitious material:
a. Fly ash: Identify source and provide testing results to demonstrate compliance with requirements of ASTM C618 and this Section.
1) Include supplier's report certifying the total alkali content of the material, expressed as equivalent percentage of sodium oxide (Na_2Oe).

F. Certificates:
1. Current NRMCA certification for all plants and trucks that will be used to supply concrete.

G. Source quality control Submittals:
   1. Truck batch tickets for each load of concrete delivered to the site, whether accepted or rejected.
   2. Concrete supplier's quality control plan. Include the following elements, at a minimum:
      a. Names and qualifications of key quality control personnel:
         1) Quality control manager.
         2) Testing and inspection personnel.
      b. Names and qualifications of testing laboratories:
         1) Each laboratory shall hold current accreditation from the AASHTO Accreditation Program, or other accreditation program acceptable to the Engineer, for each test performed.
      c. Example forms for: Inspection reports, certificates of compliance, and test results.
      d. Quality control procedures: Method and frequency of performing each procedure, including inspections and materials testing. At a minimum, the plan shall include:
         1) Daily testing of aggregate gradation.
         2) Monthly testing of cement quality.
         3) Monthly testing of fly ash quality.
      e. Procedures to control quality characteristics, including standard procedures to address properties outside the specified operating limits, and example reports to document non-conformances and corrective actions taken. Include procedure for notifying Contractor and Engineer of non-conformances.
      f. Procedures for verifying that:
         1) Materials are properly stored during concrete batching operations.
         2) Batch plants have the ability to maintain concrete consistency during periods of extreme heat and of low temperatures.
         3) Admixtures are dispensed in the correct dosages within the accuracy requirements specified.
         4) Delivery trucks have a valid NRMCA certification card.
      g. Procedures for verifying that weighmaster certificate for each load of concrete shows:
         1) Cement and supplementary materials are from sources designated in the approved Submittals.
         2) Concrete as-batched complies with the constituent weights designated in the approved Submittals.
         3) Corrections for aggregate moisture are being correctly applied.
         4) Any mix water withheld from the batch.
      h. Procedures for visually inspecting concrete during discharge.

H. Field quality control Submittals:
   1. Contractor's notifications of readiness for concrete placement.
   2. Contractor's reports of field quality control testing.
      a. Include with each report the concrete batch ticket number and identification numbers for associated cylinders used for compressive strength testing.
      b. Testing results for slump, temperature, unit weight, and air entrainment.
      c. Testing results for compressive strength at 7 and 28 days, and for any compressive strength tests after 28 days.

d. Note on batch ticket the amount of water that was withheld and the maximum amount that can be added on site as “Max add water.” Record on the batch ticket the volume of water actually added at site.
e. Note on the batch ticket the concrete mix classification as defined in Table 3 of this Section.

I. Special procedure Submittals:
1. Sequence of concrete placing:
a. Submit proposed sequence of placing concrete showing proposed beginning and ending of individual placements. Submittal shall include plans sections and details to address all pours.
2. Cold weather concreting plan.
3. Hot weather concreting plan.
4. Repair of defective concrete: Submit mix design for repair materials to be used.

1.06 QUALITY ASSURANCE

A. Pre-installation meetings:
1. Schedule and conduct pre-installation meeting at least 10 days prior to batching and placing of concrete.
a. Provide additional meetings if necessary, to discuss specific concrete Submittals, mixes, or placing and curing conditions.
b. Notify Engineer of location and time of each conference.
2. Required attendees:
a. Contractor including Contractor's superintendent and key personnel.
b. Concrete supplier.
c. Technical representative(s) of supplier(s) of concrete admixtures.
d. Subcontractor(s) providing pumping, placing, finishing, and curing.
e. Subcontractor(s) providing embedded items (structural embedded plates, electrical conduit).
f. Sampling and testing personnel.
g. Engineer.
h. On-site inspectors representing Engineer.
i. Other persons deemed by the Engineer and the Contractor to be critical to the quality and efficiency of the Work.
3. Agenda:
a. Review of requirements of Drawings and Specifications.
b. Project and product safety requirements.
c. Discussion of points of interface and coordination between various trades or products to be used in the Work.
d. Contractor's schedule for cast-in-place concrete work.
e. Mix designs, mix tests, and Submittals.
f. Admixture types, dosing, performance, requirements for monitoring, and limits on dosing or re-dosing at the site.
g. Placement and consolidation methods, techniques, and equipment and the effects of those methods on form pressures.
h. Slump and limits on placing time or conditions to maintain placeability.
1) Field adjustment of slump and air content.
i. Procedures for finishing, curing, and retention of moisture during these operations.
j. Procedures and protection for hot and cold weather conditions.

k. Requirements and coordination for inspections.
    1) Responsibility for test specimen curing and storage.
    2) Distribution of test reports.
l. Other Specification requirements requiring coordination between parties to the work.

4. Prepare and submit minutes of the pre-installation meeting as specified in Section 01312 - Project Meetings.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
1. Deliver, store, and handle concrete materials in manner that prevents damage and inclusion of foreign substances.
2. Deliver and store packaged materials in original containers until ready for use.
3. Deliver aggregate to mixing site and handle in such manner that variations in moisture content will not interfere with steady production of concrete of specified degree of uniformity and slump.

B. Acceptance at site:
1. Reject material containers or materials showing evidence of water or other damage.
2. Concrete mixes: Do not accept or incorporate into the Work concrete mixes that do not comply with the specified requirements for water content, slump, temperature, and air content.

1.08 PROJECT CONDITIONS

A. Cold weather concreting: During periods of cold weather as defined in this Section, implement cold weather concreting procedures in this Section.

B. Hot weather concreting: During periods of hot weather as defined in this Section, implement hot weather concreting procedures in this Section.

1.09 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in a manner that completes all placing operations from one construction, contraction, or expansion joint to another construction, contraction, or expansion joint.

B. Joints at each end of the placement shall be as indicated on the Drawings, or as identified and accepted in advance by the Engineer.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. It is the intent of this Section to secure, for every part of the Work, concrete with a homogeneous mixture, that, when hardened, will have required strength, watertightness, and durability.

B. It is the intent of this Section to procure a workable, low-shrinkage concrete mix that maximizes aggregate content and minimizes paste content.

C. Performance requirements:
   1. General:
      a. Except as otherwise specified, provide concrete composed of Portland cement, supplemental cementitious materials, aggregate, admixtures and water, proportioned and mixed to produce a plastic, workable mixture in accordance with requirements of this Section, and suitable to specific conditions of placement.
      b. Proportion aggregates to produce an gradation of aggregate that combines fine and coarse aggregate in well-graded proportions that maximizes the aggregate content and minimizes the paste content of the mix. Gradation should maximize long-term durability and strength of the concrete mixture.
      c. Durability requirements will be deemed to be satisfied when:
         1) Mixture is proportioned with a well-graded combined aggregate.
         2) Specified water-cement ratio is satisfied.
         3) Concrete contains the specified range of air content.
         4) Maximum specified paste content is satisfied.
         5) Requirements of ASTM C1778 to reduce the risk of deleterious alkali-aggregate reactions are satisfied. Reduce alkali loading of concrete, provide minimum supplemental cementitious material content, or both as required.
            a) Size and Exposure Conditions (ASTM C1778, Table 2): Concrete exposed to humid air, buried or immersed Concrete exposed to alkalies in service.
            b) Structure Class (ASTM C1778, Table 3): Class SC3 Class SC 4.
      d. Proportion materials in a manner that will secure the lowest cement content, water-cementious materials ratio, and paste volume that is consistent with good workability that provides a plastic and cohesive mixture, and that provides a slump that is within the specified range.
      e. Construction and expansion joints have been positioned in structures as indicated on the Drawings, and curing methods have been specified, for purpose of to reduce the number and size of cracks, resulting from normal expansion and contraction expected from the concrete mixes specified.
      f. Remove and replace, or repair as specified in this Section, non-conforming work and surfaces with cracks, voids and honeycombs, or surface wetness.
   2. Workmanship and methods: Provide concrete work, including detailing of reinforcing, conforming with best standard practices and as set forth in ACI CODE-318, and ACI CODE-350.

2.02 MATERIALS - GENERAL

A. Water and ice:
   1. Water for concrete mixes, for washing aggregate, and for curing concrete: Clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances from a municipal potable water source.
   2. Do not use water from concrete production operations, or combined water from concrete production operations as defined in ASTM C1602.

2.03 MATERIALS - CONCRETE MIX CONSTITUENTS

A. Water and ice:
   1. As specified in the preceding paragraphs.

B. Cementitious materials:
   1. Portland cement:
      a. In accordance with ASTM C150.
         1) Type IISingle source: To provide uniformity of appearance, for each structure use only one source, type, and brand of Portland cement for walls and slabs that will be exposed in the finished work.
         2) Confirm adequate supply of cement over duration of project before making trial batches or beginning concrete placements.
      b. Cement for finishing: Provide cement from same source and of same type as concrete to be finished or repaired.

C. Supplementary cementitious materials:
   1. Fly ash:
      a. Class C or Class F fly ash in accordance with the requirements of ASTM C618, except as modified in this Section.
         1) Class C may be used in concrete made with Type II Portland cement.
         2) Class F required if used in concrete mixes containing aggregates classified as potentially reactive based on ASTM C1293 or ASTM C1260.
            a) CaO content: Less than 18 percent.
      b. Loss on ignition: Not exceeding 3 percent.
      c. Replace Portland cement at ratio of 1.0 pound fly ash for each pound of cement, up to minimum and maximum replacement as specified in “Requirements for Mix Proportioning.”

D. Admixtures:
   1. General:
      a. Do not include admixtures, other than those specified, unless written acceptance has been obtained from the Engineer during Submittal of mix designs.
      b. Admixtures shall be compatible with concrete constituents and with other admixtures.
         1) All admixtures in a given mix shall be products of the same manufacturer to ensure compatibility.
         2) Admixture manufacturers: One of the following, or equal.
            a) Euclid Chemical.
            b) GCP Applied Technologies (formerly W.R. Grace).
            c) Master Builders Solutions/Sika.
            d) Sika Corp.
      c. Do not use admixtures containing chlorides, calculated as chloride ion, in excess of 0.5 percent by weight of cement.
      d. Use in accordance with manufacturer's recommendations. Add each admixture to concrete mix separately.
      e. Admixtures used shall be the same products used in concrete trial batches, or the same products used in concrete represented by submitted field test records.

2. Air entraining admixture (AEA):
    a. In accordance with ASTM C260 and dosed to provide entrained air percentages specified in this Section.
    b. Provides entrained air as bubbles, evenly dispersed at the time of placement and during curing.
3. Water reducing admixture(WRA):
    a. May be used at the Contractor's option.
    b. Conforming to ASTM C494, Type A (water-reducing).
        1) ASTM C494, Type D (water-reducing and retarding) may be used during periods of hot weather with prior acceptance by the Engineer.
    c. Not containing air-entraining agents.
    d. Liquid form before adding to the concrete mix.
4. Shrinkage reducing admixture (SRA):
    a. May be used at Contractor's option.
        1) Provide shrinkage reducing admixture in sufficient dosage so as to produce shrinkage within the limits specified.
    b. Not containing expansive agents.
    c. In accordance with ASTM C494, Type S (specific performance).
    d. One of the following, or equal:
        1) Euclid Chemical: Eucon SRA Series.
        2) GCP Applied Technologies: Eclipse Series.
        3) Master Builders Solutions/Sika: SRA Series.
5. Set-controlling admixtures:
    a. Shall not be used without prior acceptance from Engineer.

E. Coloring admixtures:
1. Conduit encasement coloring agent:
    a. Red color concrete used for encasement of electrical ducts, conduits, and similar type items.
    b. Manufacturers: One of the following or equal:
        1) Davis Co., #100 Utility Red.
        2) Euclid Chemical Co., Increte Division, “Colorcrete Brick Red”.
        3) I. Reiss Co., Inc., equivalent product.
    c. Conduit encasement concrete: Mix into each cubic yard of concrete 10 pounds of coloring agent.

F. Aggregate:
1. General:
    a. Provide concrete aggregates that are sound, graded as specified, and free of deleterious material in excess of allowable amounts specified.
    b. Provide aggregates to produce in place concrete with unit weight as follows:
        1) Normal weight concrete: Not less than 140 pounds per cubic foot.
    c. Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, and other construction materials.
    d. Do not use aggregate recycled from fresh concrete returned to the batching facility.

2. Alkali-silica reactivity:
    a. Provide aggregate classified as aggregate-reactivity class of R0 in accordance with ASTM C1778 with expansion not greater than 0.10 percent at 14 days when tested in accordance with ASTM C1260, and not greater than 0.04 percent at 1 year when tested in accordance with ASTM C1293.
3. Fine aggregate:
    a. Material graded such that 95 to 100 percent of material passes the No. 4 (4.75 mm) sieve, when sampled in accordance with ASTM D75 and D3665, and tested in accordance with ASTM C136.
    b. Provide fine aggregate consisting of clean, natural sand, or sand prepared from crushed stone or crushed gravel.
    c. In accordance with ASTM C33 requirements for grading, deleterious substances, soundness, and alkali reactivity, except as modified in the following paragraphs:
        1) Grading: For sieve sizes listed in ASTM C33 for fine aggregate, not more than 45 percent passing any sieve and retained on the next consecutive sieve.
        2) Deleterious substances: Not in excess of the percentages by weight specified in Table 1 of this Section.

Table 1 - Fine Aggregate, Limits on Deleterious Substances

Item	Test Method	Percent (maximum)
Materials finer than No. 200 sieve(2)	ASTM C117	3.00(2)
Clay lumps and friable particles	ASTM C142	1.00
Lightweight particles (SG < 2.40)	ASTM C123	1.00
• Chert or shale(1)	ASTM C295	1.00(1)
Coal and lignite	ASTM C123	0.50

Notes:

1. ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage of lightweight particles (sum of shale, chert, coal and lignite) not greater than 1.00, testing under ASTM C295 will not be required.
2. For manufactured sand, if material finer than the No. 200 sieve consists of crusher dust and the aggregate is essentially free of clay or shale, maximum percentage may be increased to 5.0 percent.

        3) Organic impurities: Free of injurious amounts of organic matter and producing a supernatant liquid with color not darker than “standard color” when tested in accordance with ASTM C40.
        4) Soundness: In accordance with requirements of ASTM C33 when tested in accordance with ASTM C88 using sodium sulfite solution.
4. Coarse aggregate:
    a. Materials graded such that not more than 10 percent of material passes the 3/8-inch sieve, when sampled in accordance with ASTM D75 and D3665 and tested in accordance with ASTM C136.
    b. Consisting of gravel, crushed gravel, crushed stone, or a combination of these materials having clean, hard, durable particles free from calcareous coatings, organic matter, or other deleterious substances.

c. Conforming to the requirements of ASTM C33, Class 4S for physical properties, deleterious substances, and alkali reactivity, except as modified in the following paragraphs:
   1) Grading:
      a) Size number as specified in ASTM C33, and as indicated in Table 3 of this Section, except as otherwise specified or accepted by the Engineer.
      b) Weights of flat or elongated particles (particles having a length greater than 3 times average width or thickness) not exceeding 15 percent when tested in accordance with ASTM D4791.
   2) Deleterious substances: Not in excess of the percentages by weight specified in Table 2 of this Section and having total of all deleterious substances exceeding 2 percent.

Table 2 - Coarse Aggregate, Limits on Impurities

Item	Test Method	Percent (maximum)
Clay lumps and friable particles	ASTM C142	0.50
Lightweight particles (SG < 2.40)	ASTM C123	1.25
• Chert or shale(1)	ASTM C295	1.00(1)
Materials finer than No. 200 sieve	ASTM C117	0.50(2)
Coal and lignite	ASTM C123	0.25

Notes:
1. ASTM C123 tests for particles in the sample having a specific gravity less than 2.40. ASTM C295 is used to identify which of those lightweight particles are chert, shale, or coal and lignite. If testing under ASTM C123 indicates a combined percentage (sum of shale, chert, coal and lignite) not greater than 1.25, testing under ASTM C295 will not be required.
2. When material finer than No. 200 sieve consists of crusher dust, maximum percentage may be increased to 1.00 percent. When mix design complies with provisions of ASTM C33, Table 4, footnote C, the maximum percentage may be increased in accordance with the equation in footnote C, up to a maximum of 1.5 percent.

   3) Abrasion loss: Loss not greater than 45 percent after 500 revolutions when tested in accordance with ASTM C131.
   4) Soundness: Loss not greater than 10 percent when tested in accordance with ASTM C88 using sodium sulfate solution.

2.04 MATERIALS FOR PLACING, CURING AND FINISHING

A. General:
   1. Materials shall be compatible with concrete and with other materials.

B. Cement grout:
   1. Use: For spreading over surface of construction and cold joints in concrete before placing additional concrete above those joints.
   2. As specified in Section 03600 - Grouting.

C. Concrete sealer:
   1. As specified in Section 03366 - Concrete Finishes.
   2. Not for use in water-containment structures.

D. Evaporation retardant:
   1. Use: For mitigating surface moisture evaporation from freshly placed concrete during rapid drying conditions. Placed after screeding.
   2. Waterborne, monomolecular, spray-applied compound, with fugitive dye to indicate coverage.
   3. Manufacturers: One of the following or equal:
      a. Euclid Chemical Co., Eucobar.
      b. Master Builders Solutions/Sika, MasterKure ER 50.

E. Nonslip abrasive:
   1. Aluminum oxide abrasive size 8/16, having structure of hard aggregate that is, homogenous, nonglazing, rustproof, and unaffected by freezing, moisture, or cleaning compounds.
   2. Manufacturers: One of the following or equal:
      a. Abrasive Materials, Inc.
      b. Exolon Co.
      c. “Non-Slip Aggregate”, Euclid Chemical Co.

F. Plastic membrane for curing:
   1. Polyethylene film: In accordance with ASTM C171.
   2. Properties:
      a. Color: White.
      b. Thickness: Nominal thickness of polyethylene film shall not be less than 0.0040 inches when measured in accordance with ASTM D2103. Thickness of polyethylene film at any point shall not be less than 0.0030 inches.
      c. Loss of moisture: Not exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

G. Sprayed membrane curing compound:
   1. Combination curing and sealing products (“cure and seal”) will not be permitted.
   2. Properties:
      a. Clear type with fugitive dye conforming with ASTM C309, Type 1D and containing no wax, paraffin, or oils.
      b. For concrete placed or cured during hot weather, curing compound shall be as specified, except that:
         1) It shall include a white, reflective fugitive dye.
         2) Moisture loss during a 72-hour period shall not exceed 9 pounds per cubic yard when tested in accordance with ASTM C156.

H. Surface-applied sealing system:
   1. Manufacturers: One of the following or equal:
      a. Euclid Chemical Co., Vandex Super.
      b. Kryton International, Inc., Krystol T1.
      c. Xypex Chemical Corp., Xypex Concentrate.
   2. Where surface-applied sealing system is placed over concrete containing permeability reducing admixture for concrete exposed to hydrostatic conditions (PRAH), provide products of same manufacturer providing the admixture.

2.05 EQUIPMENT

A. General:
   1. Provide adequate equipment and facilities for accurate measurement and control of materials and for readily changing proportions of material into mixers.

B. Batching equipment, or batch plant.
   1. Capable of controlling delivery of all material to mixer within 1 percent by weight of individual material.

C. Mixing equipment:
   1. Mixers may be of stationary plant, paver, or truck mixer type, as appropriate to the Work.
   2. Capable of combining aggregates, water, and cementitious materials, and admixtures within specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation.
      a. Maintain concrete mixing equipment in good working order, and operate at loads, speeds, and timing recommended by manufacturer or as specified.
      b. Proportion cementitious materials and aggregate by weight.
   3. If bulk cementitious materials are used, weigh them on separate visible scale which will accurately register scale load at any stage of weighing operation from zero to full capacity.
   4. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer ready for complete mixing with all mixing water.
   5. Procedure of mixing cementitious materials with sand or with sand and coarse aggregate for delivery to project site, for final mixing and addition of mixing water will not be permitted.
   6. Retempering of concrete will not be permitted.
   7. Discharge entire batch before recharging.
   8. Volume of mixed material per batch: Not exceed manufacturer's rated capacity of mixer.
   9. Equip each mixer with device for accurately measuring and indicating quantity of water entering concrete, and operating mechanism such that leakage will not occur when valves are closed.
   10. Equip each mixer with device for automatically measuring, indicating, and controlling time required for mixing:
      a. Interlock device to prevent discharge of concrete from mixer before expiration of mixing period.
   11. Transit-mixed concrete:
      a. Mix and deliver in accordance with ASTM C94.
      b. Total elapsed time between addition of water at batch plant and discharging completed mix.
      c. Not to exceed 90 minutes.
      d. Elapsed time at project site shall not exceed 30 minutes.
      e. Under conditions contributing to quick setting, total elapsed time permitted may be reduced by the Engineer.
      f. Equip each truck mixer with device interlocked to prevent discharge of concrete from drum before required number of turns and furnish device that is capable of counting number of revolutions of drum.

12. Continuously revolve drum after it is once started until it has completely discharged its batch:
    a. Do not add water until drum has started revolving.
    b. Right is reserved to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

D. Other types of mixers: For other types of mixers, mixing shall be as follows:
    1. Mix concrete until there is uniform distribution of materials, and discharge mixer completely before recharging.
    2. Neither speed nor volume loading of mixer shall exceed manufacturer's recommendations.
    3. Continue mixing for minimum of 1-1/2 minutes after all materials are in drum, and for batches larger than 1 cubic yard increase minimum mixing time 15 seconds for each additional cubic yard or fraction thereof.

2.06 CONCRETE MIXES

A. General:
    1. Develop and provide mix design for each Concrete Class listed in Table 3 of this Section.
    2. Select and proportion mixes and document properties using 1 of the 2 methods that follow. Procedures and requirements for use of each alternative are specified in subsequent paragraphs of this Section.
        a. Field experience method.
        b. Trial batch method.
    3. Organize and submit mix designs with data on all constituent materials and products for that mix for Engineer's review.
    4. Do not place concrete until the mix design for that Concrete Class has been accepted by Engineer.
    5. After acceptance, do not modify accepted mixes or provide new mixes without Engineer's prior review and acceptance of the proposed alternative.
        a. Exception: At all times, adjust batching of water to compensate for free moisture content of the fine aggregate used.
        b. For any change to approved mixes, Engineer may require new trial batching and testing program as specified in this Section before acceptance and use.
        c. For any change to approved mixes, make modifications within limits set forth in this Section.
        d. If there is change in source or quality of any constituent of the concrete class or mix, the revised mix will be considered a new class of concrete and shall require full re-submittal of all data describing mix constituents, design, and testing.
    6. Material sampling, mix designs, trial batch preparation and testing, modifications to mix designs, and any re-testing required to satisfy the requirements of this Section or to obtain satisfactory performance shall be at Contractor's expense and shall not be considered cause for delay.

B. Measurements of materials:
   1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
   2. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
   3. Accuracy of weighing devices: Furnish devices that have capability of providing successive quantities of individual material that can be measured to within 1 percent of desired amount of that material.
   4. Measuring or weighing devices: Subject to review by the Engineer. Shall bear valid seal of the Sealer of Weights and Measures having jurisdiction.
   5. Weighing cementitious materials:
      a. Weigh cementitious materials separately.
      b. Cement in unbroken standard packages (sacks): Need not be weighed.
      c. Weigh bulk cementitious materials and fractional packages.
   6. Measure mixing water by volume or by weight.

C. Requirements for mix proportioning:
   1. Develop and provide mixes that:
      a. Can be readily worked into corners and angles of forms and around reinforcement, without excessive vibration, and without permitting materials to segregate or free water to collect on surface.
      b. Prevent unnecessary or haphazard changes in the consistency of the concrete supplied.
   2. Constituent materials:
      a. Provide concrete mixes composed of Portland cement, blended aggregates, admixtures and water.
         1) Admixtures required for each concrete class are indicated in Table 3 of this Section. Admixtures not specifically required by that table for a specific Concrete Class are optional and may be included at the discretion of the Contractor based on Contractor's planned means and methods of construction.
      b. In no case shall returned fresh concrete or its constituents be incorporated into concrete batched for the Work.
   3. Minimum specified compressive strength:
      a. Minimum specified compressive strength is designated at 28 days, unless otherwise indicated in Table 3 of this Section.
      b. For locations where the placed concrete is adequately protected and is not subjected to loads for an extended period during construction, the Contractor may request that the period for achieving the minimum specified compressive strength be extended to 56 days. If accepted by the Engineer, provide mixes that achieve at least 75 percent of their minimum specified compressive strength after 28 days.
   4. Proportions and consistency:
      a. Ratio of water to cementitious materials, and cementitious materials content:
         1) Conform to maximum and minimum cementitious material content requirements specified in Table 3 of this Section.

2) Cementitious materials content: Consisting of Portland cement as indicated in Table 3 of this Section, plus supplemental cementitious materials if aggregate testing indicates potentially reactive aggregates:
    a) Fly ash content:
        (1) Minimum: 15 percent of the total weight of cementitious materials.
        (2) Maximum: 25 percent of the total weight of cementitious materials.

b. Aggregate size and content:
    1) Blend aggregates to produce an optimized gradation that combines well-graded coarse, intermediate, and fine aggregates in proportions that maximize the aggregate content of the mix, and that minimize the cement paste content of the mix.
        a) Percentage of individual fractions of the combined aggregate gradation retained on individual sieve sizes: Within the range shown in Attachment C - Combined Aggregate Gradation Chart ("Tarantula Curve").
        b) Sum of the percentages of individual fractions retained on the No. 8, No. 16, and No. 30 sieves: Greater than 20 percent.
        c) Sum of the percentages of individual fractions retained on the No. 30, No. 50, No. 100, and No. 200 sieves: Within the range of 25 percent to 40 percent.

c. Determine bulk density and void content of the combined gradation of aggregates in accordance with ASTM C29. Results for combined aggregates shall not be the summation of results of testing of the individual gradations.
    1) Sample the combined aggregate from a flowing aggregate stream or conveyor in accordance with ASTM D75. Take care to ensure that the sample is representative of the proportions of the combined aggregate of the proposed mix.
    2) Reduce sample of combined aggregate to test sample size in accordance with ASTM C702, Method A - mechanical splitter or Method B - quartering.
    3) Perform bulk density test of combined aggregate in accordance with ASTM C29, Procedure A - rodding.
    4) Determine void content of the combined aggregate in accordance with ASTM C29, Procedure A - rodding. Specific gravity of the combined aggregate shall be determined in accordance with ASTM C136.

d. Paste content: Limited to the following:
    1) Class A mixes without air entrainment: Maximum 28 percent measured by volume.
    2) Class A mixes with air entrainment: Maximum 28 percent measured by volume plus the target air content.
    3) Paste content shall be limited to 200 percent of the void content of the combined aggregate gradation determined by ASTM C29.

e. Total water content:
    1) Not exceeding the water to cementitious material ratio specified in Table 3 of this Section.

f. Coarseness/workability (Shilstone Method):
   1) Proportion mixes to fall into the “Optimal” zone (Zone II) when plotted on the Coarseness Factor Chart (“Coarseness Factor” versus “Workability Factor”) included as Attachment B - Coarseness Factor Chart to this Section. Provide plot for each Class A mix to be used in the Work.
   2) Coarseness factor (CF) for each mix shall be calculated as the percent of the combined aggregate gradation retained on the 3/8 inch sieve, divided by the percent of the combined aggregate gradation retained on the Number 8 sieve, multiplied by 100, or:

$$CF = \frac{(\%\ \text{retained on 3/8 in sieve})}{(\%\ \text{retained on No. 8 sieve})} \times 100$$

   3) Workability factor (WF) for each mix shall be the percent of the combined aggregate gradation retained on the Number 8 sieve, adjusted for cement content in the mix.
      a) Determine volume of total cementitious material in the mix.
      b) For each 94 pounds of cement content above 564 pounds per cubic yard, increase workability factor by 2.5 units.
      c) For each 94 pounds of cement below 564 pounds per cubic yard, decrease workability factor by 2.5 units.
      d) Proportion adjustment factor by linear interpolation for each fraction of 94 pounds above or below the 564 pound basis.
      e) Example:
      650 pounds per cubic yard = 564 pounds + 86 pounds.
      Adjustment = (86 lb / 94 lb) x 2.5 = + 2.28.

D. Concrete Classes for use in the Work:
   1. Provide concrete classes listed in Table 3 of this Section.
   2. Provide normal weight concrete, having minimum weight of 140 pounds per cubic foot, unless otherwise noted.
   3. Pumped concrete:
      a. Provide pumped concrete that complies with all requirements of this Section.
      b. Mixes placed by pumping shall be considered a sub-class of each concrete class listed in Table 3 of this Section. Prepare and submit a separate mix design for each mix to be placed by pumping.
   4. Class PM concrete: In addition to the requirements of Table 3 of this Section, conform to the following:
      a. Minimum 28 day flexural strength: 650 psi when tested in accordance with ASTM C293.
      b. Cementitious materials content: 75 percent Portland cement plus 25 percent Class F fly ash (by weight).
      c. Aggregate:
         1) Minimum 55 percent coarse aggregate conforming to ASTM C33 size number 357 or size number 467.
         2) Substitute ASTM C33 size number 57 or size number 67 if mechanical paving equipment is not used.
   5. Class M concrete: In addition to the requirements of Table 3 of this Section, conform to the requirements for Class A concrete.

Table 3 - Concrete Classes									
Concrete Class[1]	Minimum Specified Compressive Strength at 28 days, f'c [2] (pounds per square inch)	Ratio of water to cementitious materials[3] (minimum - maximum).	Cementitious Materials Content (pounds per cubic yard of concrete by weight)[4]	Cement Type	Maximum Chloride Content (percent by weight of cement)	Maximum Size of Coarse Aggregate (ASTM C33)	Air Entrainment (percent), (n/a: not applicable)	Admixtures required[4,5]	Slump Range (inches)
A	4,000 4,500	0.40 to 0.42	535 to 575	ASTM C150, Type II(MH)	0.15	#57	6±1.5	AEA WRA	2 to 4
A-NA	4,000 4,500	0.40 to 0.45	535 to 575	ASTM C150, Type II(MH)	0.15	#57	n/a	WRA	2 to 4
C	2,500	0.62 max.	423 min.	ASTM C150, Type II(MH)	No limit	#57	6±1.5	AEA WRA	3 to 6
CE	3,000	0.62 max.	423 min.	ASTM C150, Type II(MH)	No limit	#8	5±1.5	AEA WRA	3 to 6
PM	5,000	0.40	535 to 575	ASTM C150, Type II(MH)	0.15	#57	5±1.5	AEA WRA	3 to 6

Notes:

1. Sub classes within major concrete classes are designated as follows:
   NA: Without air entrainment.
2. At locations where concrete will not be subjected to load from other elements of the structure or from Contractor's placing and/or backfilling operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Engineer.
3. W/C Ratio = Ratio of water to cementitious materials by weight. Include weight of admixtures in the water content of the mix when the quantity of the admixtures exceeds 10 ounces per 100 pounds of cement.
4. Cementitious material includes Portland cement plus supplemental cementitious materials. If trial batch testing demonstrates that the required strength cannot be met at 28 or 56 days with the specified combined aggregate gradation and the paste content limits, cementitious material content may be increased with Engineer's approval if Class M concrete is provided and Thermal Control Plan and Temperature Monitoring Program in accordance with Section 03703 - Thermal Control of Concrete is provided for cast-in-place concrete elements. Cement content and/or threshold for the thermal control requirement may be adjusted by the Engineer based on the Equivalent Cement Content (ECC) of the approved Class M concrete mix.
5. Admixtures are designated as follows:
   AEA: Air entraining admixture.
   HRWR: High-range water-reducing admixture.
   PRAH: Permeability-reducing admixture for concrete exposed to hydrostatic conditions.
   SFR: Synthetic fiber reinforcement.
   SRA: Shrinkage-reducing admixture.
   WRA: Water-reducing admixture.

E. Install Concrete Classes in accordance with the following requirements unless otherwise indicated on the Drawings.
   1. Class A concrete: Structural concrete.
      a. Use Class A concrete at all locations unless other Classes are specified or indicated on the Drawings.
   2. Class A-NA concrete: Structural concrete without air entrainment.
      a. Class A-NA concrete may be used in lieu of Class A at indoor slabs (not subject to freezing and thawing) where inclusion of an air-entraining admixture makes it difficult to achieve the specified concrete finish.
   3. Class C concrete: Miscellaneous concrete fill and encasement.
      a. Class C concrete may be used for fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and where indicated on the Drawings.
   4. Class CE concrete: Use Class CE for electrical conduit encasements.
   5. Class PM concrete: Use for concrete pavement, cart paths, curbs, gutters, and sidewalks.

F. Concrete mix design documented by field experience:
   1. Mix design:
      a. Prepare preliminary mix design for each Concrete Class. Submit mix design with product and testing data for materials to be used in the mix for Engineer's review.
   2. Historical records for similar mix.
      a. Determinations of similarity of materials and proportions between historical and proposed mixes shall be by the Engineer, and that shall be final.
      b. Historical record - Materials:
         1) Submit with each mix design the following data for a previously-supplied concrete mix similar to that proposed for this Work.
         2) Records demonstrating that the previously supplied mix included similar materials and proportions as those of the proposed mix.
            a) Documentation that the same concrete supplier will provide both mixes.
            b) Documentation that the materials used was from the same suppliers and had essentially the same properties, demonstrated by test data, as those proposed.
            c) Documentation that proportions of materials in the record mix are essentially the same as those proposed and that the specified compressive strength of the record mix is within 1,000 pounds per square inch of that required by this Section.
            d) Concrete supplier's statement describing any changes made to production of the record mix during the time period reported.
            e) Concrete supplier's statement that preparation and quality control procedures for the record mix were essentially the same as those to be employed for this Work.
      c. Historical record - Testing:
         1) Submit with each record mix, corresponding test data for slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.

2) Only records satisfying the following requirements will be accepted.
    a) All tests were conducted within a period of 1 year preceding the date of the Submittal.
    b) All tests were conducted over a period including not less than 45 days.
    c) Record of compressive strength testing includes at least 30 tests for slump and 28-day compressive strength.
    d) Record of compressive strength tests is consecutive. In other words, it includes all tests conducted on the subject mix within the 1-year time period described above (not just selected tests during that period).
    e) Submit concrete supplier's sworn statement confirming that all tests for the record mix have been reported.
    f) Tests for drying shrinkage are described in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing".
    g) Provide supplementary testing if requested by Engineer.

d. For mixes determined to be similar and to have an acceptable test history, acceptance criteria shall be as follows:
    1) Acceptance criteria:
        a) Slump: All tests within limits specified for record mix.
        b) Compressive strength: Average compression strength for tests, as determined by ACI CODE-350 not less than minimum required average strength.
        c) Drying shrinkage: Within limits stated in subsequent paragraphs of this Section for "concrete mix design documented by trial batch preparation and testing".

G. Concrete mix design documented by trial batch preparation and testing:
1. Mix design and trial batches:
    a. Prepare preliminary mix design for each Concrete Class. Submit mix design with product and testing data for each combination of materials and proportions to be used for Engineer's review.
        1) Determine water content of the mix based on curves showing the relation between water-cementitious materials ratio and the 7- and 28-day compressive strength of the concrete.
        2) Determine each curve using 4 or more points, each representing the average compressive strength value of at least 3 specimens tested at each age.
    b. After materials and proposed mix designs have been accepted by Engineer, have trial batches for each concrete mix design prepared by Contractor's testing laboratory.
        1) Prepare trial batches using the cementitious materials, aggregates, and admixtures proposed to be used for the Work.
        2) Provide batches of sufficient quantity to determine slump, workability, consistency, setting time, and finishing characteristics, and to provide sufficient specimens for testing.

c. For each trial batch, make and test specimens to determine and report slump, compressive strength (with relationships for rate of strength gain between testing ages), and drying shrinkage.
    1) If trial batches do not produce concrete conforming to the specified requirements for slump, strength, workability, consistency, drying shrinkage, restrained shrinkage, and finishing, change mix proportions and, if necessary, sources of materials.
    2) Make additional trial batches and perform additional tests until a batch that conforms to requirements of this Section is produced.

2. Testing - Slump:
    a. Determine slump in accordance with ASTM C143.
    b. Acceptance criterion: Slump within range specified.
3. Testing - Compressive strength:
    a. Prepare 4 inch diameter by 8 inch long cylinders in accordance with ASTM C31 for tests specified in this Section.
    b. Determine average compressive strength:
        1) Test at least 12 cylinders from each trial batch for compressive strength in accordance with ASTM C39.
        2) Test 4 cylinders at 7 days, another 4 at 28 days, and another 3 at 56 days.
        3) Calculate average compression strength for 7 day tests, for 28 day tests, and for 56 day tests.
        4) Calculate ratios for:
            a) Average 7 day strength to average 28 day strength.
            b) Average 28 day strength to average 56 day strength.
    c. Determine the required average compressive strength for each mix, f'cr, as described in the following paragraphs:
        1) Calculate required average compressive strength (f'cr) based on the minimum specified 28-day compressive strength, f'c, plus a standard deviation determined from the test history available for that mix.
        2) Determine f'cr as specified in ACI CODE-350, except as modified in the following paragraphs:
            a) Where 15 or more 28-day compressive strength tests are available, calculate standard deviation as described in the preceding paragraphs for "concrete mix design documented by field experience". Add this standard deviation to the specified minimum compressive strength to determine the required average compressive strength (f'cr) for the mix.
            b) Where fewer than 15 compressive strength tests at 28 days are available, determine minimum required compressive strength, (f'cr) from Table 4 of this Section.

Table 4 - Required Average Compressive Strength, Fewer than 15 Tests Available

Minimum Specified Compressive Strength, f'c (pounds per square inch)	Required Average Compressive Strength, f'cr (pounds per square inch)
Less than 3,000	f'c + 1,000
3,000 to 5,000	f'c + 1,200
Over 5,000	f'c + 1,400

d. Acceptance criterion: Average compressive strength of the 4 cylinders tested at 28 days, or of the 4 cylinders tested at 56 days when permitted by the Engineer, shall equal or exceed the required average compression strength, f'cr for that concrete mix design.

4. Testing - Chloride content:
   a. Submit test results showing that the concrete mix contains water-soluble chloride ion content contributed from the constituents including water, aggregates, cementitious materials, and admixtures is less than the limit specified in Table 3 of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days.
5. Testing - Drying shrinkage - Prism specimens:
   a. Class A (including A, A-NA, A-SP, and A-NA-SP) , Class M, and Class PM: From trial batch for each mix, prepare 10 drying shrinkage specimens in accordance with ASTM C157 Divide specimens into 2 groups of 5 specimens each: 1 group including shrinkage-reducing admixture, and 1 group without shrinkage-reducing admixture.
   b. Prepare, cure, and test both groups in accordance with ASTM C157, except as modified in the following paragraphs.
      1) Remove drying shrinkage specimens from molds at age of 23 hours, plus or minus 1 hour, after trial batching.
         a) Immediately place them in lime-saturated water maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, for at least 30 minutes.
         b) Remove specimens from the water and wipe with a damp cloth.
         c) Measure to nearest 0.0001 inch to determine original length.
         d) Record measurements and re-submerge specimens in lime-saturated water at 73 degrees Fahrenheit, plus or minus 3 degrees, for moist curing.
      2) Maintain submerged curing conditions at 73 degrees Fahrenheit, plus or minus 3 degrees, for 7 days. 7 days after batching, remove specimens from water and repeat measuring procedures.
      3) Immediately store specimens in a humidity controlled room maintained at 73 degrees Fahrenheit, plus or minus 3 degrees, and at 50 percent relative humidity plus or minus 4 percent for remainder of the test.
      4) At periods of 14, 21, 28, and 56 days after batching, remove specimens from curing room and repeat measurements.
   c. Drying shrinkage test report:
      1) Report measurements of all specimens at 1, 7, 14, 21, 28, and 56 days after batching.
      2) Using measured length at 7 days as base length for drying shrinkage, calculate the following for each measuring period:
         a) Drying shrinkage of each specimen. Determine as difference between the 7-day base length and measured length for each period.
         b) Average of these differences. If drying shrinkage of any specimen departs from the average of the measurements for each period by more than 0.0004 inch, disregard results obtained from that specimen.
         c) Percentage of drying shrinkage from batching to date of measurement.

d. Drying shrinkage acceptance criteria:
    1) Average shrinkage of trial batch concrete specimen group at 28 days after batching, when measured and cured as indicated, shall not exceed 0.035 percent.
e. Mixes accepted by Engineer:
    1) Retain drying shrinkage test specimens. Bag in re-sealable plastic bags and submit to Engineer.
    2) Indicate trial batch identifier, specimen number, and date of final measurements on each specimen bag.

6. Modulus of elasticity: Tests: Test 2 cylinders at 28 days for static modulus of elasticity in compression in accordance with ASTM C469.
    a. Required results: Modulus of elasticity shall not be less than 54,000 times square root of the 28-day strength of the cylinders.

2.07 SOURCE QUALITY CONTROL

A. Sample and test materials in accordance with the following requirements:
    1. Sampling, testing, and reporting frequency:
        a. In preparation for mix design submittals and trial batch tests.
        b. Whenever there is a change in source of the material, or a significant change in the characteristics or quality of materials from the same source.
        c. For each 10,000 cubic yards of concrete mix produced.
        d. At intervals not exceeding 90 calendar days, unless otherwise specified in the following paragraphs.
    2. Supplemental cementitious materials.
        a. Sample and test fly ash in accordance with ASTM C311.
    3. Aggregate:
        a. Sample combined aggregate in accordance with ASTM D75 and D3665, and test for gradation in accordance with ASTM C136.
        b. At least once every 30 days, and when requested by the Engineer.
        c. Submit test results.
    4. Cementitious materials:
        a. Sample and test cementitious materials and provide mill certificates demonstrating compliance with ASTM C150 and additional requirements of this Section.
            1) Determine alkali content by method set forth in ASTM C114.
        b. At least once every 90 days, and when requested by the Engineer.
        c. Submit test results.

B. Batch materials in accordance with the following requirements:
    1. Concrete batch weights: Control and adjust so as to secure maximum yield, and at all times maintain proportions of concrete mix within specified limits.
    2. Aggregates:
        a. Obtain aggregate from a source capable of providing uniform quality, moisture content, and grading during any single day's operation.
        b. Furnish satisfactory means at batching plant for checking moisture content of fine aggregate for each batch.

3. Admixtures:
    a. Batch solutions using mechanical batcher capable of accurate measurement.
    b. Air entraining admixture: Add to batch in portion of the mixing water, unless otherwise recommended by the admixture manufacturer.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare and submit mix designs for each Concrete Class indicated in Table 3 of this Section.

B. Submit proposed sequence of concrete placements. After acceptance, adhere to proposed sequence of placing concrete, except when specific changes are requested by the Contractor and accepted by the Engineer.
    1. Use construction methods and sequence work to allow concrete placement to reach adequate strength and to be constructed with required support to prevent overstress of the concrete structure during construction.

C. Make provisions for monitoring weather conditions:
    1. Install an outdoor weather station capable of measuring and recording ambient temperature, wind speed, and humidity. Furnish instruments accurate to within 2 degrees Fahrenheit, 5 percent relative humidity, and 1 mile per hour wind speed.
    2. Monitor the weather forecast beginning at least 48 hours prior to any concrete placement and make provisions for cold weather concreting or hot weather concreting if those conditions exist or are forecast to exist during the period of placement, finishing, and curing.
        a. Record temperature, relative humidity, and wind speeds for each placement beginning at least 24 hours before scheduled delivery of concrete.

D. Place no concrete without Engineer’s prior acceptance of conditions.

E. Notify the Engineer in writing that preparations are complete and ready for placement of concrete. Such notification shall indicate readiness, not just intention, to place concrete for the designated portion of the Work.
    1. Submit notification to Engineer on forms provided by or acceptable to the Engineer and bearing the signature of Contractor’s superintendent.
        a. Sample form is included at the end of this Section, see Attachment B - Coarseness Factor Chart.
    2. Submittal of notification will be Contractor’s certification that preparations are complete and in accordance with the Contract Drawings and Specifications.
    3. Provide notification for Engineer to make final observations at the locations of concrete placements not less than 24 hours before commencing placement of concrete.

3.02 CONCRETE JOINTS

A. Locations of joints are indicated on the Drawings.
   1. In order to preserve strength and watertightness of structures, make no other joints, except as authorized by the Engineer.
   2. Construct joints where indicated, and as indicated on the Drawings.
   3. Where joint locations are not indicated on the Drawings, submit Contractor's proposed locations for Engineer's review and acceptance. Provide construction joints in slabs and walls at intervals not greater than 35 feet.

B. Time between placements of adjacent concrete separated by joints.
   1. Provide not less than 3 days (72 hours) between placement of adjacent sections for the following:
      a. Slabs.
      b. Walls.
   2. Provide not less than 7 days (168 hours) between placement of the lower and upper pours for the following:
      a. Walls over slabs.
      b. Slabs over walls.
      c. Slabs keyed into the sides of walls.

C. Edges of joints:
   1. Provide joints have edges detailed as indicated on the Drawings.
   2. Protect wall and slab surfaces at edges from concrete splatter. Thoroughly clean adjacent surfaces after completion of each placement.

D. Keyways in joints:
   1. Provide keyways in joints unless specifically noted otherwise on the Drawings.
   2. Treat lumber keyway material with form release coating, applied in accordance with manufacturer's instructions.

E. Joint construction:
   1. Preparation of forms:
      a. Provide cleanout holes at base of each wall and column for inspection and cleaning.
      b. Wash forms and adjacent joint surfaces of sawdust, chips, and other debris after forms are built, and immediately before concrete or grout placement.
      c. Should formwork confine sawdust, chips, or other loose matter in such manner that it is impossible to remove them by flushing with water, use a vacuum cleaner for their removal, and then flush cleaned surfaces with water.
   2. Before placing concrete against previously placed concrete, thoroughly clean the prior placement of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter by means of pressure washing.
   3. Provide and install waterstops, expansion joint material, and other similar materials as indicated on the Drawings and as specified.
      a. Take special care to ensure that waterstops are secured in proper position.
      b. Take special care to ensure that concrete is well consolidated around and against waterstops during placement.

4. Horizontal joints:
    a. As initial placement over cold joints, thoroughly spread bed of cement grout as specified in Section 03600 - Grouting.
        1) Thickness: Not less than 1/2 inch or more than 1 inch.
    b. For wall placements above planned cold joints, placement of cement grout will not be required for locations where the wall mix includes high-range water-reducing admixture (“superplasticizers”), and the Contractor can demonstrate dense concrete joints without voids or honeycomb after the forms are removed.

3.03 MEASURING AND BATCHING MATERIALS

A. Measurements of materials:
    1. Proportion and measure cementitious materials and aggregates by weight.
        a. Weigh cementitious materials separately.
        b. If bulk cementitious materials are used, weigh them on separate visible scale that will accurately register scale load at any stage of weighing operation from zero to full capacity.
        c. Cement in unbroken standard packages (sacks) need not be weighed.
    2. Mixing water: Measure by volume or by weight.
    3. Other mix constituents: Measure by weight, except as otherwise specified or accepted by the Engineer.
    4. Weighing and measuring devices:
        a. Use equipment designed and constructed specifically for that purpose.
        b. Furnish devices capable of weighing successive quantities of individual material measured to within 1 percent of desired weight of that material.
        c. Bearing valid seal of the department of weights and measures for the authority having jurisdiction over the Work.
    5. Measurements and measuring devices:
        a. Subject to review by the Engineer.

B. Batching:
    1. Admixtures shall be added at the concrete batch plant.
    2. Addition of admixtures in the field is permitted only with prior acceptance by the Engineer, and only when the following conditions are satisfied:
        a. Dosage and mixing is personally overseen by concrete supplier's trained technologist.
        b. Adequate mixing is provided after addition.
        c. Maximum time to placement of concrete remains 90 minutes after water added to mix - not 90 minutes after any field additions/adjustments.
        d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

3.04 MIXING AND TRANSPORTING

A. Machine mixing:
    1. Prevent cementitious materials from coming into contact with aggregate or with water until materials are in mixer and ready for complete mixing with all mixing water.

2. Procedure of mixing cementitious materials with sand, or with sand and coarse aggregate, for delivery to project site for final mixing and addition of mixing water is not permitted.
3. Remixing of concrete that has started to take its initial set (“retempering”)is not permitted.
4. Discharge entire batch before recharging.
5. Volume of mixed material per batch: Not exceeding manufacturer's rated capacity of mixer.

B. Transit-mixed concrete:
   1. Mix and deliver in accordance with ASTM C94, except as modified in this Section.
   2. Total elapsed time between addition of water at batch plant and discharging completed mix:
      a. Not to exceed 90 minutes or 300 revolutions of the mixing drum.
      b. Under conditions contributing to rapid setting, total elapsed time permitted may be reduced by the Engineer.
   3. Temperature - minimum and maximum allowable during mixing and transporting:
      a. Minimum: 50 degrees Fahrenheit.
      b. Maximum: 90 degrees Fahrenheit.
   4. Continuously revolve drum after it is started until it has completely discharged its batch.
      a. Do not add water until drum has started revolving.
      b. Engineer reserves the right to increase required minimum number of revolutions or to decrease designated maximum number of revolutions allowed, if necessary, to obtain satisfactory mixing. Contractor will not be entitled to additional compensation because of such increase or decrease.

C. Concrete delivery:
   1. Furnish to the Engineer a delivery ticket for each batch of ready mixed concrete within 24 hours after delivery. Include the following information on each ticket:
      a. Time of day concrete was batched, and time of day that discharge from the truck is complete.
      b. Printed record of the individual weight of each of the following constituents in the batch: Fine aggregate, coarse aggregate, cement, pozzolan, and water.
      c. Concrete Class as defined in Table 3 of this Section.
      d. Type, brand, and quantity of each admixture in the batch.
      e. Total volume of water allowed in the mix, volume of mixing water added at the batch plant, volume of mixing water withheld from the mix during batching, and total volume of any water added to the mix after leaving the batch plant.
         1) In no case shall volume of mixing water withheld result in a water/cementitious materials ratio less than the minimum values specified in Table 3 of this Section.
      f. Number of revolutions of transit truck at arrival on site, and total number of revolutions when discharge is complete.
      g. Volume of concrete delivered in the batch.
      h. Numerical sequence of the batch delivered for that placement.

2. Additional water may only be added to the mix when the following conditions are fully satisfied:
    a. Batch ticket showing total volume of water already added and maximum volume of water that may be added is available for Engineer's observation before any additional water is added.
    b. Total volume of water in the mix after the addition will be less than the maximum allowable volume of water indicated on the ticket.
    c. Full concrete load is still within the truck's mixing drum, and truck has not begun to discharge the load. Under no conditions shall water be added in the field to a partial truckload of concrete.
    d. Volume of water added, and time of addition are clearly marked for record on the batch ticket delivered to the Engineer.
3. Addition of admixtures in the field is permitted only with prior approval by the Engineer, and when the following conditions are satisfied:
    a. Dosage and mixing is personally overseen by concrete supplier's trained technologist and admixtures supplier's representative.
    b. Adequate mixing time is provided after addition of admixtures.
    c. Maximum time to placement of concrete remains 90 minutes after water is added to the mix - not 90 minutes after any field additions/adjustments.
    d. Slump at discharge after additions/modifications conforms to the requirements of Table 3 of this Section.

D. Conveying concrete:
1. Convey concrete from mixer to location of final deposit by methods that prevent separation or loss of materials.
2. Use equipment for chutes, pumps, and conveying of concrete of such size and design as to ensure practically continuous flow of concrete, from delivery to the point of placement, without separation of materials.
3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from chute or conveying device.
4. Keep equipment for conveying concrete thoroughly clean by washing and scraping upon completion of any day's placement.

3.05 PLACING AND CONSOLIDATING

A. Preparation:
1. Obtain Engineer's acceptance of completed preparations before placing concrete.
    a. Notify Engineer in writing that all preparations are complete and ready for placement of concrete. Such indication shall indicate readiness, not just intention, to place concrete for the designated portion of the Work.
    b. Submit completed Attachment D - Contractor's Concrete Placement Checklist Form.
2. Confirm completeness of the following before notification of readiness is given to Engineer:
    a. Place forms, reinforcement, screeds, anchors, ties, and inserts in final position.
    b. Reinforcement is secure and properly fastened in its correct position.
    c. Loose form ties at construction joints have been retightened.

d. Dowels, bucks, sleeves, hangers, pipes, conduits, anchor bolts, and any other fixtures required to be embedded in concrete have been placed and adequately anchored.
e. Forms have been cleaned of debris and form release agents are applied as specified.

3. Preparation for placement of footings and slabs on grade:
   a. Do not place concrete on ground or compacted fill until subgrade is in moist condition acceptable to the Engineer.
   b. If necessary, sprinkle subgrade with water not less than 6 or more than 20 hours in advance of placing concrete.
   c. If subgrade surface becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
   d. Do not place concrete if subgrade is muddy or soft.
4. Keep sufficient protective coverings on hand at all times for protection of concrete during and after placement.
   a. Protect concrete placed before rain to prevent water from coming in contact with such concrete.
   b. Protect concrete placed before winds to prevent excessive drying or embedment of debris in the finished surfaces.

B. Concrete placement:
1. Do not place concrete:
   a. With slump outside the limits specified in Table 3 of this Section.
   b. In which initial set has occurred, or that has been retempered.
   c. During rainstorms or high velocity winds.
2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
   a. Do not deposit concrete in large quantities in one place, and then work material along forms with vibrator or by other methods.
3. Do not drop concrete freely into place from height greater than 5 feet. Use tremies for placing concrete where drop is over 5 feet.
4. Place concrete on slopes starting from bottom of slope and working upward.
5. Place concrete in horizontal lifts not exceeding 24 inches in depth and bring up evenly in all parts of forms.
6. After concrete placement begins, continue in a continuous operation without significant interruption until the end of the placement. Plan and implement precautions to prevent any delay, between layers or adjacent volumes, from exceeding 20 minutes.
7. If concrete is to be placed over previously placed concrete and more than 20 minutes has elapsed, spread layer of cement grout over surface before placing additional concrete. Provide grout layer thickness of not less than 1/2 inch or more than 1 inch.
8. Placement of concrete for slabs, beams, or walkways:
   a. If cast monolithically over walls or columns, do not commence until concrete in walls or columns has been allowed to set and shrink.
   b. Allow set time of not less than 1 hour for shrinkage.
      1) During waiting time, keep top surface of concrete moist, but not wet.
      2) Do not permit water to pond or stand on the surface.
      3) Do not coat surface with evaporation retarders or curing agents.
   c. Start placement above wall or column with layer of cement grout as described in the preceding paragraph.

C. Consolidating concrete:
   1. Consolidate concrete with aid of acceptable mechanical vibrators.
   2. Thoroughly consolidate concrete around reinforcement, pipes, or other shapes built into the Work.
   3. Provide sufficiently intense vibration to cause concrete to flow and settle readily into place and to visibly affect concrete over radius of at least 18 inches.
   4. Vibrators:
      a. Keep sufficient vibrators on hand at all times to vibrate concrete as placed.
      b. In addition to vibrators in actual use while concrete is being placed, have on hand a minimum of 1 spare vibrator in operable condition.
      c. Do not place concrete until it has been confirmed that all vibrating equipment, including spares, are in operable condition.
   5. Place concrete solidly against forms and concrete surfaces, leaving no voids or honeycomb.
   6. Make concrete solid, compact, and smooth. If for any reason surfaces or interiors have voids or are in any way defective, repair such concrete in manner acceptable to the Engineer.
   7. Do not over-vibrate so as to produce segregation.

3.06 FINISHING CONCRETE

A. Provide concrete finishes in accordance with Section 03366 - Concrete Finishes, unless otherwise indicated on the Drawings.

B. Liquid evaporation retardant:
   1. Under conditions that result in rapid evaporation of moisture from the surface of the concrete, coat the surface of the concrete with a liquid evaporation retardant immediately after screeding.
   2. Conditions that result in rapid evaporation of moisture are defined as any combination of ambient temperature, concrete temperature, relative humidity, wind speed, and solar radiation intensity that creates conditions that will evaporate water from a free concrete surface at a rate equal to or greater than 0.1 pounds per square foot per hour as determined by the Menzel Formula and nomograph published in ACI PRC-305 and included as Attachment A - Menzel Formula and Nomograph to this Section.
   3. Apply evaporation retardant again after each finishing operation as necessary to prevent drying shrinkage cracks.
   4. Do not work evaporation retardant into the surface of the concrete.
   5. Do not use evaporation retardant as finishing aid (to rehydrate surface a creamy state for finishing).

C. Concrete sealer:
   1. Floors and slabs to receive concrete sealer: See Room Finish Schedule on the Drawings, and Section 03366 - Concrete Finishes.

3.07 CURING

A. Cure concrete by methods specified in this Section.

B. Keep concrete continuously moist and at an average daily temperature of at least 50 degrees Fahrenheit for a minimum of 7 days after placement.
    1. Provide at least 350 degree days of curing (350 degrees times 7 days of 24 hours each).
    2. If hourly temperatures at any surface of a concrete placement drop below 50 degrees Fahrenheit during the curing period, count the period below 50 degrees Fahrenheit as zero degrees, and extend the curing time to compensate.

C. Schedule of curing methods:
    1. Cure the following concrete surfaces using water curing, or plastic membrane curing.
        a. Floor surfaces of water containment structures.
        b. Surfaces where additional concrete will be placed over or against the surface, including concrete joints.
        c. Surfaces where grout or other toppings will be placed over the surface.
        d. Slabs scheduled to receive concrete sealer, or other bonded or adhered architectural finishes.
        e. Formed surfaces scheduled to receive coatings, paint, adhered masonry, cementitious materials, or other similar finishes, and where formwork is removed within 7 days after concrete placement.
        f. Horizontal concrete surfaces at tops of walls.
    2. Cure the following concrete surfaces by water curing, plastic membrane curing, or sprayed curing membrane. Selection of methods shall be at the Contractor's option.
        a. Surfaces not listed in the preceding paragraph.

D. Water curing:
    1. Keep surfaces of concrete constantly and visibly wet, day and night, for period of not less than 7 days.
        a. Each day forms remain in place will be counted as 1 day of water curing.
        b. Do not loosen form ties during period when concrete is cured by leaving forms in place. No further curing credit will be allowed for forms remaining in place after contact has been broken between concrete surface and forms.
    2. Begin water curing as soon as concrete attains initial set.
    3. Maintain a wet surface by ponding, continuous sprinkling, covering with saturated burlap, or otherwise saturating the surface by means acceptable to Engineer.
        a. Flood top of walls with water at least 3 times per day and keep surfaces moist at all times during the 7-day curing period.
        b. Provide plastic sheet material over surfaces if required to maintain a wet surface during arid or windy conditions. See plastic membrane curing requirements for additional details.
    4. Use water having a temperature within 20 degrees Fahrenheit of the temperature of concrete, and not lower than the minimum temperature allowed for the concrete surface during curing.

E. Plastic membrane curing:
    1. Install plastic membrane as soon as concrete is finished and can support limited pedestrian traffic without damage.

2. Cover entire surface of finished concrete with membrane.
3. Anchor membrane to prevent uplift from wind or air trapped below the sheet.
4. Fully seal joints and edges to provide full seal around perimeter.
5. Keep concrete under plastic membrane moist, regularly monitoring surfaces and adding supplemental moisture if necessary. Add water as specified for water curing.

F. Sprayed membrane curing compound:
   1. Apply curing compound to concrete surface after repairing and patching, and within 1 hour after forms are removed.
      a. If more than 1 hour elapses after removal of forms, do not use membrane curing compound. Instead, provide water curing for not less than 7 days.
      b. Do not remove sprayed membrane curing compound from concrete in less than 7 days after initial application.
      c. When application of curing compound at concrete joints is accepted by Engineer, take care to apply curing compound to all surfaces along full profile of joints.
   2. Apply curing compound by mechanical, power operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
      a. Apply curing compound in at least 2 coats.
      b. Apply each coat in direction turned 90 degrees from application direction of the preceding coat.
      c. Apply curing compound in sufficient quantity so that concrete has uniform appearance and its natural color is effectively and completely concealed immediately after spraying.
      d. Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
   3. Thickness and coverage of curing compound:
      a. Provide curing compound having film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
      b. Contractor is cautioned that method of applying curing compound specified in this Section may require more curing compound than normally suggested by manufacturer of curing compound and is more than is customary in the trade. Apply amounts specified in this Section, regardless of manufacturer's recommendations or customary practice.
   4. If Contractor desires to use a curing compound other than specified product, coat sample areas of concrete wall with proposed curing compound, and also coat similar adjacent area with the specified compound in the manner specified, for comparison:
      a. If proposed sample is not equal or better, in opinion of the Engineer, the proposed substitution will not be allowed.
   5. Removal of curing compound.
      a. After curing period is complete, remove curing compound placed on surfaces that will receive additional concrete, including all concrete joint surfaces, by heavy sandblasting or by other means acceptable to Engineer. Complete removal and cleanup prior to placing any new concrete against the surface.
      b. Where additional finishes will be applied over concrete surfaces, unless otherwise recommended by the manufacturer of the finish to be applied, remove curing compound by sandblasting. Provide blasting as necessary to fully remove curing compound.

6. Prior to final acceptance of the Work, remove, by sandblasting or by other method acceptable to the Engineer, any curing compound on surfaces exposed to process water or exposed to view, so that only natural color of finished concrete is visible and uniform over the entire surface.

3.08 PROTECTION

A. General:
   1. Keep forms in place, as specified in Section 03102 - Concrete Formwork, to provide curing and to protect concrete surfaces and edges from damage.
   2. Immediately after forms are removed, carefully examine concrete surfaces, and repair any irregularities in surfaces and finishes as specified.

B. Loading of concrete members:
   1. Placement of loads on or against green concrete is not permitted.
   2. Do not place soil against walls, or fill over the top of concrete until conditions designated in the following paragraphs are satisfied:
      a. Walls have been cast to their full height in the structure and have achieved their minimum specified 28-day compressive strength.
      b. Connecting slabs and beams that brace the walls are in place, are complete, and (in the case of concrete) have achieved their minimum specified 28-day compressive strength.

3.09 HOT WEATHER CONCRETING

A. Implement hot weather concrete procedures during periods of hot weather as defined in this Section.
   1. Comply with the recommendations of ACI PRC-305 and this Section.

B. If placements during hot weather are expected, and when requested by the Engineer, prepare a hot weather concreting plan.
   1. Maintain at least 1 copy on site.
   2. Provide plan for review if requested by the Engineer.
      a. Include procedures for batching, delivery, placement, curing, protection, and monitoring and recording the temperature of the concrete and the surrounding environment.
      b. Describe procedures to be implemented in the event of abrupt changes in weather conditions, or in the event of equipment failure.
      c. Review hot weather concreting plan during pre-construction meeting. Make provisions to address any concerns expressed by Engineer before beginning concrete placements.

C. Preparation:
   1. Do not place concrete against forms, reinforcement, or embedments with a surface temperature greater than 120 degrees Fahrenheit.
      a. If necessary, to maintain maximum concrete temperature during placing, cool forms and reinforcement to temperature below 90 degrees Fahrenheit using water or shades.
      b. Do not allow water to puddle in forms or placement areas.

2. Moisten forms or subgrade to maintain a saturated surface without standing water or soft spots.
3. Provide windbreaks, shades, fog spray, sprinkling, wet cover, or other means required to protect concrete from premature loss of moisture and rapid temperature gain.

D. Batching and delivery:
   1. Retarding admixtures will not be permitted.
   2. Temperature of concrete delivered for placement shall not exceed 90 degrees Fahrenheit.
      a. Maintain uniform temperature in the mix below this level during batching, delivery, placing, and consolidation.
      b. Temperature of mix, even if below the maximum allowable temperature specified, shall be maintained at a level to avoid loss of slump, flash setting, or cold joints in placements.
   3. If necessary:
      a. Mix water may be chilled or replaced with ice to maintain mix temperature. Where mix water is replaced with ice, provide replacement at a 1-to-1 ratio by weight.
      b. Shade transit mixed concrete trucks, or cool mixing outside of container with water to control temperature of concrete.

E. Placing and finishing:
   1. Place and finish concrete promptly. Place so that vertical lift lines will not be visible in exposed concrete surfaces.
   2. Provide plastic sheeting, fog nozzles, shades or other means to reduce concrete temperature and protect from moisture loss.

F. Protection and curing:
   1. Furnish and locate maximum/minimum temperature recording thermometers in sufficient numbers to confirm concrete temperatures over full area and edges of concrete.
   2. Flatwork: Protect and cure using water curing methods as specified in this Section.
      a. Water curing:
         1) Keep concrete continuously wet and make provisions for runoff.
         2) For sprinkling or soaker hoses, maintain temperature of water as close as possible to the temperature of the concrete to minimize effects of thermal shock.
   3. Formed surfaces: Protect and cure using forms left in place or membrane curing methods as specified in this Section.
      a. Cover forms and keep continuously moist for at least 24 hours after placement.
      b. Loosen forms as soon as this can be accomplished without damaging the concrete.
      c. Maintain continuously moist surfaces by fogging or spraying with water, or by application of curing compound as specified.

3.10 FIELD QUALITY CONTROL BY CONTRACTOR

A. Provide quality control over the Work of this Section as required by Section 01450 - Quality Control.

B. Field tests:
   1. During progress of construction, provide testing to determine whether the concrete, as being produced, complies with requirements specified.
   2. Sampling and testing shall be performed by Contractor's testing laboratory. See Section 01455 - Regulatory Quality Assurance - Special Tests and Inspections for requirements.
      a. Cooperate in testing by allowing free access to the Work for testing laboratory to sample and test materials.
      b. Provide full access for Engineer to observe concrete sampling and testing at any time.
      c. Contractor is responsible for providing care of and curing conditions for test specimens in accordance with ASTM C31 until specimens are collected by testing laboratory.
      d. Provide 4 firmly braced, insulated, heated, closed wooden curing boxes, each sized to hold 10 specimens. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through shipment to Owner's testing laboratory.
   3. Testing shall include:
      a. Sampling of concrete in accordance with ASTM C172.
      b. Temperature of concrete at delivery in accordance with the requirements of ASTM C1064 and as specified in this Section.
      c. Slump of concrete using slump cone in accordance with requirements of ASTM C143. Test slump at the following intervals:
         1) At the beginning of each placement.
         2) As often as necessary to keep slump within the specified range, but not less than every 6th truck.
         3) When requested to do so by the Engineer.
         4) Observe concrete during slump test for signs of segregation.
            a) Observe concrete to see if mortar or moisture flows from slumped concrete.
            b) Reject concrete if mortar or moisture flows out of mix.
      d. Unit weight of concrete in accordance with ASTM C138.
      e. Air entrainment in accordance with ASTM C173. Test air content at the following intervals:
         1) At beginning of each placement.
         2) As often as necessary to keep entrained air within specified range, but not less than every 6th truck.
         3) When requested to do so by the Engineer.
         4) Test air entrainment in concrete in accordance with ASTM C173. If air entraining admixtures used for the Work require alternate testing procedures, advise the independent testing laboratory well in advance of the dates of testing, and confirm that appropriate equipment and personnel are provided for the test.
         5) Make air test at point of delivery (discharge from mixer). For pumped concrete, make air tests at point of delivery and at point where expelled after pumping for placement.

f. Compressive strength in accordance with ASTM C39. Required number of cylinders is as follows:
    1) Not less than 6 cylinder specimens, 4 inches in diameter by 8 inches long, will be tested for each 150 cubic yards of each class of concrete, with minimum of 6 specimens for each class of concrete placed; not less than 6 specimens for each half day's placement; and not less than 2 sets of 6 specimens for each structure.
    2) 1 cylinder will be broken at 7 days, 1 at 14 days, and 3 at 28 days. 6th cylinder may be used to evaluate strength after 28 days if requested by the Engineer.
    3) Retain and store “6th cylinders” (tested and untested) at testing laboratory until 56 days. Break “6th cylinder” when directed by the Engineer.
g. Provide full access for Engineer to observe concrete sampling and testing at any time.

3.11 FIELD QUALITY CONTROL BY OWNER

A. Provide on-site inspection and field quality assurance for the Work of this Section as specified in Section 01450 - Quality Control.

B. Special tests and inspections: See Section 01455 - Regulatory Quality Assurance.

C. Field inspections:
1. Required inspections:
    a. Observe construction for conformance to the Contract Documents and the accepted submittals.
2. Records of inspections:
    a. Provide record of each inspection.
    b. Submit copies to Contractor upon request.

D. Field tests:
1. Engineer may request, at any time, additional testing to confirm that materials being delivered and placed conform to the requirements of the Contract Documents.
    a. If such additional testing shows that the material do not conform to the specified requirements, Contractor shall pay the cost of these tests.
    b. If such additional testing shows that the materials do conform to the specified requirements, Owner will pay the cost of these tests.

3.12 NON-CONFORMING WORK

A. Remove and replace or repair non-conforming and defective work.
1. Provide repairs having strength equal to or greater than specified concrete for areas involved.
2. Provide replacement or repair of non-conforming work by means acceptable to the Engineer and at no additional cost to Owner.
3. Project schedule will not be extended based on work to address non-conforming concrete.

B. Concrete not conforming to the specified requirements for properties of plastic concrete: Remove from the site and replace with conforming materials at no additional cost to Owner.
   1. Temperature: Do not use concrete having a temperature above or below the limits specified in this Section.
   2. Slump: Do not place concrete that does not conform to requirements for slump.
   3. Air entrainment: Do not use concrete that does not conform to requirements for percentage of entrained air.

C. Concrete not conforming to the specified requirements for compressive strength:
   1. Concrete is expected to reach a compressive strength equal to or greater than the minimum specified compressive strength f'c in Table 3 of this Section.
   2. Strength of concrete will be considered acceptable if following conditions are satisfied.
      a. Averages of all sets of 3 consecutive strength test results is greater than or equal to the specified compressive strength f'c.
      b. No individual strength test (average of 3 cylinders) falls below the strength specified in Table 6 of this Section.
      c. Where relationships between 7-day and 28-day compressive strength, or between 28-day and 56-day compressive strength, have been provided as part of the mix design submittals:
         1) 7-day strength may be considered as an indication of 28-day strength provided effects of temperature and humidity between 7 days and 28 days are taken into account.
         2) 28-day strength may be considered as indication of 56-day strength provided effects of temperature and humidity between 28 days and 56 days are taken into account.

Table 6 - Strength Compliance Requirements

Minimum Specified Compressive Strength, f'c (pounds per square inch)	Lower Bound of an Individual Compressive Strength Test (pounds per square inch)
Less than 5,000	f'c - 500
Over 5,000	f'c - (0.10 x f'c)

   3. Non-compliant strength tests.
      a. Mark non-compliant strength test reports to highlight the non-complying results, and immediately forward copies to all parties on the test report distribution list.
      b. Initial treatment may consist of additional curing of affected portion(s) followed by not less than 3 cores at each affected area, taken in accordance with ASTM C42 and ACI CODE-318. Obtain Engineer's acceptance of proposed coring locations before proceeding with that work.
      c. Submit report of compressive strength testing for Engineer's review.
      d. If requested by the Engineer, provide additional cores, and obtain petrographic testing in accordance with ASTM C856. Submit results for Engineer's review.
      e. If additional curing does not bring the average strength of 3 cores taken in affected area to at least specified compressive strength f'c, designate such concrete in affected area will be considered defective.

f. Engineer may require the Contractor to strengthen defective concrete by means of additional concrete, additional reinforcing steel, or replacement of defective concrete, all at the Contractor's expense.

D. Concrete sections or surfaces with honeycombing and voids:
   1. Provide repairs having surface appearance and finish consistent with that of the surrounding work and acceptable to the Engineer.
   2. Do not patch, repair, or cover defective Work without prior inspection by the Engineer.
   3. Preparation of concrete for repair:
      a. Make no repair until Engineer has accepted methods for preparing surfaces and for making and curing repairs.
      b. Chip out and key-in imperfections in the Work to make them ready for repair.
      c. Coat bonding surfaces and edges of repair area with one of the following bonding agents as accepted by the Engineer.
         1) Epoxy bonding agent as specified in Section 03071 - Epoxies; or
         2) Epoxy resin/Portland cement bonding agent as specified in Section 03072 - Epoxy Resin/Portland Cement Bonding Agent.
   4. Methods of repair:
      a. Dry pack mortar method:
         1) Use for holes having depth nearly equal to or greater than least surface dimension of hole, for cone-bolt holes, and for narrow slots cut for repair.
         2) Smooth holes: Clean and roughen by heavy sandblasting before repair.
         3) Install dry-pack mortar as specified in Section 03600 - Grouting.
      b. Cement mortar method:
         1) Use for holes too wide to dry pack and too shallow for concrete replacement; and for comparatively shallow depressions, large or small, that extend no deeper than nearest surface reinforcement.
         2) Install cement mortar as specified in Section 03600 - Grouting.
      c. Concrete replacement:
         1) Use when holes extend entirely through the concrete section or when holes are more than 1 square foot in area and extend halfway or more through the section.
         2) Form, place, consolidate, and cure concrete of same mix as the surrounding work.

E. Leaking construction joints and cracks in concrete walls and slabs:
   1. Repair cracks that develop in walls or slabs, and repair cracks that show any signs of leakage until all leakage is stopped.
   2. Pressure inject visible cracks in the following areas, other than hairline cracks and crazing, with repair products and methods acceptable to the Engineer.
      a. Floors and walls of water bearing structures.
      b. Walls and overhead slabs of passageways and occupied spaces where the opposite face of the member is exposed to weather or may be washed down and where the opposite face does not receive a separate waterproofing membrane.

c. Other items not specified to receive separate waterproofing membrane including slabs over water channels, wet wells, reservoirs, and other similar surfaces.

3. Continue pressure injection of cracks as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or date of final repair, whichever occurs later in time.

F. Leaking expansion joints in concrete walls or slabs that include waterstops:
   1. Repair any signs of leakage until all leakage is stopped.
   2. Pressure inject visible leaks with hydrophilic polyurethane foam resin as specified in Section 03933 - Hydrophilic and Hydrophobic Foam Polyurethane Resin Injection System.
   3. Continue pressure injection along joints lines as specified until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion or date of final repair, whichever occurs later in time.

G. Walls and slabs at overhead channels that leak or sweat because of porosity or cracks too small for successful pressure injection with epoxy.
   1. Seal on water or weather side by coating using surface-applied sealing system as specified in this Section.
   2. Apply as recommended by manufacturer published instructions. Where concrete continues to sweat or leak, apply additional coats of surface-applied sealing system until the sweating or leaks stop.
   3. Continue application of surface-applied sealing system until structure is watertight and remains watertight for not less than 1 year after date of Substantial Completion, or date of final repair, whichever occurs later in time.

END OF SECTION

ATTACHMENT A - MENZEL FORMULA AND NOMOGRAPH

MENZEL FORMULA AND NOMOGRAPH

Source: ACI PRC-350

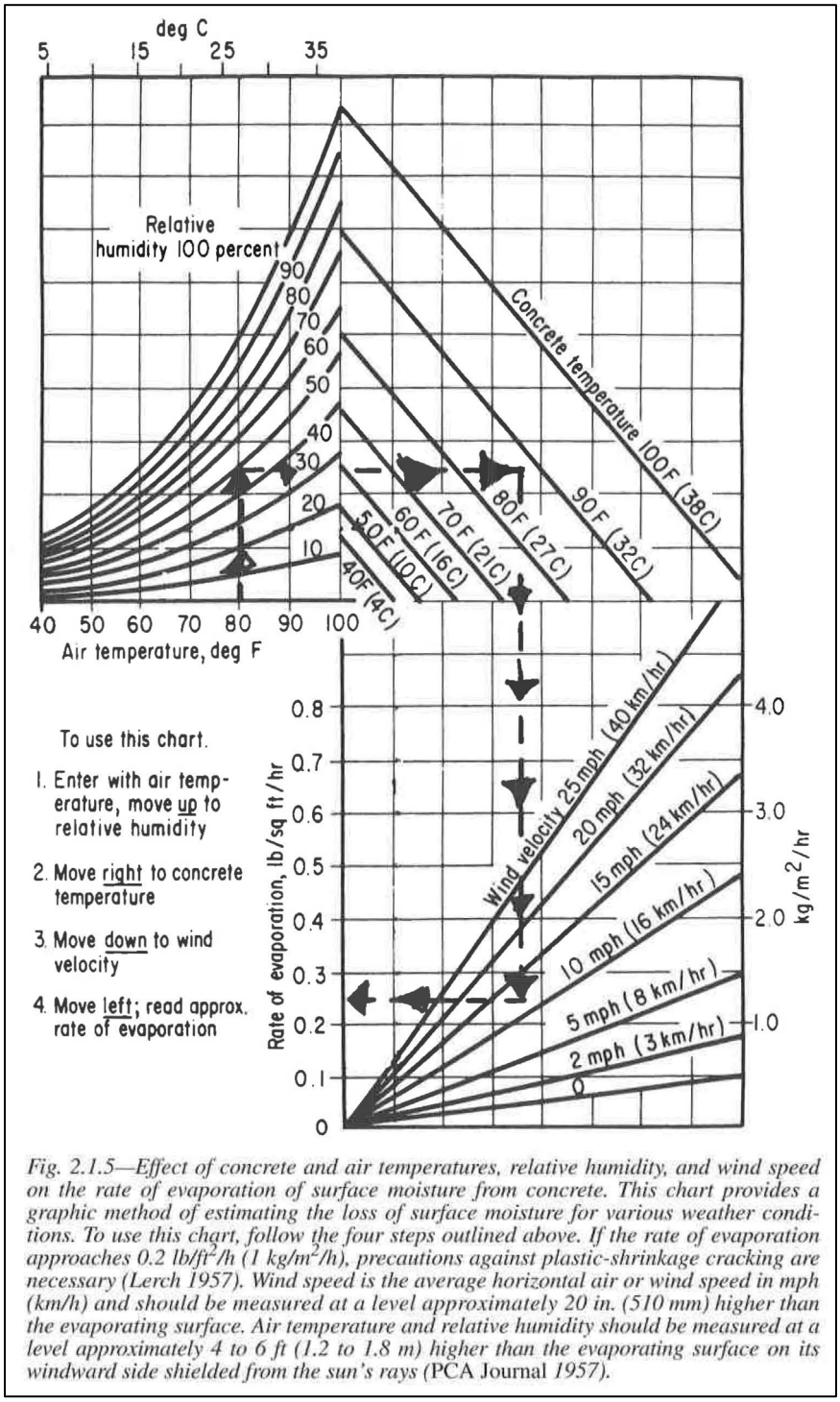


*Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind speed on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use this chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lb/ft²/h (1 kg/m²/h), precautions against plastic-shrinkage cracking are necessary (Lerch 1957). Wind speed is the average horizontal air or wind speed in mph (km/h) and should be measured at a level approximately 20 in. (510 mm) higher than the evaporating surface. Air temperature and relative humidity should be measured at a level approximately 4 to 6 ft (1.2 to 1.8 m) higher than the evaporating surface on its windward side shielded from the sun's rays (*PCA Journal *1957).*

ATTACHMENT B - COARSENESS FACTOR CHART

COARSENESS FACTOR CHART

Source: ACI PRC-302.1-15, Figure 8.9.2.2.

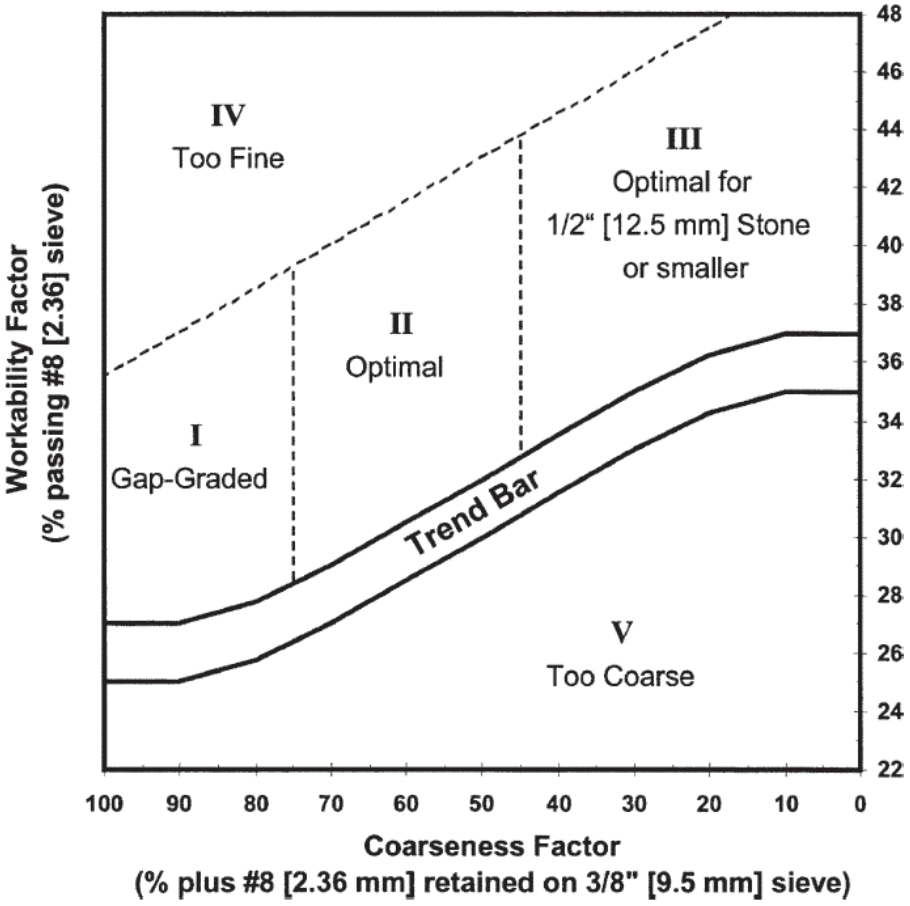
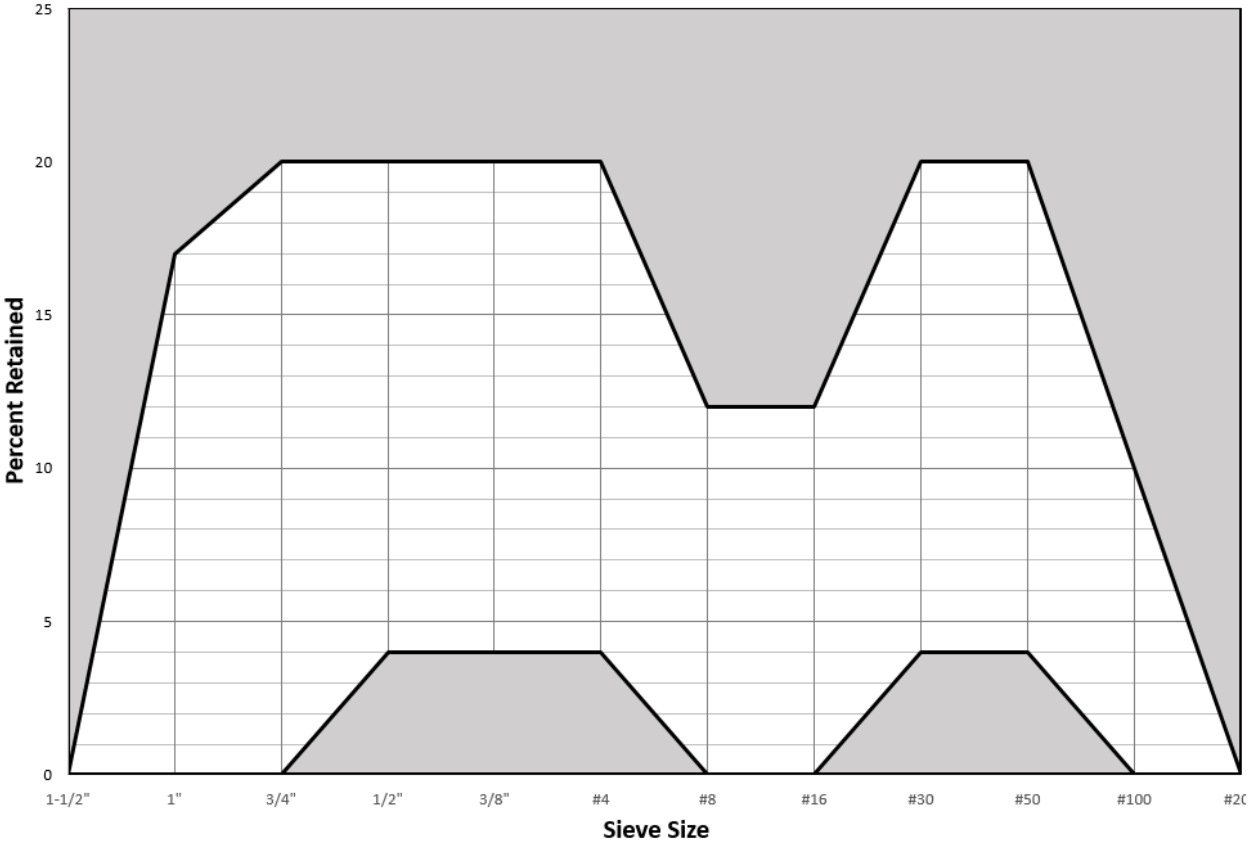


Fig. 8.9.2.2—Coarseness factor chart for evaluating potential performance of mixture.

ATTACHMENT C - COMBINED AGGREGATE GRADATION CHART

COMBINED AGGREGATE GRADATION CHART



ATTACHMENT D - CONCRETE PLACEMENT CHECKLIST

CONCRETE PLACEMENT CHECKLIST

Project: _____ Class of Concrete: _____
Project No.: _____ Test Cylinders Taken? Yes: _____ No: _____

Preparation Slab	Contractor	N/A
Compaction Subgrade		
Filter Fabric/Drain Rock-ABC/Separator Fabric		
Drain Rock, Pea Gravel & Void Form		
Starter Wall Forms		
Reinforcing Steel		
Screeds		

Embedded Items	Contractor	N/A
A. Anchor Bolts		
B. Water Stop		
C. Rebar		
D. Electrical		
E. Plumbing Rough-in		
F. Mechanical		
G. HVAC		

Concrete Placement Equip.	Contractor	N/A
A. Crane		
B. Buckets		
C. Hoppers		
D. Vibrators		
E. Elephant trunks		
F. Floodlights		
G. Pump Truck		

Building Department Notification	
Date:	Time:

Prep Wall Concrete	Contractor	N/A
Access To Work		
Ladders Secured		
Clean up and Washed Out		
Reinforcing Steel		

Forms	Contractor	N/A
A. Alignment & Grade		
B. Scaffolding		
C. Sleeves & Wall Castings		
D. Embedded Items		
E. Electrical		
F. Plumbing Rough-in		
G. Piping		

Record of Curing Conditions During Placement	
	Start: Finish:
Date:	
Time:	
Weather:	
Temperature:	
Comments:	

Location of Placement _____

The Contractor certifies the above-proposed concrete placement is prepared as indicated and is in accord with the Contract Drawings and Specifications. The Contractor requests permission to begin placement of concrete on the date of _____ at _____. The estimated number of yards is _____. The estimated duration of the placement is _____.

By: _____
Contractor

Released for placement by: _____
Engineer

SECTION 03366

CONCRETE FINISHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Concrete finishes.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 117-10 - Specification for Tolerances for Concrete Construction and Materials and Commentary.

B. International Concrete Repair institute (ICRI):
   1. Guideline No. 301.2: Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Architectural concrete:
      a. Concrete surfaces that will be exposed to view in the finished work.
         1) For purposes of this Section, includes exposed concrete surfaces that are designated to receive paint or coatings.
         2) Exposed concrete in open basins, channels, and similar liquid-containing structures: Surfaces will be considered exposed to view if located above the water line as defined in this Section.
   2. Grade line: A reference line that separates surfaces considered to be above grade from those considered to be below grade. Located 12 inches below finished grades at the perimeter of the structure.
   3. Water line: A reference line that separates surfaces considered to be above the water level (and visible in the finished work) from those considered to be below the water level (and not visible in the finished work). For each water-bearing cell of a structure, defined as a line located 2 feet below the normal operating water level in that cell.

1.04 QUALITY ASSURANCE

A. Qualifications:
   1. Finishing personnel:
      a. Use qualified flatwork finishers.
      b. Finishing supervisor must have at least 5 years of experience finishing concrete.

B. Mockups:
    1. Construct mockup panels showing finishing of formed surfaces for review by the Engineer.
        a. Construct mockup panels demonstrating concrete finishes for vertical surfaces:
            1) Construct mockup panels for F4 and F5 finishes and tie-hole repairs for review by the Engineer.
    2. Construct mockup slabs showing finishing of unformed surfaces for review by the Engineer.
        a. Construct mockup slabs demonstrating concrete finishes for horizontal surfaces:
            1) Construct mockup slabs for S1, S2, S4, and S5 finishes.
    3. Include the following elements in mockup panels and slabs.
        a. Concrete joints:
            1) Horizontal and vertical joints of the types included in the Work.
        b. Concrete repairs:
            1) Repairs using materials and procedures proposed for the Work.
    4. Construct mockup panels and slabs at beginning of project for review by the Engineer.
    5. Panels and portions thereof accepted by the Engineer will serve as the standard of quality and workmanship for the Work.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:
    1. Deliver and store packaged materials in original containers until ready for use.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials for mortar:
    1. As specified in Section 03300 - Cast-in-Place Concrete, unless otherwise noted.
    2. Where finished surfaces will be visible in the finished work, use same cement used for concrete batches in that area. Add white cement if required to obtain color match between base concrete and finishing mortars.

2.02 MIXES

A. Cement mortar:
    1. As specified in Section 03600 - Grouting.

B. Dry-pack mortar:
    1. As specified in Section 03600 - Grouting.

C. Mortar mix for F4 finish ("F4 Mortar"):
   1. Consisting of 1 part cement and 1-1/2 parts of fine sand passing Number 100 screen. Mix with enough water and emulsified bonding agent to have consistency of thick cream.

D. Mortar mix for F5 finish ("F5 Mortar"):
   1. Consisting of 1 part cement to 1-1/2 parts of sand passing Number 16 screen.

2.03 EVAPORATION RETARDANT

A. As specified in Section 03300 - Cast-in-Place Concrete.

2.04 NON-SLIP ABRASIVE

A. Type: Aluminum oxide abrasive of size 8/16, having structure of hard aggregate. Homogeneous, non-glazing, rust-proof, and unaffected by freezing, moisture, and cleaning compounds.

B. Manufacturers: One of the following, or equal:
   1. Abrasive Materials Incorporated, Hillsdale MI.
   2. Exolon Company, Tonawanda NY.

2.05 CONCRETE SEALERS

A. Floor sealer and dust-proofer:
   1. Non-membrane forming, breathable, non-yellowing, penetrating sealer designed to densify and seal a cured concrete surface.
   2. Low odor, VOC content of 0 grams per liter, and stable when exposed to ultraviolet radiation from sunlight.
   3. Manufacturers: One of the following, or equal:
      a. Dayton Superior: Day-Chem Sure Hard Densifier (J-17).
      b. Euclid Chemical Company: Euco Diamond Hard.
      c. L&M Construction Chemicals: Seal Hard.
      d. W.R. Meadows: Liqui-Hard.

PART 3 EXECUTION

3.01 CONCRETE FINISHING - FORMED SURFACES

A. Scope:
   1. Finish formed surfaces with one of the finishes specified in the following paragraphs and as indicated in the Schedule of Concrete Finishes in this Section.
   2. Formed surfaces are those surfaces that the plastic concrete is placed against a temporary containment surface that will be removed after the concrete sets and takes its final form.

B. General:
   1. Provide setting and curing time from casting of concrete to removal of forms as specified in Section 03300 - Cast-in-Place Concrete.
   2. Provide curing after removal of forms as specified in Section 03300 - Cast-in-Place Concrete.
   3. Materials and mixes for finishes.
      a. Cement: Add white cement to mortars and grouts used for finishing if required to match color of repairs to surrounding surfaces.
   4. Grinding:
      a. Grinding of architectural concrete is not permitted, unless demonstrated on the sample panel and accepted in advance by the Engineer.
      b. Where grinding of concrete surfaces is permitted:
         1) Perform grinding using an iron-free wheel, such as an aluminum oxide wheel, to avoid entrapment of particles that produce rust stains.
         2) At locations where plastic-protected reinforcing bar supports are used, limit grinding to a maximum depth of 1/16 inch.

C. F1 finish: “Rough Form Finish”:
   1. Repair defective work.
   2. Remove fins and other projections larger than 1/2 1 inch.
   3. Fill tie holes using dry-pack mortar.
   4. After removal of any curing compounds, fill depressions larger than 1 1 1/2-inch wide or 1/2-inch deep using dry-pack mortar.
   5. Leave surface with texture imparted by forms.
   6. Surface irregularity: Not exceeding a 1-inch gap when measured over the length of a 5-foot straightedge.

D. F2 finish: “Form Finish”:
   1. Repair defective work.
   2. Remove fins and other projections larger than 1/4 inch.
   3. Fill tie holes using dry-pack mortar.
   4. Fill depressions.
      a. Fill after removal of any curing compounds.
      b. Fill depressions larger than 1/2 3/4 inch in width or 1/2 inch in depth using cement mortar.
      c. Fill larger voids and depressions, use dry-pack mortar.
   5. Leave surfaces with texture imparted by forms.
   6. Surface irregularity: Not exceeding a 1/4-inch gap when measured over the length of a 5-foot straightedge.

E. F3 finish: “Smooth Form Finish”:
   1. Repair defective work.
   2. Repair rough or irregular surface finishes resulting from failure of form release agent or other form conditions and provide a smooth, uniform surface appearance.
   3. Remove fins: Grind offsets, projections, and rough spots larger than 1/8 inch smooth.
   4. Fill tie holes using dry pack mortar.

5. Fill depressions:
    a. Fill after removal of any curing compounds.
    b. Fill depressions 1/4 inch 1/2 inch and larger in depth or 3/4 inch in width using cement mortar.
    c. For larger depressions, fill using dry pack mortar.
6. Top coat tie holes and filled depressions with cement mortar to provide uniform appearance.
7. Leave surfaces with texture that is generally smooth and uniform in appearance.
8. Surface irregularity: Not exceeding a 1/8 inch gap when measured over the length of a 5-foot straightedge.

F. F4 finish: “Rubbed Finish”:
1. As specified for F3 finish, except prepare surfaces and fill depressions 1/16 inch or larger in depth or width as follows.
2. Fill depressions.
    a. “Brush-off” sandblast surfaces to expose all depressions and voids near the surface of the concrete.
    b. Thoroughly wet surfaces and begin filling depressions while surfaces are still damp.
    c. Use clean burlap, sponge rubber floats, or trowels to rub plastic F4 mortar over the entire surface to be finished. Fill pits, holes, and depressions.
    d. Wipe surfaces clean. Do not leave any mortar on the surface, except that within the depressions.
    e. Cure: Moist cure surfaces.

G. F5 finish: “Stoned Finish”:
1. As specified for F3 finish, except add stoned finish as follows:
2. Fill depressions:
    a. Wet surfaces thoroughly with brush.
    b. Rub wetted surfaces with a hard wood float dipped in water containing 2 pounds of Portland cement per gallon of water.
    c. Rub surfaces until form marks and projections are removed.
    d. Using a brush, spread plastic grindings from the rubbing operation uniformly over the surface. Work the material in to fill pits and small voids.
    e. Cure: Moist cure brushed surfaces for at least 72 hours.
3. Finish surfaces:
    a. After curing, obtain final finish by rubbing with a No. 50 grit carborundum stone.
    b. Continue rubbing until entire surface has a smooth texture and is uniform in color.
    c. Cure: Continue curing for remainder of specified time.
4. Note: If surfaces have become too hard to finish as specified in the preceding paragraphs, the following alternative procedure may be used:
    a. Sandblast and wash related surfaces exposed to view, whether finished or not.
    b. While surfaces are still damp, rub surface with mortar mix for F5 finish.
    c. Finish by rubbing mortared surface with No. 60 grit carborundum stone. Add F5 mortar until surface is evenly filled without excess mortar. Continue stoning until surface is hard.
    d. Moist cure surface for 72 hours.

e. After curing, make surface smooth in texture and uniform in color by rubbing with a No. 50 or No. 60 grit carborundum stone.
f. Continue curing until 7-day curing period is complete.

3.02 CONCRETE FINISHING - UNFORMED SURFACES

A. Scope:
1. Finish unformed surfaces with one of the finishes specified in the following paragraphs and as indicated in the Schedule of Concrete Finishes in this Section.
2. Unformed surfaces are those surfaces that are not cast against a temporary containment and the specified finish is achieved by tooling.

B. General:
1. Concrete placement:
a. Place concrete at a rate that allows spreading, straight-edging, and initial floating before bleed water appears.
1) Consider characteristics of concrete mixes used, including potential for accelerating or retarding effects of admixtures, fly ash, and temperatures, on plans for and scheduling of placement and finishing.
b. Place, consolidate, strike-off, and screed concrete level to bring surfaces to required planes and lines. Eliminate high and low spots.
c. Strike tops of walls and similar surfaces smooth and finish as specified to a texture consistent with that of adjacent formed surfaces.
d. After screeding, apply evaporation retardant to concrete surface if weather conditions will result in rapid evaporation of moisture from the surface of the concrete. Do not work evaporation retardant into the surface of the concrete.
2. Floating and re-straightening:
a. Float concrete to compact and consolidate the surface.
b. Initial floating:
1) Provide initial floating immediately after screeding.
2) Perform by hand using a wide bull float, darby, or highway straightedge.
3) Complete before excess moisture or bleed water is present on the surface.
c. Wait for concrete to stiffen and for the bleed water to stop rising and dissipate before proceeding with edging, hand-tooled jointing, and second floating.
d. After initial floating, apply evaporation retardant to concrete surface if weather conditions will result in rapid evaporation of moisture from the surface of the concrete. Do not work evaporation retardant into the surface of the concrete.
e. Second floating:
1) Do not commence until bleed water has dissipated and concrete has stiffened enough to support weight of finishers and finishing equipment.
2) May be by hand, or, if accepted by the Engineer, may be done using a bladed power float equipped with float shoes, or a power disk float.
3) Float surfaces to a true, even plane, with no coarse aggregate visible.
4) Evaporation retardant may not be applied after second floating.

f. Flatness:
    1) Specified tolerances for flatness may require re-straightening of the surface between first and second floating operations and before steel troweling. Re-straighten concrete as required.
    2) Modify power equipment with alternate float shoes or other equipment if required to achieve specified flatness.

3. Troweling: Where finishes require troweling, conform to the following requirements:
    a. After surface moisture from floating has disappeared, steel trowel to a smooth, hard, dense concrete surface.
    b. Provide at least 2 trowelings.
        1) Avoid excessive troweling.
        2) Use smaller trowels for successive troweling.
        3) Make each successive troweling perpendicular to the previous pass.
    c. Do not add dry cement or additional water to the surface during troweling.
    d. In lieu of hand steel troweling, a power machine for finishing concrete may be used if accepted by the Engineer.
        1) Do not use power machine if concrete has not attained the set necessary to permit finishing without introduction of high and low spots into the concrete surface.
        2) Use equipment in full compliance with the manufacturer's recommendations.
        3) Use smaller blades or higher pressure for each successive troweling.
        4) Hand trowel areas of the concrete not accessible to power equipment.
        5) Tolerances for flatness specified may require re-straightening of the surface during finishing. Modify power equipment with alternate shoes or other equipment if required to achieve these requirements.
    e. Finishing with a fresno trowel or finishing to a "fresno finish" is not allowed.
4. Finishing tolerances:
    a. Slabs sloped to drain: Finish surfaces to adequately drain toward designated points or lines, regardless of tolerances specified.

C. S1 finish: "Scratch Finish":
1. Place, consolidate, and screed concrete level.
2. Provide initial floating of concrete.
3. Provide surface conforming to the "Conventional" floor flatness tolerance requirements of ACI 117 using the manual straightedge method (maximum 1/2-inch gap in 10 feet at 90 percent of locations; maximum 3/4-inch gap at any location), unless otherwise indicated.
4. Before final set, roughen the surface with rakes.
    a. For sloped surfaces, rake grooves in the direction of drainage.
    b. Provide roughness equivalent to CSP 6 surface as designated by ICRI Guideline 310.2.
5. Pressure wash surface to remove laitance before placing grout or toppings.

D. S2 finish: "Floated Finish":
1. Place, consolidate, and screed concrete to required elevations and slopes.
2. Provide initial and second floatings of concrete. Float to a uniform texture.

3. Provide surface conforming to the “Flat” floor flatness tolerance requirements of ACI 117 using the manual straightedge method (maximum 1/4-inch gap in 10 feet at 90 percent of locations; maximum 3/8-inch gap at any location), unless otherwise indicated.
4. Remove laitance and leave surface clean.

E. S3 finish: “Steel Trowel Finish”:
1. Place, consolidate, and screed concrete to required elevations and slopes.
2. Provide S2 Floated Finish.
3. Provide 2 trowelings:
4. Provide finish conforming to the “Flat” floor flatness tolerance requirements of ACI 117 (maximum 1/4-inch gap in 10 feet), unless otherwise indicated.

F. S4 finish: “Steel Trowel Finish - Free of Trowel Marks”:
1. Finish as specified for S3 Steel Trowel Finish, except that final troweling shall remove all trowel marks from the slab surface.

G. S5 finish: “Broomed Finish”:
1. Finish as specified for S2 Floated Finish, except modify as follows:
2. Finish surface by drawing a fine-hair broom lightly across the freshly floated surface.
    a. Provide resulting roughness for a non-skid surface. Finishing and roughness is subject to review and acceptance by the Engineer.
    b. Direction of brooming:
        1) General:
            a) In same direction of and parallel to expansion joints.
            b) Perpendicular to primary direction of traffic.
        2) For sloped slabs, parallel to the direction of drainage.
        3) For round roof slabs, in the radial direction.

H. S6 finish: “Non-Slip Abrasive Finish”:
1. Place, consolidate, and screed concrete to required elevations and slopes.
2. Provide initial floating of surface.
3. Prepare and apply abrasive as recommended by the manufacturer.
    a. Apply using a shake screen or other accepted method to ensure even coverage without segregation of the abrasive.
    b. Install abrasive at a rate of 25 pounds for each 100 square feet of surface area.
4. After concrete has hardened enough to support the weight of a person, and unless otherwise indicated by the abrasive manufacturer, apply approximately 2/3 of the abrasive material required for coverage.
5. Finish as specified for S2 Floated Finish, except that re-floating is not required.
6. Apply remaining abrasive material at right angles to the first application and in locations necessary to provide the minimum specified thickness.
7. Immediately after the second application, re-float the surface to embed abrasive.
8. Finish as specified for S2 Steel Trowel Finish. Trowel abrasive into the surface, properly exposing material to produce a non-slip finish.

I. Concrete sealer:
   1. See Room Finish Schedule Drawings for locations of floors and slabs receiving concrete sealer finish.
   2. Apply sealer in accordance with manufacturer’s instructions.

3.03 FIELD QUALITY CONTROL

A. Provide field quality control for the Work of this Section as specified in Section 01450 - Quality Control.

B. Field quality control by Contractor:
   1. Field inspections and testing:
      a. Submit records of inspections and testing to Engineer within 24 hours after completion.
   2. Manufacturer's services.
      a. Non-slip abrasive finish. Before beginning installation, conduct pre-installation meeting with manufacturer's technical representative to review product use and installation requirements.

C. Field quality control by Owner:
   1. Special inspections, special tests, and structural observation:
      a. Not required.
   2. Field inspections:
      a. Observe construction for conformance to the Contract Documents and the accepted Submittals.
      b. Provide record of each inspection. Submit copies to Engineer upon request.

3.04 NON-CONFORMING WORK

A. Unsatisfactory finishes that have hardened will require removal, grinding, topping, or other correction acceptable to the Engineer.

B. Re-work or refinish unsatisfactory finishes at no additional cost to the Owner.

C. See Section 03300 - Cast-In-Place Concrete for requirements.

3.05 SCHEDULE OF CONCRETE FINISHES

A. Formed surfaces: See Table 03366-A.

B. Unformed surfaces: See Table 03366-B.

Table 03366-A - Concrete Finishes - Formed Surfaces					
	Elements	**Location**	**Surface Exposure**	**Finish**	**Notes**
EXTERIOR SURFACES	Walls Columns Slab edges	Wet structure:	Above grade or water line:		
			- Exposed to view	F4	
			- Covered	F2	1
			Below grade or water line:		
			- No coating	F1	
			- Bituminous coating	F2	
			- Waterproofing	F3	
		Dry structure:	Above grade line:		
			- Exposed to view	F4	
			- Covered	F2	1
			Below grade line:		
			- No coating	F1	
			- Bituminous coating	F2	
			- Waterproofing	F3	
INTERIOR SURFACES	Walls Columns Slab edges	Wet structure:	Open basin:		
			- Above water line	F4	
			- Below water line	F3	
			Covered basin		
			- Above water line	F3	
			- Below water line	F3	
		Dry structure:	Exposed to view	F4	
			Covered	F2	2
	Overhead slabs and beams	Wet structure:	Open basin	F3	3,4
			Covered basin	F2	4
		Dry structure:	Exposed	F3	3,4
			Covered by ceiling	F1	4

Notes:
1. Coverings include additional surfaces applied over the concrete, such as veneer, stucco, plaster, etc.
2. Coverings include additional surfaces applied over the concrete, such as veneer, stucco, plaster, furring strips with drywall, etc.
3. Applies to overhead surfaces visible from normal pedestrian travel routes.
4. At overhead slabs and beams, patch tie holes on sides of members.

Table 03366-B - Concrete Finishes - Unformed Surfaces					
	Element	**Location**	**Exposure**	**Finish**	**Notes**
EXTERIOR SURFACES	Footings	Extensions	Exposed	S3	
			Covered by soil	S2	
	Slabs and beams - exposed	Walking or possible walking paths	Tops of treatment structures	S5	1,2,6
			Stairs & landings	S5	
		Roofs	Exposed	S5	
			Covered by roofing	S2	
	Slabs and beams - submerged	Unless otherwise noted	All	S3 S5 if concrete is air entrained	6
	Walls, Corbels	Top of wall or corbel	All	S3	One troweling
	Sidewalks	All		S5	
	Equipment Slabs	All		S5	
INTERIOR SURFACES	Floor slabs, includes flat and sloping surfaces	Wet structure	Exposed		
			- Basins & channels	S3	
			Covered		
			- To receive basin bottom grout	S1	4
			- To receive concrete fill	S1	5
		Dry structure	Exposed		
			- Pipe galleries	S4	3
			- Stairs & landings	S4	
			- Shops & garages	S4	
			- Equipment rooms	S4	
			Covered		
			- Tile on mortar bed	S2	
			- Resilient flooring	S3	
			- Carpet	S3	

Notes:
1. Includes slabs covering tanks, basins, channels and similar structures.
2. Includes tops of walls or beams that serve as walkways.
3. In galleries with slabs subject to wetting, provide broom finish (S5) where indicated on the Drawings.
4. Finish for basin bottom grout: See Section 03565 - Basin Bottom Grout.
5. Finish for concrete fill: See Floor slab, wet structure, exposed basins and channels.
6. Slabs include flat and sloping surfaces.

C. Finish concrete surfaces in accordance with Finish Schedule indicated on the Drawings.

END OF SECTION

SECTION 03600

GROUTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cement grout.
   2. Cement mortar.
   3. Dry-pack mortar.
   4. Epoxy grout.
   5. Grout.
   6. Non-shrink epoxy grout.
   7. Non-shrink grout.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-inch cube specimens).
   2. C230 - Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   3. C531 - Standard Test Method for Liner Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   4. C579 - Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes.
   5. C939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   6. C942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
   7. C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
   8. C1181 - Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

B. International Concrete Repair Institute (ICRI):
   1. 310.2R - Selecting and specifying Concrete Surface Preparations for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

1.03 SUBMITTALS

A. Cement grout:
   1. Mix design.
   2. Material Submittals.

B. Cement mortar:
   1. Mix design.
   2. Material Submittals.

C. Non-shrink epoxy grout:
   1. Manufacturer's literature.

D. Non-shrink grout:
   1. Manufacturer's literature.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to jobsite in their original, unopened packages or containers, clearly labeled with manufacturer's product identification and printed instructions.

B. Store materials in cool dry place and in accordance with manufacturer's recommendations.

C. Handle materials in accordance with the manufacturer's instructions.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Non-shrink epoxy grout:
   1. Manufacturers: One of the following, or equal:
      a. Five Star Products, Inc., Five Star DP Epoxy Grout.
      b. L&M Construction Chemicals, Inc., EPOGROUT.
      c. Master Builder Solutions/Sika, MasterFlow 648.
   2. Non-shrink epoxy grout shall be 100 percent solid, premeasured, prepackaged system containing 2-component thermosetting epoxy resin and inert aggregate.
   3. Maintain flowable consistency for at least 45 minutes at 70 degrees Fahrenheit.
   4. Shrinkage or expansion: Less than 0.0006 inches per inch when tested in accordance with ASTM C531.
   5. Minimum compressive strength: 10,000 pounds per square inch at 24 hours and 14,000 pounds per square inch at 7 days when tested in accordance with ASTM C579, Method B.
   6. Compressive creep: Not exceed 0.0037 inches/per inch when tested under 400 pounds per square inch constant load at 140 degrees Fahrenheit in accordance with ASTM C1181.
   7. Coefficient of thermal expansion: Not exceed 0.000018 inches per inch per degree Fahrenheit when tested in accordance with ASTM C531, Method B.

B. Non-shrink grout:
   1. Manufacturers: One of the following, or equal:
      a. Five Star Products, Inc., Five Star Grout.
      b. L&M Construction Chemicals, Inc., CRYSTEX.
      c. Master Builder Solutions/Sika, MasterFlow 928.
   2. In accordance with ASTM C1107.
   3. Preportioned and prepackaged cement-based mixture.

4. Contain no metallic particles such as aluminum powder and no metallic aggregate such as iron filings.
5. Require only addition of potable water.
6. Water for pre-soaking, mixing, and curing: Potable water.
7. Free from emergence of mixing water from within or presence of water on its surface.
8. Remain at minimum flowable consistency for at least 45 minutes after mixing at 45 degrees Fahrenheit to 90 degrees Fahrenheit when tested in accordance with ASTM C230.
    a. If at fluid consistency, verify consistency in accordance with ASTM C939.
9. Dimensional stability (height change):
    a. In accordance with ASTM C1107, volume-adjusting Grade B or C at 45 degrees Fahrenheit to 90 degrees Fahrenheit.
    b. Have 90 percent or greater bearing area under bases.
10. Have minimum compressive strengths at 45 degrees Fahrenheit to 90 degrees Fahrenheit in accordance with ASTM C1107 for various periods from time of placement, including 5,000 pounds per square inch at 28 days when tested in accordance with ASTM C109 as modified by ASTM C1107.

2.02 MIXES

A. Cement grout:
    1. Use same sand-to-cementitious materials ratio for cement grout mix that is used for concrete mix.
    2. Use same materials for cement grout that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete.
    4. For spreading over surfaces of construction or cold joints.

B. Cement mortar:
    1. Use same sand-to-cementitious materials ratio for cement mortar mix that is used for concrete mix.
    2. Use same materials for cement mortar that are used for concrete.
    3. Use water-to-cementitious materials ratio that is no more than that specified for concrete being repaired.
    4. At exposed concrete surfaces not to be painted or submerged in water: Use sufficient white cement to make color of finished patch match that of surrounding concrete.

C. Dry-pack mortar:
    1. Proportions by weight: 1 part Portland cement to 2 parts concrete sand.
        a. Portland cement: As specified in Section 03300 - Cast-in-Place Concrete.
        b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.

D. Epoxy grout:
    1. Consist of mixture of epoxy or epoxy gel and sand.
        a. Epoxy: As specified in Section 03071 - Epoxies.
        b. Epoxy gel: As specified in Section 03071 - Epoxies.
        c. Sand: Clean, bagged, graded, and kiln-dried silica sand.

2. Proportioning:
    a. For horizontal work: Consist of mixture of 1 part epoxy with not more than 2 parts sand.
    b. For vertical or overhead work: Consist of 1 part epoxy gel with not more than 2 parts sand.

E. Grout:
    1. Mix in proportions by weight: 1 part Portland cement to 4 parts concrete sand.
        a. Portland cement: As specified in Section 03300 - Cast-in-Place Concrete.
        b. Concrete sand: As specified in Section 03300 - Cast-in-Place Concrete.

F. Non-shrink epoxy grout:
    1. Mix in accordance with manufacturer's installation instructions.

G. Non-shrink grout:
    1. Mix in accordance with manufacturer's installation instructions such that resulting mix has flowable consistency and is suitable for placing by pouring.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect concrete surfaces to receive grout or mortar and verify that they are free of ice, frost, dirt, grease, oil, curing compounds, paints, impregnations, and loose material or foreign matter likely to reduce bond or performance of grout or mortar.

3.02 PREPARATION

A. Surface preparation for grouting other baseplates:
    1. Remove grease, oil, dirt, dust, curing compounds, laitance, and other deleterious materials that may affect bond to concrete and bottoms of baseplates.
    2. Roughen concrete surfaces in contact with grout to ICRI CSP-6 surface profile or rougher.
        a. Remove loose or broken concrete.
    3. Metal surfaces in contact with grout: Grit blast to white metal surface.

3.03 INSTALLATION

A. Mixing:
    1. Cement grout:
        a. Use mortar mixer with moving paddles.
        b. Pre-wet mixer and empty out excess water before beginning mixing.
    2. Cement mortar:
        a. Use mortar mixer with moving paddles.
        b. Pre-wet mixer and empty out excess water before beginning mixing.
    3. Dry-patch mortar:
        a. Use only enough water so that resulting mortar will crumble to touch after being formed into ball by hand.

4. Non-shrink epoxy grout:
    a. Keep temperature of non-shrink epoxy grout from exceeding manufacturer's recommendations.
5. Non-shrink grout:
    a. May be drypacked, flowed, or pumped into place. Do not overwork grout.
    b. Do not retemper by adding more water after grout stiffens.

B. Placement:
1. Cement grout:
    a. Exercise care in placing cement grout because it is required to furnish structural strength, impermeable water seal, or both.
    b. Do not use cement grout that has not been placed within 30 minutes after mixing.
2. Cement mortar:
    a. Use mortar mixer with moving paddles.
    b. Pre-wet mixer and empty out excess water before beginning mixing.
3. Epoxy grouts:
    a. Wet surfaces with epoxy for horizontal work or epoxy gel for vertical or overhead work prior to placing epoxy grout.
4. Non-shrink epoxy grout:
    a. Mix in complete units. Do not vary ratio of components or add solvent to change consistency of mix.
    b. Pour hardener into resin and mix for at least 1 minute and until mixture is uniform in color. Pour epoxy into mortar mixer wheelbarrow and add aggregate. Mix until aggregate is uniformly wetted. Over mixing will cause air entrapment in mix.
5. Non-shrink grout:
    a. Add non-shrink cement grout to premeasured amount of water that does not exceed the manufacturer's maximum recommended water content.
    b. Mix in accordance with manufacturer's instructions to uniform consistency.

C. Curing:
1. Cement based grouts and mortars:
    a. Keep continuously wet for minimum of 7 days. Use wet burlap, soaker hose, sun shading, ponding, and in extreme conditions, combination of methods.
    b. Maintain above 40 degrees Fahrenheit until it has attained compressive strength of 3,000 pounds per square inch, or above 70 degrees Fahrenheit for minimum of 24 hours to avoid damage from subsequent freezing.
2. Epoxy based grouts:
    a. Cure grouts in accordance with manufacturers' recommendations.
        1) Do not water cure epoxy grouts.
    b. Do not allow any surface in contact with epoxy grout to fall below 50 degrees Fahrenheit for minimum of 48 hours after placement.

D. Grouting equipment bases, baseplates, soleplates, and skids: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

E. Grouting other baseplates:
   1. General:
      a. Use non-shrink grout as specified in this Section.
      b. Baseplate grouting shall take place from 1 side of baseplate to other in continuous flow of grout to avoid trapping air in grout.
      c. Maintain hydrostatic head pressure by keeping level of grout in headbox above bottom of baseplate. Fill headbox to maximum level and work grout down.
      d. Vibrate, rod, or chain non-shrink grout to facilitate grout flow, consolidate grout, and remove trapped air.
   2. Forms and headboxes:
      a. Build forms using material with adequate strength to withstand placement of grouts.
      b. Use forms that are rigid and liquidtight. Caulk cracks and joints with elastomeric sealant.
      c. Line forms with polyethylene for easy grout release. Coating forms with 2 coats of heavy-duty paste wax is also acceptable.
      d. Headbox shall be 4 to 6 inches higher than baseplate and shall be located on 1 side of baseplate.
      e. After grout sets, remove forms and trim back grout at 45 degree angle from bottom edges of baseplate.

3.04 FIELD QUALITY CONTROL

A. Non-shrink epoxy grout:
   1. Test for 24-hour compressive strength in accordance with ASTM C579, Method B.

B. Non-shrink grout:
   1. Test for 24-hour compressive strength in accordance with ASTM C942.

END OF SECTION

SECTION 03926

STRUCTURAL CONCRETE REPAIR

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Repairing damaged structural concrete.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
   2. C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading).
   3. C348 - Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars).
   4. C666 - Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   5. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

1.03 SUBMITTALS

A. Product data: Submit manufacturer's data completely describing structural repair concrete materials.

B. Certificates of Compliance.

C. Manufacturer's instructions.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: The manufacturer of the specified product shall have been in existence for a minimum of 10 years.

B. Allowable tolerances: Deviation from plumb or level shall not exceed 1/8 inch within 10 feet in any direction, as determined with a 10-foot straight edge.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver the specified product in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers.

B. Store and condition the specified product as recommended by the manufacturer.

C. Deliver, store, and handle packaged materials in the manufacturer's original, sealed containers, each clearly identified with the manufacturer's name, and name and type of product.

D. Store materials subject to damage by dirt and moisture in a clean, dry location, off the ground, and suitably protected.

1.06 PROJECT CONDITIONS

A. Existing conditions:
   1. Hot weather: ACI 305.
   2. Cold weather: ACI 306.
   3. Do not place concrete repair mortar during precipitation unless adequate protection is provided.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Structural repair concrete composed of cementitious material capable of being placed in formed vertical and overhead applications, and on horizontal surfaces.

B. Design requirements:
   1. Provide material suitable for performing in environments subject to corrosive attack by chlorides and sulfates, freeze/thaw cycles, low permeability, and abrasion resistant.
   2. Provide concrete repair mortar cement that is placeable from 1 inch in depth and extendable in greater depths.
   3. Concrete repair mortar shall be capable of being poured in place or troweled in place to suit the conditions encountered.

2.02 MATERIALS

A. Structural repair concrete:
   1. Manufacturers: One of the following or equal:
      a. Master Builder Solutions/Sika, MasterEmaco S 466CI.
      b. Sika Corp., SikaTop 123 Plus.
   2. Compressive strength: As follows in accordance with ASTM C109:
      a. 1 day: 2,500 pounds per square inch, minimum.
      b. 7 day: 6,000 pounds per square inch, minimum.
      c. 28 day: 7,000 pounds per square inch, minimum.
   3. Bond strength by slant shear: 2,200 pounds per square inch minimum at 28 days, in accordance with ASTM C882 modified.
   4. Flexural strength: 2,000 pounds per square inch minimum at 28 days, when tested in accordance with ASTM C293, or 770 pounds per square inch minimum at 28 days when tested in accordance with ASTM C348.
   5. Rapid freeze/thaw durability: In accordance with ASTM C666; Procedure A.
      a. Relative durability factor at 300 cycles: 95 percent minimum.

6. Working time: 30 to 40 minutes.
7. Color: Concrete gray.

B. Water: Potable, clean, not detrimental to concrete.

C. Form materials:
   1. Smooth finish.
   2. Brace as required to maintain tolerances.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that concrete surfaces and exposed reinforcing are clean and free of contaminants.

3.02 PREPARATION

A. Prepare existing concrete by cleaning with steel brush and applying bonding agent in accordance with manufacturer's instructions.

B. Thoroughly clean reinforcement and other embedded items to remove loose rust and other objectionable matter.

C. Thoroughly wet wood forms, except coated plywood, and adjacent concrete at least 1 hour in advance of placing concrete; securely close cleanout end inspection ports; repeat wetting as necessary to keep forms damp.

D. Damaged concrete:
   1. Areas to be repaired shall be clean, sound, and free of contaminants.
      a. Remove loose and deteriorated concrete by mechanical means acceptable to the Engineer.
      b. Saw cut perimeter 1/2-inch maximum.
   2. Chip concrete substrate to obtain a surface profile of 1/16 inch to 1/8 inch in depth with a new fractured aggregate surface.
      a. Area to be repaired shall be not less than 1 inch in depth.
   3. Concrete removal shall extend along the reinforcing steel to locations along the bar free of bond inhibiting corrosion, and where the bar is well bonded to surrounding concrete.

E. Use the following procedures where reinforcing steel with active corrosion is encountered:
   1. Sandblast reinforcing steel to remove contaminants and rust.
   2. Determine section loss, splice new reinforcing steel where there is more than 15 percent loss as directed by the Engineer.
      a. If more than half the diameter of the reinforcing steel is exposed, chip out behind the reinforcing steel a minimum of 1/2 inch. Distance chipped behind the reinforcing steel must also equal or exceed the minimum placement depth of the accepted material.

F. Treat cracks in the substrate at the area of patching or overlay work as directed by the Engineer.

G. Extend existing control and expansion joints through any concrete repair.

H. Apply an epoxy-bonding agent to area to be repaired, as specified in Section 03071 - Epoxies, prior to patching concrete with polymer-modified Portland cement mortar.

3.03 MIXING

A. Mix in accordance with manufacturer's mixing instructions.

3.04 INSTALLATION

A. Formed surface finishes:
   1. Smooth finish:
      a. Obtain by the use of plywood, sheet metal, or lined wood forms; no fins, pockmarks, or other irregularities shall be present in the exposed surfaces of concrete.
      b. Place no structural repair concrete without prior authorization of the Engineer.

B. Verify that form materials are in place and ready to receive installation of concrete repair material.

C. Install in accordance with manufacturer's installation instructions.

D. In accordance with ACI recommendations, apply concrete repair material only when ambient conditions of moisture, temperature, humidity, and wind are favorable for curing.

E. Scrub mortar into substrate, filling cracks, voids, and pores.

F. For new construction, finish of repaired area shall match required finish for concrete being repaired.

G. For existing concrete, finish of repair area shall match finish of concrete being repaired.

H. During the curing process, protect concrete repair from rain, wind, or freezing as required:
   1. Keep sufficient covering on hand at all times for protection of repair concrete.

3.05 CLEANING

A. Remove debris and excess material. Leave work site in a neat, clean condition.

END OF SECTION

SECTION 03931

EPOXY INJECTION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Epoxy injection system.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C881 - Standard Test Method for Epoxy-Resin-Base Bonding Systems for Concrete.
   2. C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear.
   3. D638 - Standard Test Method for Tensile Properties of Plastics.
   4. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
   5. D695 - Standard Test Method for Compressive Properties of Rigid Plastics.
   6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Manufacturer's data completely describing epoxy injection system materials and including test methods and results for strength in tension, flexure, compression and bond; flexural modulus of elasticity; coefficient of thermal expansion; and elongation.

C. Quality control submittals:
   1. Certificates of Compliance.
   2. Manufacturer's Instructions.

D. Special procedure submittals:
   1. Protection plan for surrounding areas and non-cementitious surfaces.

1.04 QUALITY ASSURANCE

A. Products:
   1. Provide materials that are new and use them within shelf life limitations set forth by manufacturer.

B. Qualifications:
   1. Installer:
      a. Minimum 5 years' experience in concrete repair, with focus on application of similar systems and products to projects of similar size and scope.

C. Pre-installation meeting:
   1. At least 1 week prior to commencing work of this Section, convene a meeting at the project site to review and discuss the following:
      a. Surface preparation.
      b. Substrate conditioning and pre-treatment.
      c. Installation procedures.
      d. Environmental conditions (including weather forecast) and curing requirements.
      e. Testing and inspection procedures.
      f. Protection of surrounding surfaces and equipment.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact. Labels shall include product identification, batch numbers, and shelf life information.

B. Store materials off the ground and away from moisture and direct sunlight, and at temperatures within manufacturer's recommended range.

C. Pre-condition materials to manufacturer's recommended temperatures before mixing and using.

1.06 PROJECT CONDITIONS

A. Take precautions to protect surfaces and equipment in the work area from damage and staining.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Repair materials shall be free of chlorides or alkalis (except for those attributed to water).
   2. To ensure compatibility of materials and methods, a single manufacturer shall produce and provide all products used together in a single area of concrete repair.

B. Manufacturers: One of the following, or equal:
   1. Master Builders Solutions/Sika, MasterInject 1500.
   2. Sika Chemical Corp., Sikadur 35 Hi-Mod LV.

C. Epoxy:
   1. In accordance with ASTM C881, Types I, II and IV, Grade 1, Class C.
   2. Water-insensitive 2-component low viscosity, epoxy adhesive material containing 100 percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified:

Table 1. Epoxy, Physical Properties		
Characteristic	**Test Method**	**Required Results, minimum(1),(2)**
Viscosity (mixed)	--	250 to 375 centipoise
Tensile Strength	ASTM D638	7,500 pounds per square inch
Tensile Elongation at Break	ASTM D638	1 percent
Compressive Strength	ASTM D695	11,000 pounds per square inch
Compressive Modulus	ASTM D695	2.5×10^5 pounds per square inch
Bond Strength, slant shear, hardened concrete to hardened concrete	ASTM C882	1,500 pounds per square inch at 2 days at minimum 73 degrees Fahrenheit. Concrete shall fail before failure of epoxy.
Heat Deflection Temperature	ASTM D648	124 degrees Fahrenheit

Notes:
(1) Properties for mixes with neat epoxy.
(2) Results after 7-day cure at temperature between 72 and 78 degrees Fahrenheit, unless otherwise noted.

2.02 EQUIPMENT

A. Injection pump:
   1. Use positive displacement injection pump with interlock to provide in-line mixing and metering system for 2 component epoxy.
   2. Use pressure hoses and injection nozzle designed to properly mix of 2 components of epoxy.
   3. Standby injection unit may be required.

PART 3 EXECUTION

3.01 PREPARATION

A. Surface preparation:
   1. Confirm that surface temperature and moisture conditions are within manufacturer's recommended limits. Condition surfaces to within those limits before commencing epoxy injection.
   2. Sweep or clean area in vicinity of cracks that will be injected with epoxy. Leave area in generally clean condition after epoxy injection is complete.
   3. Clean cracks so they are free from dirt, laitance, and other loose matter.

3.02 INSTALLATION

A. Install and cure epoxy materials in accordance with manufacturer's installation instructions.

B. Mixing:
   1. Mix epoxy in accordance with manufacturer's installation instructions.
   2. Do not use solvents to thin epoxy system materials introduced into cracks or joints.

C. Injection:
   1. Apply adequate surface seal to crack to prevent leakage of epoxy.
   2. Establish injection points at distance along crack not less than thickness of cracked member.
   3. Crack injection sequence:
      a. Inject epoxy into crack or joint at first port with sufficient pressure to advance epoxy to adjacent port. Start at lowest port along the injection line and work upwards.
      b. Seal original port and shift injection to next adjacent port where epoxy appears.
      c. Continue port-to-port injection until crack has been injected for its entire length.
      d. For small amounts of epoxy, or where excessive pressure developed by injection pump might further damage structure, premixed epoxy and use hand caulking gun to inject epoxy if acceptable to the Engineer.
      e. Seal ports, including adjacent locations where epoxy seepage occurs, as necessary to prevent drips or run out.
      f. After epoxy injection is complete, remove surface seal material, and refinish concrete in area where epoxy was injected to match existing concrete. Leave finished work and work area in a neat, clean condition.

3.03 FIELD QUALITY ASSURANCE

A. Provide Contractor quality control as specified in Section 01450 - Quality Control.

B. Field inspections and testing:
   1. Submit records of inspections and tests to Engineer within 24 hours after completion.

C. Manufacturer's services.
   1. Pre-installation meeting: Provide manufacturer's technical representative to attend pre-installation meeting specified in this Section.

3.04 FIELD QUALITY CONTROL

A. Provide Owner's quality assurance for the Work of this Section as specified in Section 01450 - Quality Control.

B. Special inspections special tests, and structural observation:
   1. Not required.

C. Field inspections:
   1. Preparation.
      a. Review manufacturer's product data and installation instructions.

2. Required inspections.
    a. Observe surfaces to be injected for temperature and moisture conditions and for surface preparation.
    b. Observe conditioning and mixing of epoxy resin components.
    c. Observe injection procedures for filling cracks.
3. Records of inspections:
    a. Provide record of each inspection.
    b. Submit to Engineer upon request.

3.05 NON-CONFORMING WORK

A. Rework surface finishes that do not match surrounding concrete to the satisfaction of the Engineer at no additional cost to the Owner.

END OF SECTION

SECTION 03933

HYDROPHILIC AND HYDROPHOBIC FOAM POLYURETHANE RESIN INJECTION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Hydrophilic foam polyurethane resin injection system.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D3574 - Standard Test Methods for Flexible Cellular Materials-Slab, Bonded, and Molded Urethane Foams.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: Submit manufacturer's data completely describing polyurethane resin injection system materials.

C. Quality control Submittals:
   1. Certificates of Compliance.
   2. Manufacturer's instructions.
   3. Protection plan for surrounding areas and non-cementitious surfaces.

1.04 QUALITY ASSURANCE

A. Products:
   1. Provide materials that are new and use them within shelf life limitations set forth by the manufacturer.

B. Qualifications:
   1. Installer:
      a. Minimum 5 years' experience in concrete repair with focus on application of similar systems and products to projects of similar size and scope.

C. Pre-installation meeting:
   1. At least 1 week prior to commencing work of this Section, convene a meeting at the project site to review and discuss the following:
      a. Surface preparation.
      b. Substrate conditioning and pre-treatment.
      c. Installation procedures.
      d. Environmental conditions (including weather forecast) and curing requirements.
      e. Testing and inspection procedures.
      f. Protection of surrounding surfaces and equipment.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact. Labels shall indicate product identification, batch numbers, and shelf life.

B. Store materials off the ground, away from moisture and direct sunlight, and at temperatures within manufacturer's recommended range.

C. Pre-condition materials to manufacturer's recommended temperatures before using.

1.06 PROJECT CONDITIONS

A. Take precautions to protect surfaces and equipment in the work area from damage and staining.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Polyurethane resin injection systems that will be in direct contact with water after the Work is completed shall comply with applicable federal, state, or local regulations.
      a. Confirm compliance by submitting documentation that products have been tested and listed in accordance with NSF-61 requirements. Provide testing by a nationally-recognized agency acceptable to Engineer.
   2. Repair materials shall be free of chlorides or alkalis (except for those attributed to water).
   3. To ensure compatibility of materials and methods, a single manufacturer shall produce and provide all products used together in a single area of concrete repair.

B. Manufacturers: One of the following, or equal:
   1. Master Builders Solutions/Sika, MasterInject 1210 IUG (formerly Concresive 1210 IUG).
   2. Sika Corp., SikaFix HH LV.

C. Resin:
   1. Water-insensitive 1-part low-viscosity polyurethane resin adhesive material containing 100-percent solids and meeting or exceeding following characteristics when tested in accordance with standards specified:

Physical Characteristic	Required Results
Viscosity	400 to 600 CPS at 70 degrees Fahrenheit
Flash Point	Greater than 200 degrees Fahrenheit
Corrosiveness	Non-corrosive
Reaction Time	75 to 90 seconds at 80 degrees Fahrenheit
Toxicity	Non-toxic

a. Uncured.
b. Cured foam (1:1):

Physical Characteristic	Test Method	Required Results
Tensile Strength	ASTM D3574	150 to 400 pounds per square inch
Elongation	ASTM D3574	400 to 1,200 percent

2.02 EQUIPMENT

A. Pump unit:
   1. Furnish unit to be used for injection that is positive displacement type with interlock to provide in-line mixing and metering system for 1 component polyurethane resin.
   2. Furnish pressure hoses and injection nozzle of such design as to allow proper mixing of polyurethane resin.
   3. Standby injection unit may be required.

B. Resin pump: Operating pressure in excess of 2,000 pounds per square inch with a variable pressure control trigger mechanism with attached pressure gauge, on the downstream end of the material supply hose.

C. Water pump: High-pressure water blaster capable of 1,000 pounds per square inch or higher pressure.

D. Incidentals: To be determined by site conditions and Contractor. See Installation Bulletin 6I12 - Urethane Injection, from Master Builders Solutions Construction Chemicals, LLC.

PART 3 EXECUTION

3.01 PREPARATION

A. Surface preparation:
   1. Confirm that surface temperatures and moisture conditions are within manufacturer's recommended limits. Condition surfaces to within those limits before commencing urethane injection.
   2. Sweep or clean area in vicinity of cracks and joints that will be injected with polyurethane resin.
   3. Clean cracks and joints so they are free from dirt, laitance, and other loose matter.

3.02 INSTALLATION

A. Install and cure polyurethane resin materials in accordance with manufacturer's installation instructions.

B. Mixing:
   1. Mix urethane in accordance with manufacturer's installation instructions.

C. Injection:
   1. Apply adequate surface seal to crack or joint to prevent escape of polyurethane resin.
   2. Establish injection ports along seal at a spacing not greater than the thickness of cracked member.
   3. Inject polyurethane resin into crack or joint at first port with sufficient pressure to advance polyurethane resin to adjacent port. Start at lowest port along the injection line and work upwards.
      a. Seal original port and shift injection to next adjacent port at which polyurethane resin appears.
      b. Continue port-to-port injection until each crack or joint has been injected for its entire length.
   4. For small amounts of polyurethane, or where excessive pressures developed by injection pump unit might further damage the structure, material mixed and installed with a hand caulking gun may be used if acceptable to the Engineer.
   5. Seal ports, including adjacent locations where polyurethane resin seepage occurs, as necessary to prevent drips or run out.
   6. After injection is complete, remove surface seal material and re-finish concrete in the area where the polyurethane was injected to match surrounding concrete. Leave finished work and work area in a neat and clean condition.

3.03 FIELD QUALITY CONTROL

A. Provide Contractor quality control as specified in Section 01450 - Quality Control.

B. Field inspections and tests:
   1. Submit records of inspections and test to Engineer within 24 hours after completion.

C. Manufacturer’s services.
   1. Pre-installation meeting: Provide manufacturer’s technical representative to attend pre-installation meeting specified in Section 01450 - Quality Control.

3.04 FIELD QUALITY ASSURANCE

A. Provide Owner quality assurance as specified in Section 01450 - Quality Control.

B. Special inspections, special tests, and structural observation:
   1. Not required.

C. Field inspections:
   1. Preparation.
      a. Review manufacturer’s product data and installation instructions.
   2. Required inspections:
      a. Observe surfaces to be injected for temperature and moisture conditions.
      b. Observe conditioning and preparation of urethane resin.
      c. Observe injection procedures for filling cracks.
   3. Records of inspections:
      a. Provide record of each inspection.
      b. Submit to Engineer upon request.

3.05 NON-CONFORMING WORK

A. Cracks, after injection, shall show no evidence of running or seeping water. Re-inject as necessary to provide watertight seal at no additional cost to Owner.

B. Rework surface finishes that do not match surrounding concrete to the satisfaction of the Engineer at no additional cost to Owner.

END OF SECTION

SECTION 05120

STRUCTURAL STEEL FRAMING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Structural steel shapes and plate.
   2. Fasteners and structural hardware:
      a. High-strength bolts.
   3. Welding.
   4. Bolting.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC):
   1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
   2. 360 - Specification for Structural Steel Buildings.

B. American Iron and Steel Institute (AISI):
   1. Steel alloys (“types”) as indicated.

C. American Welding Society (AWS):
   1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
   2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
   3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
   4. D1.1 - Structural Welding Code - Steel.
   5. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
   1. A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
   2. A36 - Standard Specification for Carbon Structural Steel.
   3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   6. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   7. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
   8. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   9. A992 - Standard Specification for Structural Steel Shapes.

10. F436 - Standard Specification for Hardened Steel Washers.
11. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
12. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
13. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

E. Research Council on Structural Connections (RCSC):
1. Specification for Structural Joints Using High-Strength Bolts (RCSC Specification).

1.03 DEFINITIONS

A. Snugtight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.

B. Stainless steel related terms:
1. Descaling: Removal of heavy, tightly adherent oxide films resulting from hot-forming, heat-treatment, welding, and other high-temperature operations.
2. Pickling: Chemical descaling of stainless steel using aqueous solutions of nitric and hydrofluoric acid, or various proprietary formulations as specified.
3. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.

1.04 SUBMITTALS

A. Product data:
1. Stainless steel: Fabricator name and qualifications, member dimensions and structural section properties, and specifications and procedures used for pickling and passivating members.

B. Shop drawings:
1. Fabrication and erection drawings.

C. Quality control submittals:
1. Welding procedure specifications (WPS) in accordance with AWS D1.1 and D1.6.
    a. Submit WPS for each type of welded joint used, whether prequalified or qualified by testing.
        1) State electrode manufacturer and specific electrodes used.
        2) Indicate required AWS qualification for joint.
    b. Submit WPS with shop drawings that indicate those welds.
    c. Submit Procedure Qualification Record (PQR) in accordance with AWS D1.1 and D1.6 for welding procedures qualified by testing.

2. Welder qualifications: For each welding process and position:
   a. Welder's qualification certificates.
   b. Contractor's statement that certificate will be "in effect" at the time(s) welding will be performed based on the "Period of Effectiveness" provisions of AWS D1.1 and D1.6.
3. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

1.05 QUALITY ASSURANCE

A. Welding:
   1. Perform welding of structural metals in accordance with AWS D1.1 using welders who have current AWS qualification certificate for the process, position, and joint configuration to be welded.
   2. Make Welding Procedure Specifications available at the locations where welding is performed.
   3. Notify Engineer at least 24 hours before starting shop or field welding.
   4. Engineer may check materials, equipment, and qualifications of welders.
   5. Remove welders performing unsatisfactory Work, or require requalification.
   6. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
   7. Contractor shall bear costs of retests on defective welds.
   8. Contractor shall also bear costs in connection with qualifying welders.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.

B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS

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

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Carbon Steel		
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items	A36	--
Rolled W and WT shapes	A992	Grade 50
Hollow structural sections/HSS: Round, square, or rectangular (including “pipe” where indicated for structural members and supports)	A500	Grade C

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Stainless steel		
Plate, sheet, and strip	A240	Type 304(1) or 316(2)
Bars and shapes	A276	Type 304(1) or 316(2)
Notes: 1. Use Type 304L (low-carbon stainless steel) if material will be welded. 2. Use Type 316L (low carbon stainless steel) if material will be welded.		

2.02 FASTENERS AND STRUCTURAL HARDWARE

A. General:
   1. Materials: Of domestic manufacture.
   2. Where fasteners and hardware are specified to be galvanized, hot-dip galvanize in accordance with ASTM A153 or ASTM F2329, unless otherwise specified.

B. All thread rods:
   1. Carbon steel:
      a. In accordance with ASTM A36 unless otherwise indicated on the Drawings.
      b. Nuts: ASTM A194.
      c. Washers: ASTM F436.
   2. Galvanized carbon steel:
      a. In accordance with ASTM A36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A153.
      b. Nuts: ASTM A194, hot-dip galvanized in accordance with ASTM A153.
      c. Washers: ASTM F436, hot-dip galvanized in accordance with ASTM A153.
   3. Stainless steel:
      a. Units descaled, pickled, and passivated as specified in “Fabrication” in this Section.
      b. Threaded rods and nuts to be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship all thread rods with properly fitting nuts attached.
      c. Alloy Type 304 or Type 316 as indicated on the Drawings.
      d. Type 304:
         1) Rod: ASTM F593, Group 1, Condition CW, coarse threads.
         2) Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
         3) Washers: Type 304 stainless steel.
      e. Type 316:
         1) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
         2) Nuts: ASTM F594. Match alloy of rod (group and UNS designation).
         3) Washers: Type 316 stainless steel.

C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

D. High-strength bolts:
   1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators. Carbon steel - Uncoated:
      a. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1**.**
      b. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade C.
      c. Washers:
         1) Adjacent to normal, oversized, and short-slotted holes: Circular, square or rectangular beveled, clipped, or extra thick washers in accordance with ASTM F436, Type 1. Flat circular washers unless otherwise indicated on the Drawings.
         2) Adjacent to long slotted holes: Fabricated from 5/16-inch thick plate conforming to ASTM A36.

2.03 ISOLATING SLEEVES AND WASHERS

A. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.04 GALVANIZED SURFACE REPAIR

A. Manufacturers: The following or equal:
   1. Jelt, Galvinox.

2.05 THREAD COATING

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

2.06 SUPPLEMENTARY PARTS

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

2.07 FABRICATION

A. Shop assembly:
   1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
   2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
   3. Round off sharp and hazardous projections and grind smooth.
   4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
   5. Take responsibility for correct fitting of metalwork.
   6. Welded connections:
      a. Comply with AWS requirements for the metals to be welded.

b. Weld only in accordance with approved Welding Procedure Specifications.
c. Keep Welding Procedure Specifications readily available for welders and inspectors during fabrication processes.

B. Stainless steel shapes and assemblies:
1. For structural members such as W shapes, S shapes, channels, angles, and similar rolled shapes not available in quantity, size, and type of stainless steel specified or indicated on the Drawings:
a. Fabricate shapes from dual grade stainless steel.
b. Fabricate beams and channels to ASTM A6 tolerances.
2. Cleaning and passivation:
a. Following shop fabrication of stainless steel members and bolts, clean and passivate fabrications at point of manufacture.
b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a bright passive finished surface with no etching, pitting, frosting, or discoloration.
c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
d. Pre-clean, chemically de-scale (“pickle”), passivate, and final-clean fabrications in accordance with the requirements of ASTM A380.
1) If degreasing is required before cleaning (pickling) to remove scale or iron oxide, cleaning with citric acid treatments is permissible; however, such treatments shall be followed inorganic cleaners.
2) Pickle and passivate stainless steel using a nitric acid solution in accordance with ASTM A380, Annex A2, Table A2.1, Part II.
3) Pickling by citric acid treatment or sulfuric acid treatment is not considered to satisfy the requirements of this Section.
e. Inspect after cleaning using methods specified for “gross inspection” in ASTM A380.
f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the site.

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

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 ERECTION

A. General:
   1. Fabricate structural and foundry items to true dimensions without warp or twist.
   2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
   3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
   4. Do not shift out of alignment, re-drill, re-shape, or force fit fabricated items.
   5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
   6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
   7. Erect structural steel in accordance with AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
   8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
   9. Round off sharp or hazardous projections and grind smooth.
   10. Paint or coat steel items as specified in Section 09960 - High-Performance Coatings.

B. Stainless steel. Take all necessary precautions to avoid iron contamination of stainless steel during delivery, storage, and handling.
   1. Segregate stainless steel from iron.
   2. Tools and handling devices.
      a. Do not use iron tools clamps, chokes, working surfaces, or brushes when fabricating, handling, and erecting stainless steel.
      b. Do not use tools that have been contaminated by contact with iron.
      c. Use stainless steel, polymer coated, or wood tools and handling equipment. Do not use tools that have been contaminated by contact with iron or steel.

C. Welding: General:
   1. Make welds full penetration type, unless otherwise indicated on the Drawings.
   2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.

D. Welding: Carbon steel:
   1. General: In accordance with AWS D1.1:
      a. Weld ASTM A36 and A992 structural steel, and ASTM A500 and A501 structural tubing with electrodes in accordance with AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:

E. Welding - stainless steel:
   1. General: In accordance with AWS D1.6.
   2. Field welding of stainless steel will not be permitted.
   3. Passivation of field-welded surfaces:
      a. Provide cleaning, pickling and passivating as specified under “Fabrications” of this Section. Clean using Derustit Stainless Steel Cleaner, or equal.

F. Interface with other products:
   1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

G. Fasteners: General:
   1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
   2. Anchor bolts and anchor rods: Install as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry to the "snugtight" condition.
   3. All thread rods in drilled holes bonded to concrete with adhesive: Install as specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

H. Fasteners: High-strength carbon steel bolts:
   1. Connections with high-strength bolts shall in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
   2. Provide pre-tensioned joints at bolted connections, except where slip-critical or snugtight connections are indicated on the Drawings.
   3. Joints: Slip-critical.
      a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with RCSC Specification.
      b. Furnish hardened flat washers in accordance with ASTM F436:
         1) On outer plies with slotted holes.
         2) When 1 or more plies of the connected material has a yield strength less than 40 ksi.
         3) Under element, nut, or bolt head, turned in tightening.
      c. Install tension indicator washers, placed in accordance with ASTM F959 Figure X1, to confirm adequate tightening of bolts.
      d. Tighten bolts to full pretension.

4. Joints: Pre-tensioned.
    a. Joint preparation, assembly, and tightening shall be as specified for slip-critical connections, except that the requirements for un-coated faying surfaces shall not apply.
5. Joints: Snugtight:
    b. Install bolts with washers where required in accordance with RCSC Specification.
    c. Tighten bolts to bring the connected plies into firm contact. Tightening shall progress systematically beginning with the most rigid part of the joint. More than 1 cycle through the bolt pattern may be required to achieve this condition.
    d. Verify adequate tightening of bolts by visual observation to confirm that washers have been installed at locations required in accordance with RCSC Specification, and that the plies of the connected parts have been brought into firm contact.

I. Fasteners: Stainless steel bolts:
1. Connections shall be snugtight joints unless otherwise indicated on the Drawings.
2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.
3. Rotate nuts using a slow, smooth action without interruptions. Avoid over-tightening.

3.03 FIELD QUALITY CONTROL

A. Provide quality control as specified in Section 01450 - Quality Control.

3.04 FIELD QUALITY ASSURANCE

A. Provide quality assurance as specified in Section 01450 - Quality Control.

B. Special inspections, special tests, and structural observation:
1. Provide as specified in Section 01455 - Regulatory Quality Assurance.

END OF SECTION

SECTION 05140

STRUCTURAL ALUMINUM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Structural aluminum products, including sheet, pipe, extrusions, and associated accessories.

1.02 REFERENCES

A. American Welding Society (AWS):
   1. A5.10 - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.
   2. D1.2 - Structural Welding Code - Aluminum.

B. ASTM International (ASTM):
   1. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   2. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
   3. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

1.03 SUBMITTALS

A. Quality control Submittals:
   1. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory including chemical and tensile properties of each shipment of structural metal or part thereof having common properties. Tests and analyses shall be made in accordance with applicable ASTM Standards.
   2. Welder’s certificates.

1.04 QUALITY ASSURANCE

A. Qualifications:
   1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
   2. Notify Engineer 24 hours minimum before starting shop or field welding.
   3. Engineer may check materials, equipment, and qualifications of welders.
   4. Remove welders performing unsatisfactory work or require to requalify.
   5. Engineer may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
   6. Contractor shall bear costs of retests on defective welds.
   7. Contractor shall bear costs in connection with qualifying welders.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural sheet aluminum: ASTM B209, Alloy 6061-T6.

B. Structural aluminum: ASTM B308, Alloy 6061-T6.

C. Extruded aluminum: ASTM B221, Alloy 6063-T42.

D. Isolating sleeves and washers:
   1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

E. Miscellaneous materials:
   1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.
   2. Size, form, attachment, and location shall conform to the best of current practice.
   3. In accordance with applicable ASTM Standards for materials not otherwise specified.

2.02 FABRICATION

A. Aluminum layout:
   1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
   2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.

B. Cutting aluminum:
   1. Material 1/2-inch thick or less: Shear, saw, or cut with a router.
   2. Material more than 1/2-inch thick: Saw or rout.
   3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
   4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
   5. Do not flame cut aluminum alloys.
   6. Punch or drill rivet or bolt holes to finished size before assembly:
      a. Make finished diameter of holes for bolts 1/16-inch maximum larger than nominal bolt diameter.
      b. Make holes cylindrical and perpendicular to principal surface.
      c. Do not permit holes to drift in a manner to distort metal.

C. Aluminum forming and assembly:
   1. Do not heat structural aluminum, except as follows:
      a. Heat aluminum to 400 degrees Fahrenheit for 30 minutes maximum, to facilitate bending or welding.
      b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.

D. Before assembly, remove chips lodged between contacting surfaces.

E. Welding aluminum:
   1. Perform welding of aluminum in accordance with AWS D1.2.
   2. Weld aluminum in accordance with the following:
      a. Preparation:
         1) Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
         2) Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
         3) Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
         4) Suitably prepare edges to ensure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
      b. Filler metal: Aluminum alloys in accordance with AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
      c. Perform welding of structures which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
      d. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
      e. Do not use welding process that requires use of a welding flux.
      f. Neatly make welded closures.
      g. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
      h. Make welds full penetration welds unless otherwise indicated on the Drawings.

2.03 FINISHES

A. Coating for Aluminum in contact with concrete or masonry:
   1. Epoxy mastic.
      a. As specified in Section 09960 - High-Performance Coatings, coating system EPX-M-5.
      b. [Manufacturers: One of the following or equal:
         1) Carboline, Carbomastic 15.
         2) International Paint, Bar-Rust 231.
         3) Tnemec, Series 135.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

A. Install structural aluminum products as indicated on the Drawings and specified.

B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.

C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.

D. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and true to level.

E. Rigidly support and brace structural products needing special alignment to preserve straight, level, even, smooth lines, and keep braced until concrete, grout, or dry pack mortar has hardened for a minimum 48-hour period.

F. Interface with other products:
   1. Where aluminum comes in contact with dissimilar metals, use stainless steel bolts or anchors and separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Do not paint exposed aluminum surfaces. Remove markings and leave surfaces clean. Coat those parts of aluminum which will be cast into concrete, and those parts of aluminum which will come in contact with masonry, concrete, or wood, with a minimum of 2 coats of specified coating for protection of similar metals.
   3. Coat those parts of aluminum that will be cast into concrete or that will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, as specified in Section 09960 - High-Performance Coatings.

END OF SECTION

SECTION 05190

MECHANICAL ANCHORING AND FASTENING TO CONCRETE AND MASONRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cast-in anchors and fasteners:
      a. Anchor bolts.
      b. Anchor rods.
   2. Post-installed steel anchors and fasteners:
      a. Concrete anchors.
   3. Appurtenances for anchoring and fastening:
      a. Isolating sleeves and washers.
      b. Thread coating for threaded stainless steel fasteners.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. 355.2 - Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary.

B. American National Standards Institute (ANSI):
   1. B212.15 - Cutting Tools - Carbide-tipped Masonry Drills and Blanks for Carbide-tipped Masonry Drills.

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

D. ASTM International (ASTM):
   1. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   2. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
   3. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   6. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   7. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   8. B633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.

9. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
10. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
11. F436 - Standard Specification for Hardened Steel Washers.
12. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
13. F594 - Standard Specification for Stainless Steel Nuts.
14. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
15. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

E. International Code Council Evaluation Service, Inc. (ICC-ES):
1. AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements.

1.03 DEFINITIONS

A. Built-In Anchor: Headed bolt or assembly installed in position before filling surrounding masonry units with grout.

B. Cast-In Anchor: Headed bolt or assembly installed in position before placing plastic concrete around.

C. Overhead Installations: Fasteners installed on overhead surfaces where the longitudinal axis of the fastener is more than 60 degrees above a horizontal line so that the fastener resists sustained tension loads.

D. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.

E. Post-Installed Anchor: Fastener or assembly installed in hardened concrete or finished masonry construction, typically by drilling into the structure and inserting a steel anchor assembly.

F. Terms relating to structures or building environments as used with reference to anchors and fasteners:
1. Corrosive locations: Describes interior and exterior locations as follows:
a. Locations used for delivery, storage, transfer, or containment (including spill containment) of chemicals used for plant treatment processes.
b. Exterior and interior locations at the following treatment structures:
1) Wastewater treatment facilities: Liquids stream:
a) Raw wastewater delivery and holding structures.
b) Headworks and grit facilities.
c) Primary clarifiers and primary clarifier flow splitting boxes.
d) Chlorine contact structures.

2. Wet and moist locations: Describes locations, other than “corrosive locations,” that are submerged, are immediately above liquid containment structures, or are subject to frequent wetting, splashing, or wash down. Includes:
    a. Exterior portions of buildings and structures.
    b. Liquid-containing structures:
        1) Locations at and below the maximum operating liquid surface elevation.
        2) Locations above the maximum operating liquid surface elevation and:
            a) Below the top of the walls containing the liquid.
            b) At the inside faces and underside surfaces of a structure enclosing or spanning over the liquid (including walls, roofs, slabs, beams, or walkways enclosing the open top of the structure).
    c. Liquid handling equipment:
        1) Bases of pumps and other equipment that handles liquids.
    d. Indoor locations exposed to moisture, splashing, or routine wash down during normal operations, including floors with slopes toward drains or gutters.
    e. Other locations indicated on the Drawings.
3. Other locations:
    a. Interior dry areas where the surfaces are not exposed to moisture or humidity in excess of typical local environmental conditions.

1.04 SUBMITTALS

A. General:
    1. Submit as specified in Section 01330 - Submittal Procedures.
    2. Submit information listed for each type of anchor or fastener to be used.

B. Action submittals:
    1. Product data:
        a. Cast-in anchors:
            1) Manufacturer’s data including catalog cuts showing anchor sizes and configuration, materials, and finishes.
        b. Post-installed anchors:
            1) For each anchor type, manufacturer’s data including catalog cuts showing anchor sizes and construction, materials and finishes, and load ratings.
    2. Samples:
        a. Samples of each type of anchor, including representative diameters and lengths, if requested by the Engineer.
    3. Certificates:
        a. Cast-in anchors:
            1) Mill certificates for steel anchors that will be supplied to the site.
        b. Post-installed anchors:
            1) Manufacturer’s statement or certified test reports demonstrating that anchors that will be supplied to the site comply with the materials properties specified.

4. Test reports:
    a. Post-installed anchors: For each anchor type used for the Work:
        1) Current ICC-ES Report (ESR**)** demonstrating:
            a) Acceptance of that anchor for use under the building code specified in Section 01410 - Regulatory Requirements.
            b) That testing of the concrete anchor included the simulated seismic tension and shear tests of AC193, and that the anchor is accepted for use in Seismic Design Categories C, D, E, or F and with cracked concrete.
5. Manufacturer's instructions:
    a. Requirements for storage and handling.
    b. Recommended installation procedures including details on drilling, hole size (diameter and depth), hole cleaning and preparation procedures, anchor insertion, and anchor tightening.
    c. Requirements for inspection or observation during installation.
6. Qualification statements:
    a. Post-installed anchors: Installer qualifications:
        1) Submit list of personnel performing installations and include date of manufacturer's training for each.

1.05 QUALITY ASSURANCE

A. Qualifications:
    1. Post installed anchors shall be in accordance with building code specified in Section 01410 - Regulatory Requirements.

B. Special inspection:
    1. Provide special inspection of post-installed anchors as specified in Section 01455 - Regulatory Quality Assurance and this Section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver post-installed anchors in manufacturer's standard packaging with labels visible and intact. Include manufacturer's installation instructions.

B. Handle and store anchors and fasteners in accordance with manufacturer's recommendations and as required to prevent damage.

C. Protect anchors from weather and moisture until installation.

1.07 PROJECT CONDITIONS

A. Seismic Design Category (SDC) for structures is indicated on the Drawings.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. General:
   1. Furnish threaded fasteners with flat washers and hex nuts fabricated from materials corresponding to the material used for threaded portion of the anchor.
      a. Cast-in anchors: Provide flat washers and nuts as listed in the ASTM standard for the anchor materials specified.
      b. Post-installed anchors: Provide flat washers and nuts supplied for that product by the manufacturer of each anchor.
   2. Size of anchors and fasteners, including diameter and length or minimum effective embedment depth: As indicated on the Drawings or as specified in this Section. In the event of conflicts, contact Engineer for clarification.
   3. Where anchors and connections are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.

B. Materials:
   1. Provide and install anchors of materials as in this Section.

2.02 CAST-IN ANCHORS AND FASTENERS

A. Anchor bolts:
   1. Description:
      a. Straight steel rod having one end with an integrally forged head, and one threaded end. Embedded into concrete with the headed end cast into concrete at the effective embedment depth indicated on the Drawings or specified, and with the threaded end left to project clear of concrete face as required for the connection to be made.
      b. Furnish anchor bolts with heavy hex forged head or equivalent acceptable to Engineer.
         1) Rods or bars with angle bend for embedment in concrete (i.e., “L” or “J” shaped anchor bolts) are not permitted in the Work.
   2. Materials:
      a. Ship anchor bolts with properly fitting nuts attached.
      b. Type 316 stainless steel:
         1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
         2) Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
         3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
         4) Washers: Type 316 stainless steel.
      c. Galvanized steel:
         1) Hot-dip galvanized coating in accordance with ASTM F2329.
         2) Bolt: ASTM F1554, Grade 36, heavy hex, coarse thread.
         3) Nuts: ASTM A563, Grade A, heavy hex, threads to match bolt.
         4) Washers: ASTM F436, Type 1.

B. Anchor rods:
   1. Description: Straight steel rod having threads on each end or continuously threaded from end to end. One threaded end is fitted with nuts or plates and embedded in concrete to the effective depth indicated on the Drawings, leaving the opposite threaded end to project clear of the concrete face as required for the connection to be made at that location.
   2. Materials:
      a. Stainless steel: Type 316:
         1) Rod: ASTM F593, Group 2, Condition CW, coarse threads.
         2) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of rods.
         3) Washers: Type 316 stainless steel.
         4) Plates (embedded): ASTM A240.
      b. Galvanized: steel:
         1) Hot-dip galvanized with coating in accordance with ASTM F2329.
         2) Rod: ASTM F1554, Grade 36, coarse thread.
         3) Nuts: ASTM A563, Grade A, threads to match rod.
         4) Washers: ASTM F436, Type 1.
         5) Plates (embedded): ASTM A36.

C. Epoxy bonding of reinforcing bars, all thread rods, and threaded inserts in concrete: As specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

2.03 POST-INSTALLED ANCHORS AND FASTENERS - MECHANICAL

A. General:
   1. Post-installed anchors used for the Work shall hold a current ICC Evaluation Service Report demonstrating acceptance for use under the building code specified in Section 01410 - Regulatory Requirements. Conditions of use: The acceptance report shall indicate acceptance of the product for use under the following conditions:
      1) In regions of concrete where cracking has occurred or may occur.
      2) To resist short-term loads due to wind forces.
      3) To resist short-term loading due to seismic forces for the Seismic Design Category of the structure where the product will be used.
   2. Substitutions: When requesting product substitutions, submit calculations, indicating the diameter, effective embedment depth and spacing of the proposed anchors, and demonstrating that the substituted product will provide load resistance that is equal to or greater than that provided by the anchors listed in this Section.
      a. Calculations shall be prepared by and shall bear the signature and seal of a Professional Engineer licensed in the State of Oregon.
      b. Decisions regarding the acceptability of proposed substitutions shall be at the discretion of the Engineer.

B. Concrete anchors:
   1. Description. Post-installed anchor assembly consisting of a threaded stud and a surrounding wedge expansion sleeve that is forced outward by torquing the center stud to transfer loads from the stud to the concrete through bearing,

friction, or both. (Sometimes referred to as “expansion anchors” or “wedge anchors.”)
    a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials to develop holding power.
2. Concrete anchors for anchorage to concrete:
    a. Acceptance criteria:
        1) Concrete anchors shall have a current ICC-ES Report demonstrating that the anchors have been tested and qualified for performance in both cracked and un-cracked concrete, and for short-term loading due to wind and seismic forces for Seismic Design Categories A through F in accordance with ACI 355.2 and with ICC-ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
        2) Concrete anchor performance in the current ICC-ES Report shall be “Category 1” as defined in ACI 355.2.
    b. Manufacturers: One of the following or equal:
        1) Hilti, Kwik Bolt TZ Expansion Anchor.
        2) DEWALT/Powers, PowerStud.
        3) Simpson Strong-Tie, Strong Bolt 2 Wedge Anchor.
    c. Materials. Integrally threaded stud, wedge, washer, and nut:
        1) Stainless steel: Type 316.
        2) Galvanized: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

C. Flush shells:
1. Description: Post-installed anchor assembly consisting of an internally threaded mandrel that is forced into a pre-drilled concrete hole with a setting tool until the top of the anchor is flush with the face of the concrete. Once installed, a removable threaded bolt is installed in the mandrel.
2. Flush shell anchors are not permitted in the Work.

2.04 APPURTENANCES FOR ANCHORING AND FASTENING

A. Anchor bolt sleeves:
1. Having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long.
2. Plastic sleeves:
    a. High-density polyethylene, corrugated sleeve, threaded to provide adjustment of location on the anchor bolt.
    b. Manufacturers: The following or equal:
        1) Portland Bolt & Manufacturing Co.

B. Isolating sleeves and washers:
1. Manufacturers: One of the following or equal:
    a. Central Plastics Co.
    b. Allied Corrosion Industries.
2. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers.
3. One sleeve required for each bolt.

4. Washers: The inside diameter of all washers shall fit over the isolating sleeve, and both the steel and isolating washers shall have the same inside diameter and outside diameter.
    a. Proper size to fit bolts.
    b. Two 1/8-inch thick steel washers for each bolt.
    c. G3 Phenolic: 2 insulating washers are required for each bolt:
        1) Thickness: 1/8 inch.
        2) Base material: Glass.
        3) Resin: Phenolic.
        4) Water absorption: 2 percent.
        5) Hardness (Rockwell): 100.
        6) Dielectric strength: 450 volts per mil.
        7) Compression strength: 50,000 pounds per square inch.
        8) Tensile strength: 20,000 pounds per square inch.
        9) Maximum operating temperature: 350 degrees Fahrenheit.

C. Coating for repair of galvanized surfaces:
    1. Manufacturers: The following or equal:
        a. Jelt, Galvinox.

D. Thread coating: For use with threaded stainless steel fasteners:
    1. Manufacturers: One of the following or equal:
        a. Bostik, Never-Seez.
        b. Oil Research, Inc., WLR No. 111.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION: GENERAL

A. Where anchors and fasteners are not specifically indicated on the Drawings or specified, make attachments with materials specified in this Section.

B. Substitution of anchor types:
    1. Post-installed anchors may not be used as an alternative to cast-in/built-in anchors at locations where the latter are indicated on the Drawings.
    2. Cast-in/built-in anchors may be used as an alternative to post-installed mechanical anchors at locations where the latter are indicated on the Drawings.

C. Protect products from damage during installation. Take special care to protect threads and threaded ends.

D. Accurately locate and position anchors and fasteners:
   1. Unless otherwise indicated on the Drawings, install anchors perpendicular to the surfaces from which they project.
   2. Install anchors so that at least 2 threads, but not more than 1/2 inch of threaded rod, projects past the top nut.

E. Interface with other products:
   1. Where steel anchors come in contact with dissimilar metals (aluminum, stainless steel, etc.), use stainless steel anchors and separate or isolate dissimilar metals using isolating sleeves and washers.
   2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.

3.03 INSTALLATION: CAST-IN ANCHORS

A. General:
   1. Accurately locate cast-in and built-in anchors.
      a. Provide anchor setting templates to locate anchor bolts and anchor rods. Secure templates to formwork.
      b. Brace or tie off embedments as necessary to prevent displacement during placement of plastic concrete or of surrounding masonry construction.
      c. Position and tie cast-in and built-in anchors in place before beginning placement of concrete or grout. Do not “stab” anchors into plastic concrete, mortar, or grout.
      d. Do not allow cast-in anchors to touch reinforcing steel. Where cast-in anchors are within 1/4 inch of reinforcing steel, isolate the metals by wrapping the anchors with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
   2. For anchoring at machinery bases subject to vibration, use 2 nuts, with 1 serving as a locknut.
   3. Where anchor bolts or anchor rods are indicated on the Drawings as being for future use, thoroughly coat exposed surfaces that project from concrete or masonry with non-oxidizing wax. Turn nuts down full length of the threads, and neatly wrap the exposed thread and nut with a minimum of 4 wraps of 10-mil waterproof polyvinyl tape.

B. Anchor bolts:
   1. Minimum effective embedment: 10-bolt diameters, unless a longer embedment is indicated on the Drawings.
   2. Where indicated on the Drawings, set anchor bolts in plastic, galvanized steel or stainless steel sleeves to allow for adjustment. Anchor rods:
   3. Install as specified for anchor bolts.

3.04 INSTALLATION: POST-INSTALLED MECHANICAL ANCHORS

A. General:
   1. Install anchors in accordance with the manufacturer’s instructions, ACI 355.2, the anchor’s ICC-ES Report. Where conflict exists between the ICC-ES Report and the requirements in this Section, the requirements of the ICC-ES Report shall control.

2. Where anchor manufacturer recommends the use of special tools and/or specific drill bits for installation, provide and use such tools.
3. After anchors have been positioned and inserted into concrete or masonry, do not:
    a. Remove and reuse/reinstall anchors.
    b. Loosen or remove bolts or studs.

B. Holes drilled into concrete and masonry:
1. Do not drill holes in concrete or masonry until the material has achieved its minimum specified compression strength (f'c or f'm).
2. Accurately locate holes:
    a. Before drilling holes, use a reinforcing bar locator to identify the position of all reinforcing steel, conduit, and other embedded items within a 6-inch radius of each proposed hole.
    b. If the hole depth exceeds the range of detection for the rebar locator, the Engineer may require radiographs of the area designated for investigation before drilling commences.
3. Exercise care to avoid damaging existing reinforcement and other items embedded in concrete and masonry.
    a. If embedments are encountered during drilling, immediately stop work and notify the Engineer. Await Engineer's instructions before proceeding.
4. Unless otherwise indicated on the Drawings, drill holes perpendicular to the concrete surface into which they are placed.
5. Drill using anchor manufacturer's recommended equipment and procedures:
    a. Unless otherwise recommended by the manufacturer, drill in accordance with the following:
        1) Drilling equipment: Electric or pneumatic rotary type with light or medium impact. Where edge distances are less than 2 inches, use lighter impact equipment to prevent micro-cracking and concrete spalling during drilling process.
        2) Drill bits: Carbide-tipped in accordance with ANSI B212-15. Hollow drills with flushing air systems are preferred.
6. Drill holes at manufacturer's recommended diameter and to depth required to provide the effective embedment indicated.
7. Clean and prepare holes as recommended by the manufacturer and as required by the ICC-ES Report for that anchor.
    a. Unless otherwise recommended by anchor manufacturer, remove dust and debris using brushes and clean compressed air.
    b. Repeat cleaning process as required by the manufacturer's installation instructions.
    c. When cleaning holes for stainless steel anchors, use only stainless steel or non-metallic brushes.

C. Insert and tighten (or torque) anchors in full compliance with the manufacturer's installation instructions.
1. Once anchor is tightened (torque), do not attempt to loosen or remove its bolt or stud.

D. Concrete anchors: Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Concrete Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
3/8 inch	2 1/2 inch	2 5/8 inch	8 inch
1/2 inch	3 1/2 inch	3 1/2 inch	8 inch
5/8 inch	4 1/2 inch	4 1/2 inch	10 inch
3/4 inch	5 inch	5 1/4 inch	12 inch

E. Flush shell anchors:
   1. Flush shell anchors are not permitted in the Work.
   2. If equipment manufacturer's installation instructions recommend the use of flush shell anchors, contact Engineer for instructions before proceeding.

3.05 FIELD QUALITY CONTROL

A. Contractor shall provide quality control over the Work of this Section as specified in Section 01450 - Quality Control.
   1. Expenses associated with work described by the following paragraphs shall be paid by the Contractor.

B. Post-installed anchors:
   1. Review anchor manufacturer's installation instructions and requirements of the Evaluation Service Report (hereafter referred to as "installation documents") for each anchor type and material.
   2. Observe hole-drilling and cleaning operations for conformance with the installation documents.
   3. Certify in writing to the Engineer that the depth and location of anchor holes, and the torque applied for setting the anchors conforms to the requirements of the installation documents.

3.06 FIELD QUALITY ASSURANCE

A. Owner will provide on-site observation and field quality assurance for the Work of this Section.
   1. Expenses associated with work described by the following paragraphs shall be paid by the Owner.

B. Field inspections and special inspections:
   1. Required inspections: Observe construction for conformance to the approved Contract Documents, the accepted submittals, and manufacturer's installation instructions for the products used.

2. Record of inspections:
    a. Maintain record of each inspection.
    b. Submit copies to Engineer upon request.
3. Statement of special inspections: At the end of the project, prepare and submit to the Engineer and the authority having jurisdiction inspector's statement that the Work was constructed in general conformance with the approved Contract Documents, and that deficiencies observed during construction were resolved.

C. Special inspections: Anchors cast into concrete and built into masonry.
1. Provide special inspection during positioning of anchors and placement of concrete or masonry (including mortar and grout) around the following anchors:
    a. Anchor bolts.
    b. Anchor rods.
2. During placement, provide continuous special inspection at each anchor location to verify that the following elements of the installation conform to the requirements of the Contract Documents.
    a. Anchor:
        1) Type and dimensions.
        2) Material: Galvanized steel, Type 304 stainless steel, or Type 316 stainless steel as specified in this Section or indicated on the Drawings.
        3) Positioning: Spacing, edge distances, effective embedment, and projection beyond the surface of the construction.
        4) Reinforcement at anchor: Presence, positioning, and size of additional reinforcement at anchors indicated on the Drawings.
3. Following hardening and curing of the concrete or masonry surrounding the anchors, provide periodic special inspection to observe and confirm the following:
    a. Base material (concrete or grouted masonry):
        1) Solid and dense concrete or grouted masonry material within required distances surrounding anchor.
        2) Material encapsulating embedment is dense and well-consolidated.

D. Special Inspections: Post-installed mechanical anchors placed in hardened concrete and in grouted masonry.
1. Provide special inspection during installation of the following anchors:
    a. Concrete anchors.
2. Unless otherwise noted, provide periodic special inspection during positioning, drilling, placing, and torquing of anchors.
    a. Provide continuous special inspection for post-installed anchors in "overhead installations" as defined in this Section.
3. Requirements for periodic special inspection:
    a. Verify items listed in the following paragraphs for conformance to the requirements of the Contract Documents and the Evaluation Report for the anchor being used. Observe the initial installation of each type and size of anchor, and subsequent installation of the same anchor at intervals of not more than 4 hours.
        1) Any change in the anchors used, in the personnel performing the installation, or in procedures used to install a given type of anchor shall require a new "initial inspection."

b. Substrate: Concrete or masonry surfaces receiving the anchor are sound and of a condition that will develop the anchor's rated strength.
c. Anchor:
    1) Manufacturer, type, and dimensions (diameter and length).
    2) Material (galvanized, Type 304 stainless steel, or Type 316 stainless steel).
d. Hole:
    1) Positioning: Spacing and edge distances.
    2) Drill bit type and diameter.
    3) Diameter, and depth.
    4) Hole cleaned in accordance with manufacturer's required procedures. Confirm multiple repetitions of cleaning when recommended by the manufacturer.
    5) Anchor's minimum effective embedment.
    6) Anchor tightening/installation torque.

4. Requirements for continuous special inspection:
    a. The special inspector shall observe all aspects of anchor installation, except that holes may be drilled in his/her absence provided that he/she confirms the use of acceptable drill bits before drilling, and later confirms the diameter, depth, and cleaning of drilled holes.

E. Field tests:
1. Owner may, at any time, request testing to confirm that materials being delivered and installed conform to the requirements of the Specifications.
    a. If such additional testing shows that the materials do not conform to the specified requirements, the Contractor shall pay the costs of these tests.
    b. If such additional testing shows that the materials do conform to the specified requirements, the Owner shall pay the costs of these tests.

3.07 NON-CONFORMING WORK

A. Remove misaligned or non-performing anchors.

B. Fill empty anchor holes and repair failed anchor locations using high-strength, non-shrink, non-metallic grout.

3.08 SCHEDULES

A. Stainless steel. Provide and install stainless steel anchors at all locations.

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Handrails and guardrails.
   2. Ladders.
   3. Manhole frames and covers.
   4. Metal gratings.
   5. Metal tread plate.
   6. Miscellaneous metals.
   7. Associated accessories to the above items.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45: Designations from Start to Finish.
      a. M12-C22-A41.

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

C. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A48 - Standard Specification for Gray Iron Castings.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   4. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   5. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
   8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   9. A489 - Standard Specification for Carbon Steel Lifting Eyes.
   10. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   11. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
   12. A635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.

13. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
14. A992 - Standard Specification for Structural Steel Shapes.
15. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
16. B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
17. B308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
18. B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
19. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
20. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

D. American Welding Society (AWS):
1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.

E. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

1.04 SUBMITTALS

A. Product Data:
1. Handrails and guardrails.
2. Manhole frames and covers.
3. Metal grating.

B. Shop drawings:
1. Handrails and guardrails:
   a. Including details on connection attachments, gates, kick plates, ladders, and angles.
   b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
   c. Include erection drawings, elevations, and details where applicable.
   d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
2. Ladders.
3. Metal grating.
4. Metal tread plate.
5. Miscellaneous metals.

C. Samples:
   1. Guardrails with specified finishes.

D. Quality control submittals:
   1. Design data.
   2. Test reports:
      a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and OSHA strength requirements.
      b. Gratings:
         1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
         2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Cast Iron		
Cast Iron	A48	Class 40B
Steel		
Galvanized sheet iron or steel	A653	Coating G90
Coil (plate)	A635	--
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes).	A36	--
Rolled W shapes	A992	Grade 50
Standard bolts, nuts, and washers	A307	--
High strength bolts, nuts, and hardened flat washers	F3125, Grade A325	--
Eyebolts	A489	Type 1
Tubing, cold-formed	A500	--
Tubing, hot-formed	A501	--
Steel pipe	A53	Grade B

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Stainless Steel		
Plate, sheet, and strip	A240	Type 304(1) or 316(2)
Bars and shapes	A276	Type 304(1) or 316(2)
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW
Aluminum		
Flashing sheet aluminum	B209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum-	B209	Alloy 6061-T6
Structural aluminum	B209 B308	Alloy 6061-T6
Extruded aluminum	B221	Alloy 6063-T42

Notes:
1. Use Type 304L if material will be welded.
2. Use Type 316L if material will be welded.

1. Stainless steels are designated by type or series defined by ASTM.
2. Where stainless steel is welded, use low-carbon stainless steel.

2.02 MANUFACTURED UNITS

A. Aluminum grating stair tread:
   1. Manufacturers: One of the following or equal:
      a. Harsco Industrial IKG, Aluminum Grating Stair Tread with Mebac® nosing.
      b. McNichols Co., Type A-Standard with Corrugated Angle Nosing.
   2. Material: Welded aluminum grating tread with non-slip nosing and integral end plates for bolt on attachment to stair stringers.
   3. Size:
      a. Tread width: To equal tread spacing plus 1 inch minimum.
      b. Tread length: Length to suit stringer-to-stringer dimension on the Drawings.
      c. Depth: 1-3/4 inches.
   4. Bolts: Type 316 stainless steel.

B. Handrails and guardrails:
   1. General:
      a. Design and fabricate assemblies to conform to current local, State, and OSHA standards and requirements.

b. Coordinate layout of assemblies and post spacings to avoid conflicts with equipment and equipment operators:
    1) Indicate on the shop drawings locations of such equipment.
    2) Highlight locations where railings cannot be made continuous, and obtain Engineer's directions on how to proceed before fabricating or installing railings.

2. Picket railing: Manufacturers: One of the following or equal:
    a. Julius Blum and Co., equivalent product.
    b. Craneveyor Corp., RailTec 400.
3. Steel pipe handrails and guardrails:
    a. Schedule 40 black steel pipe with minimum 1.9-inch outside diameter, or larger where indicated on the Drawings.
    b. Fabricate posts in single, unspliced pipe length.
    c. Kick plates: Galvanized steel.
    d. Attachment devices: Provide clip angles and other fasteners necessary for securing handrails and guardrails to other construction as indicated on the Drawings.
    e. Continuously weld joints and grind smooth.
    f. Bend rails to profile indicated on the Drawings, without sharp bends or flat spots. Rails shall be round after bending.
    g. Neatly weld intersection of rails and posts, and grind surfaces smooth.
    h. Hot dip galvanize guardrail and posts after fabrication.
4. Fastenings and fasteners: As recommended or furnished by guardrail manufacturer for use with this system.

C. Manhole frames and covers:
1. Material: Gray iron castings, in accordance with ASTM A48, Class 30-B.
2. Type: Heavy-duty traffic type, with combined minimum set weight of 265 pounds.
3. Machine horizontal and vertical bearing surfaces to fit neatly, with easily removable cover bearing firmly in frame without rocking.
4. Frame:
    a. Bottom flange type.
    b. Approximately 4-1/2 inches frame height.
    c. Dimensions as indicated on the Drawings.
        1) Minimum inside clear dimension may not be smaller than nominal diameter minus 2 inches.
5. Cover:
    a. Skid-resistant grid pattern design stamped with name of utility service provided by manhole, such as "ELECTRICAL," "SEWER," "TELEPHONE," or "WATER."
    b. Solid type without ventilation holes.
6. Finish: Unpainted.

D. Metal gratings:
1. General:
    a. Fabricate grating to cover areas indicated on the Drawings.
    b. Unless otherwise indicated on the Drawings, grating over an opening shall cover entire opening.
    c. Make cutouts in grating where required for equipment access or protrusion, including valve operators or stems, and gate frames.

d. Band ends of grating and edges of cutouts in grating:
    1) End banding: 1/4 inch less than height of grating, with top of grating and top edge of banding flush.
    2) Cutout banding: Full-height of grating.
    3) Use banding of same material as grating.
    4) Panel layout: Enable installation and subsequent removal of grating around protrusions or piping.
    5) Openings 6 inches and larger: Lay out grating panels with edges of 2 adjacent panels located on centerline of opening.
    6) Openings smaller than 6 inches: Locate opening at edge of single panel.
    7) Where an area requires more than 1 grating section to cover area, clamp adjacent grating sections together at 1/4-points with fasteners acceptable to Engineer.
    8) Fabricate steel grating sections in units weighing not more than pounds each.
    9) Fabricate aluminum grating sections in units of weighing not more than pounds each.
    10) Gaps between adjacent grating sections shall not be more than the clear spacing between bearing bars.
e. When requested by Engineer, test 1 section of each size grating for each span length involved on the job under full load:
    1) Furnish a suitable dial gauge for measuring deflections.
f. Grating shall be aluminum, unless otherwise specified or indicated on the Drawings.

2. Aluminum grating:
    a. Material for gratings, shelf angles, and rebates: 6061-T6 or 6063-T6 aluminum alloy, except crossbars may be 6063-T5 aluminum alloy.
    b. Shelf angle concrete anchors: Type 304 or Type 316 stainless steel.
    c. Grating rebate rod anchors: 6061-T6 or 6063-T6 aluminum alloy.
    d. Bar size and spacing: As determined by manufacturer to enable grating to support design load.
    e. Design live load: A minimum of 100 pounds per square foot uniform live load on entire grating area, but not less than the live load indicated on the Drawings for the area where grating is located.
    f. Maximum fiber stress for design load: 12,000 pounds per square inch.
    g. Maximum deflection due to design load: 1/240 of grating clear span.
    h. Maximum spacing of main grating bars: 1-1/8 inches clear between bars.
    i. Minimum grating height: 1-1/2 inches.
    j. Manufacturers: The following or equal:
        1) Harsco Industrial IKG, Swaged Aluminum I-Bar with striated finish.
3. Heavy-duty steel grating:
    a. Heavy-duty type, fabricated from structural steel and designed in accordance with AASHTO Standard Specifications for Highway Bridges, using H-20 loading.
    b. Hot-dip galvanized after fabrication in accordance with ASTM A123.
    c. Manufacturers: One of the following or equal:
        1) Reliance Steel Products Co., Heavy-Duty Steel Grating.
        2) Seidelhuber Metal Products, Inc., equivalent product.

E. Metal tread plate:
   1. Plate having a raised figured pattern on 1 surface to provide improved traction.

F. Miscellaneous aluminum:
   1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
   2. Do not weld or flame cut.

G. Miscellaneous cast iron:
   1. General:
      a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
      b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
      c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.

H. Miscellaneous stainless steel:
   1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
      a. Fabricate and install in accordance with the best practices of the trade.
   2. Cleaning and passivation:
      a. Following shop fabrication of stainless steel members, clean and passivate fabrications.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
      c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
         1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
      d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A380 to remove deposited contaminants before shipping.
         1) Passivation by citric acid treatment is not allowed.
            a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
         2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A380.
         3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A380.
      e. After cleaning, inspect using methods specified for “gross inspection” in ASTM A380.
      f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the job site.

I. Miscellaneous structural steel:
   1. Provide miscellaneous steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
      a. Fabricate and install in accordance with the best practices of the trade.

J. Isolating sleeves and washers:
   1. As indicated on the Drawings and as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

A. General:
   1. Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
   2. Interface between materials:
      a. Dissimilar metals: Where steel comes in contact with dissimilar metals (aluminum, stainless steel, etc.), separate or isolate the dissimilar metals.
         1) Make application so that the isolating or protective barrier is not visible in the completed construction.
         2) Isolating sleeves and washers: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      b. Aluminum in contact with concrete or masonry: Coat aluminum surfaces with epoxy mastic.
      c. Aluminum in contact with concrete or masonry.

B. Handrails and guardrails:
   1. General:
      a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
      b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint-gap.
      c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
      d. Space attachment brackets as indicated in the manufacturer's instructions.
   2. Aluminum pipe handrails and guardrails:
      a. During construction, keep exterior surfaces of handrails and guardrails covered with minimum 0.4 millimeters of heat shrink polyethylene film.

b. Do not remove protective film before handrails and guardrails have been accepted by Engineer nor before other work in proximity of handrails and guardrails has been completed.
c. Discontinue handrails and guardrails at lighting fixtures.
d. Provide 1/8-inch diameter weep hole at base of each post.
e. Space posts as indicated on the Drawings.
f. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
g. Space rails as indicated on the Drawings.
h. Make adequate provision for expansion and contraction of kick plates and rails.
    1) Make provisions for removable sections where indicated on the Drawings.
i. Make lower rails a single, unspliced length between posts, or continuous.
j. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
k. Draw up fasteners tight with hand wrench or screw driver.
l. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
m. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
n. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
o. Replace damaged or disfigured handrails and guardrails with new.
p. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water.
    1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
q. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.

3. Steel pipe handrail and guardrail:
    a. Anchor posts into concrete by grouting posts into galvanized steel sleeves embedded in concrete as indicated on the Drawings.
        1) Do not cut reinforcing bars in concrete.
        2) Where required to fasten guardrail to other construction, fasten as indicated on the Drawings.

C. Manhole frames and covers:
    1. Installation: As recommended by Manufacturer.

D. Metal gratings:
    1. General:
        a. Allow 1/8-inch maximum clearance between ends of grating and inside face of vertical leg of shelf angles.
        b. Horizontal bearing leg of shelf angles shall be 2 inches minimum.
        c. Install aluminum plate or angles where necessary to fill openings at changes in elevation and at openings between equipment and grating.
        d. Install angle stops at ends of grating.

e. Installed grating shall not slide out of rebate or off support.
f. Weld stops in place, unless otherwise specified or indicated on the Drawings.
g. Top surfaces of grating sections adjacent to each other shall lie in same plane.

2. Aluminum grating:
   a. Aluminum grating: Support on aluminum shelf angles or rebates.
   b.
3. Heavy-duty steel grating:
   a. Support on hot-dip galvanized structural steel rebates embedded and anchored in concrete.
   b. Use for roadways, traffic areas, and where indicated on the Drawings.

E. Stainless Steel:
   1. Welding:
      a. Passivate field-welded surfaces:
         1) Provide cleaning, pickling and passivating as specified in this Section.
         2) Clean using Derustit Stainless Steel Cleaner, or equal.

END OF SECTION

SECTION 07110

DAMPPROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Dampproofing.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1227 - Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing.

1.03 SUBMITTALS

A. Product data.

B. Shop drawings.

C. Manufacturer's Installation Instructions.

D. Warranty.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store materials in original, unopened containers in compliance with manufacturer's printed instructions.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Conform to volatile organic compound limits.

B. Do not apply bituminous dampproofing when temperatures are 40 degrees Fahrenheit or lower or when rain is forecast for the 24 hours following application.

PART 2 PRODUCTS

2.01 MATERIALS

A. Dampproofing: ASTM D1227, Asbestos Free, Emulsified Asphalt Coatings:
   1. Manufacturers: One of the following or equal:
      a. Karnak Corp., Karnak 220 AF.
      b. W.R. Meadows, Inc., Sealmastic Type 2 Asphalt Emulsion Dampproofing.

B. Sealing mastic: Type compatible with dampproofing and free of toxic solvents with thick mastic consistency and smooth and uniform in composition product as recommended by dampproofing manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that conditions are satisfactory for application of products in accordance with manufacturer's recommendations.

B. Verify that surfaces to receive dampproofing are clean, dry, reasonably smooth, free of dust, dirt, voids, cracks, or sharp projections.

3.02 APPLICATION

A. Completely cover surfaces to receive dampproofing with 2 coats:
   1. Applied by brush or spray.
   2. Apply dampproofing at manufacturer's recommended rate of application or minimum 2 gallons per 100 square feet, whichever is greater.

B. Extend dampproofing to 6 inches above finish grade.

C. Apply each coat evenly so surfaces have uniform black appearance.

D. Apply second coat at right angles to first, allowing not less than 24 hours between coats.

E. Seal around items and services projecting through dampproofing surfaces in accordance with manufacturer's recommendations.

F. Ensure sealed areas are moisture tight.

G. Backfill completely against dampproofing application within time recommended by manufacturer.

END OF SECTION

SECTION 07900

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Precast concrete joint sealant.
   3. Silicone sealant.
   4. Synthetic rubber sealing compound.
   5. Synthetic sponge rubber filler.
   6. Related materials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. M198 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

B. ASTM International (ASTM):
   1. C920 - Standard Specification for Elastomeric Joint Sealants.
   2. C990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
   3. C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
   4. C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
   5. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   6. D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

1.03 SUBMITTALS

A. Product data.

B. Samples, include color selections.

C. Manufacturer's Installation Instructions.

D. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed product for minimum 5 years with satisfactory performance record.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 5 projects of similar scope as Project with satisfactory performance record.

1.05 PROJECT/SITE CONDITIONS

A. Environmental requirements: Do not apply sealant on wet or frosty surfaces or when surface temperature is higher than 100 degrees Fahrenheit or lower than recommended by the manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products in accordance with manufacturer's recommendations.

B. Code date packages. Do not use material older than manufacturer’s published shelf life. Store materials at temperatures lower than 80 degrees Fahrenheit. Condition materials in accordance with manufacturer’s instructions prior to installation.

1.07 SEQUENCING AND SCHEDULING

A. Caulk joints prior to painting.

1.08 WARRANTY

A. Warrant to correct defective products for minimum 1 year in accordance with manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 SEALANTS

A. General:
   1. Provide colors matching materials being sealed.
   2. Where compound is not exposed to view in finished work, provide manufacturer's color which has best performance.
   3. Nonsagging sealant for vertical and overhead horizontal joints.
   4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
   5. Joint cleaner, primer, bond breaker: As recommended by sealant manufacturer.
   6. Sealant backer rod and/or compressible filler made from closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible, nonabsorbent, non-bituminous material recommended by sealant manufacturer to:
      a. Control joint depth.

b. Break bond of sealant at bottom of joint.
c. Provide proper shape of sealant bead.
d. Serve as expansion joint filler.

2.02 ACRYLIC-LATEX SEALANT

A. Permanently flexible, nonstaining, and nonbleeding latex modified acrylic sealant compound, colors as selected by Engineer from manufacturer's standard options:
1. Manufacturers: One of the following or equal:
a. Tremco, Tremflex 834.
b. Pecora Corp., Number AC-20.
c. Sonneborn, Sonolac.

2.03 PRECAST CONCRETE JOINT SEALANT

A. Preformed, cold-applied, ready-to-use, flexible joint sealant in accordance with ASTM C990 and AASHTO M 198:
1. Manufacturers: One of the following or equal.
a. Henry Corp., Ram-Nek.
b. Concrete Sealants Division, ConSeal.

2.04 SILICONE SEALANT

A. ASTM C920, Type S, Grade NS, Class 25, single component silicone sealant:
1. Manufacturers: One of the following or equal:
a. Tremco, Proglaze.
b. Pecora Corp., Number 864.
c. Dow Corning, Number 795.
d. General Electric, Number 1200 Series.

2.05 SYNTHETIC RUBBER SEALING COMPOUND

A. Manufacturer: One of the following or equal:
1. Sika Corporation, Sikaflex 2c NS or SL
2. Pacific Polymers, Elastothane 227R.

B. Material: In accordance with ASTM C920 Type M, Grade P (pourable), Class 25 and Type M, Grade NS (non-sag), Class 25; multi-part polyurethane; able to cure at room temperature to firm, highly resilient polymer; able to perform satisfactory when continuously submerged in water or sewage and exposed to direct sunlight in dry condition; with the following properties determined at 75 degrees Fahrenheit and 50 percent relative humidity:
1. Base: Polyurethane rubber.
2. Application time: Minimum 2 hours.
3. Cure time: Maximum 3 days.
4. Tack free time: Maximum 24 hours.
5. Ultimate hardness: Non-sag 25, Pourable/SL 40, within 5 Shore A.
6. Tensile strength: Non-sag 95 pounds per square inch minimum and self-leveling minimum 170 pounds per square inch when tested in accordance with ASTM D412.

7. Ultimate elongation: Minimum 340 percent when tested in accordance with ASTM D412.
8. Tear resistance: Non-sag 45 pounds per inch minimum and self-leveling minimum 85 pounds per inch when tested in accordance with ASTM D624, Die C.
9. Service temperature range: Minus 25 degrees to 158 degrees Fahrenheit.

C. Color: Gray to match concrete, unless indicated on the Drawings.

2.06 SYNTHETIC SPONGE RUBBER FILLER

A. Closed-cell expanded sponge rubber manufactured from synthetic polymer neoprene base, or resilient polyethylene foam backer rod. In accordance with ASTM C1330, Type C:
   1. Manufacturers: The following or equal:
      a. Presstite, No. 750.3 Ropax Rod Stock.

B. Characteristics:
   1. Suitable for application intended.
   2. Strength: As necessary for supporting sealing compound during application.
   3. Resiliency: Resistance to environmental conditions of installation.
   4. Bonding: No bonding to the sealing compound.
   5. Structure: Cellular, prevents absorption of water.
   6. Compatibility with other materials in joint and acceptance by manufacturer of sealing compound.
   7. Size: Minimum 25 percent greater than nominal joint width.

2.07 RELATED MATERIALS

A. Primer: Nonstaining type, recommended by sealant manufacturer to suit application.

B. Joint cleaner: Noncorrosive, nonstaining, compatible with joint forming materials and as recommended by sealant manufacturer.

C. Bond breaker tape: Pressure-sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify acceptability of joint dimensions, physical, and environmental conditions.

B. Verify that surfaces are dry, clean, and free of dirt, grease, curing compound, and other residue which might interfere with adhesion of sealants.

3.02 PREPARATION

A. Allow concrete to cure thoroughly before caulking.

B. Synthetic sponge rubber filler:
   1. Prepare surfaces designated to receive filler in accordance with manufacturer's installation instructions.
   2. Do not stretch filler beyond its normal length during installation.

C. Caulking:
   1. Verify that surfaces are dry, clean, and free of dirt, grease, curing compounds, and other residue that might interfere with adhesion of sealant.
   2. Concrete, masonry, wood, and steel surfaces: Clean and prime in accordance with manufacturer's instructions prior to caulking.

D. Synthetic rubber sealing compound:
   1. Ensure surfaces to which synthetic rubber must bond are dry and free of dust, dirt, and other foreign residue.
   2. Heavy sandblasted caulking groove to sound surface, and prime with manufacturer's recommended primer for particular surface.

E. For sidewalks, pavements, and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to depth equal to 75 percent of joint width, but neither more than 5/8 inches deep nor less than 3/8 inches deep.

F. For normal moving building joints sealed with elastomeric sealants not subject to traffic, fill joints to depth equal to 50 percent of joint width, but neither more than 1/2 inch deep nor less than 1/4 inch deep.

G. For joints sealed with acrylic-latex sealants, fill joints to depth in range of 75 percent to 125 percent of joint width.

H. Use joint filler to achieve required joint depths, to allow sealants to perform properly.

I. Prepare surfaces and install synthetic sponge rubber filler in accordance with manufacturer's recommendations.

J. Do not stretch filler beyond normal length during installation.

K. Apply bond breaker when recommended by joint sealer manufacturer.

3.03 INSTALLATION

A. Synthetic sponge rubber filler: Install filler in accordance with manufacturer's installation instructions.

B. Caulking, joints, and sealing:
   1. Construct expansion, contraction, and construction joints as indicated on the Drawings.
   2. Install pipe and conduit in structures as indicated on the Drawings.
   3. Caulk doors, windows, louvers, and other items installed in or over concrete openings inside and out.

4. Use synthetic rubber sealing compound for caulking where indicated on the Drawings or as specified, except for masonry construction and where specified otherwise.
5. Complete caulking prior to painting.
6. Verify that concrete is thoroughly cured prior to caulking.
7. When filler compressible material is used, use untreated type.
8. Apply caulking with pneumatic caulking gun.
9. Use nozzles of proper shape and size for application intended.
10. Maintain continuous bond between caulking and sides of joint to eliminate gaps, bubbles, or voids and fill joint in continuous operation without layering of compound.
11. Employ experienced applicators to caulk joints and seams in neat workmanlike manner.
12. To hasten curing of compound when used on wide joints subject to movement, apply heat with infrared lamps or other convenient means.
13. Apply synthetic rubber sealing compound with pneumatic caulking tool or other acceptable method.

3.04 CLEANING

A. Clean surfaces adjacent to sealant as work progresses.

B. Remove excess uncured sealant by soaking and scrubbing with sealant cleaning solvent.

C. Remove excess cured sealant by sanding with Number 80 grit sandpaper.

D. Leave finished work in neat, clean condition.

3.05 SCHEDULE

A. Acrylic latex:
   1. Use where indicated on the Drawings.
   2. Interior joints with movement less than 7.5 percent and not subject to wet conditions.

B. Silicone:
   1. Use where indicated on the Drawings.
   2. Joints and recesses formed where window, door, louver and vent frames, and sill adjoin masonry, concrete, stucco, or metal surfaces.
   3. Door threshold bedding.
   4. Moist or wet locations, including joints around plumbing fixtures.
   5. Stainless steel doors and frames, including joints between applied stops and frames, and around anchor bolts.
   6. Plenum joints.

C. Synthetic rubber sealing compound, non-sag Type II:
   1. Use where indicated on the Drawings.
   2. Water-bearing and earth-bearing concrete structures.
   3. Joints in masonry, concrete vertical surfaces, and metal-faced panels in vertical surfaces.

4. Joints between sheet metal flashing and trim.
5. Joints between sheet metal flashing and trim, and vertical wall surfaces.
6. Small voids between materials requiring filling for weathertight performance in vertical surfaces.
7. Perimeters of frames of doors, windows, louvers, and other openings where bonding is critical to airtight performance.
8. Expansion and control joints in masonry vertical surfaces.

D. Synthetic rubber sealing compound, self-leveling Type I:
1. Use where indicated on the Drawings.
2. Expansion and control joints in masonry, concrete horizontal surfaces, and metal panels in horizontal surfaces.
3. Small voids between materials requiring filling for weathertight performance in horizontal surfaces.
4. Pavement joints.
5. Perimeters of frames of doors, windows, louvers, and other openings in horizontal surfaces where bonding is critical to airtight performance.

3.06 FIELD QUALITY CONTROL

A. Adhesion testing:
1. Perform adhesion tests in accordance with ASTM C1521 per the following criteria:
a. Water bearing structures: 1 test per every 1,000 LF of joint sealed.
b. Exterior precast concrete wall panels: 1 test per every 2,000 LF of joint sealed.
c. Chemical containment areas: 1 test per every 1,000 LF of joint sealed.
d. Building expansion joints: 1 test per every 500 LF of joint sealed.
e. All other type of joints except butt glazing joints: 1 test per every 3,000 LF of joint sealed.
f. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION

SECTION 08320

FLOOR ACCESS DOORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Non-fire-rated floor access doors.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. Occupational Safety and Health Administration (OSHA):
   1. 29 CFR 1910-Occupational Safety and Health Standards.

1.03 SUBMITTALS

A. Product data.

B. Shop drawings that include the following:
   1. Floor access door installation recommendations.
   2. Locations of floor access doors.
   3. Door size and configuration.
   4. Live load capacity.
   5. Materials of construction and finishes provided.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Identify type and size of each floor access door in way not to damage finish prior to delivery.

B. Deliver products only after proper facilities are available.

C. Deliver and store packaged products in original containers with seals unbroken and labels intact until time of use.

D. Handle carefully to prevent damage and store on clean concrete surface or raised platform in safe, dry area.
   1. Do not dump onto ground.

E. Protect floor access doors during shipment and storage to prevent warping, bending, and corrosion.

1.05 WARRANTY

A. Provide manufacturer's warranty against defects in material and workmanship for a period of 5 years.

1.06 MAINTENANCE

A. Deliver 2 keys for each cylinder lock to Owner.

PART 2 PRODUCTS

2.01 HEAVY-DUTY OFF-STREET FLOOR ACCESS DOORS

A. Manufacturers: One of the following or equal:
   1. The Bilco Co., Model JH-20 or JDH-20 (double leaf).
   2. Babcock Davis Associates, Inc., Model BFDDH-SAL or BFDDH-DAL (double leaf).

B. Style: Single leaf or double leaf as indicated on the Drawings, aluminum, capable of withstanding minimum Standard Specifications for Highway Bridges, H-20 wheel load with a maximum deflection of 1/150 of the span, live load channel frame, with drainage couplings.

C. Door leaf: Minimum 1/4-inch, diamond-pattern plate reinforced with stiffeners as required to meet specified live load.

D. Frame: 1/4-inch channel with anchor flange around perimeter.

E. Hardware:
   1. Hinges: Each leaf equipped with a minimum of 2 heavy forged-brass hinges with stainless steel pins.
   2. Lock: Snap lock with removable handle mounted on door leaf.
   3. Grip handle: Provide vinyl grip handle designed to release cover for closing.
   4. Operating mechanism: Spring operators designed for ease of operation and automatic hold-open arm with release handle.
   5. Drainage assembly: Provide 1-1/2-inch drainage coupling located in corner of the channel frame.

2.02 FALL PROTECTION GRATING SYSTEM

A. Furnish and install on all vault access doors fall protection grating system.
   1. Door manufacturer shall install the grating system when the door is fabricated or field installed (by others) on existing doors already in use.
   2. If field installation is necessary grating system shall be installed per the manufacturer's instructions.

B. Performance characteristics:
   1. Grating panel(s) shall be high visibility safety yellow in color.
   2. Grating panel(s) shall lock automatically in the full open position.

3. Grating system shall have a 25 year warranty.
4. Grating panel(s) shall have a provision for locking to prevent unauthorized opening.

C. Grating: Panels shall be aluminum with a powder coat paint finish and designed to meet OSHA 29 CFR 1910 requirements for fall protection.

D. Hold open feature: A Type 316 stainless steel hold open device shall be provided to lock the cover in the fully open 90 degree position.

E. Hardware: All hardware shall be Type 316 stainless steel.

2.03 FINISHES

A. Floor access door finishes:
1. Aluminum: Manufacturer's standard mill finish.
2. Aluminum in contact with dissimilar metals and concrete: Manufacturer's standard bituminous coating.
3. Steel: Manufacturer's standard red oxide primer.

B. Hardware finishes:
1. Provide optional Type 316 stainless steel hardware throughout, including parts of the latch and lifting mechanism assemblies, hold-open arms, and all brackets, hinges, pins, and fasteners.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine construction to receive floor access door and verify correctness of dimensions and other supporting or adjoining conditions.

3.02 PREPARATION

A. Coordinate details with other work supporting, adjoining, or requiring floor access doors.

B. Verify dimensions and profiles for each opening.

C. Verify that location will serve portion of work to which access is required.
1. Where proposed functional location conflicts with other work, notify the Engineer before installation.

D. Apply coating to aluminum surfaces that will be in contact with dissimilar metals or concrete when there is none.

3.03 INSTALLATION

A. Install floor access doors in accordance with manufacturer's instructions.

B. Ensure correct types and adequate sizes at proper locations.

C. Securely attach frames to supporting work and ensure doors, frames, and hardware operate smoothly and are free from warp, twist, and distortion.

D. Attach drain pipe to coupling provided.
   1. Unless noted or indicated on the Drawings, provide 1-inch PVC (Sch. 80) drain line for access door.
   2. Provide necessary fittings to connect and route at least 5 feet away from door and vault perimeter.
   3. Terminate drain line 1 foot below final grade with 3 cubic feet of drain rock beneath the termination point of the drain line.

3.04 ADJUSTING

A. Adjust doors, frames, and hardware to operate smoothly, freely, and properly without binding.

3.05 CLEANING

A. Thoroughly clean surfaces of grease, oil, or other impurities; touch up abraded prime coat where applicable.

END OF SECTION

CITY OF WEST LINN, OREGON

CALAROGA SANITARY SEWER PUMP STATION REPLACEMENT

TECHNICAL SPECIFICATIONS

100% SUBMITTAL

VOLUME 2 OF 3

MARCH 2024

Digitally signed by Matthew Sprick
Contact Info: Carollo Engineers, Inc
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MATTHEW S. SPRICK

EXPIRES: 06/30/24

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CITY OF WEST LINN, OREGON

CALAROGA SANITARY SEWER PUMP STATION REPLACEMENT

MARCH 2024

RENEWAL DATE: 12/31/25

Fidel Delgado, CE Engineers

Divisions 16 and 17

pw://Carollo/Documents/OR/West Linn/201779-100000/06 Safety/CE Engineers/SubSealPage

CITY OF WEST LINN, OREGON

CALAROGA SANITARY SEWER PUMP STATION REPLACEMENT

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DIVISION 01 - GENERAL REQUIREMENTS

SECTION 09960

HIGH-PERFORMANCE COATINGS

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Coatings, including coating systems, surface preparation, application requirements, and quality control requirements.

1.02 REFERENCES

A. Abbreviations:
   1. CMU - Concrete masonry units.
   2. CSA - Coating system applicator. Specialty subcontractor retained by the Contractor to install the coating systems specified in this Section.
   3. CSM - Coating system manufacturer.
   4. CTR - Coating system manufacturer's technical representative.
   5. DFT - Dry-film thickness. Thickness of cured film, usually expressed in mils (0.001 inch).
   6. VOC - Volatile organic compound. Portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing; expressed in grams per liter (g/l) or pounds per gallon (lb/gal). VOC is determined by EPA Method 24.
   7. WFT - Wet film thickness. Coating thickness as measured immediately after application. Usually expressed in mils (0.001 inch).

B. Standards:
   1. ASTM International (ASTM):
      a. D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
      b. D2200 - Standard Practice for Use of Pictorial Surface Preparation Standards and Guides for Painting Steel Surfaces.
      c. D3359 - Standard Test Methods for Rating Adhesion by Tape Test.
      d. D3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.
      e. D4262 - Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
      f. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
      g. D4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.
      h. D4414 - Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
      i. D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast-Cleaned Steel.
      j. D4541 - Standard Test Methods for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
      k. D4787 - Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
      l. D5162 - Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates.

m. D7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
n. E337 - Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).
o. F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
p. F2170 - Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-situ Probes.

2. International Concrete Repair Institute (ICRI):
   a. 310.2 - Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.
3. NACE International (NACE):
   a. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
   b. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. National Association of Pipe Fabricators (NAPF):
   a. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.
5. NSF International (NSF):
   a. 61 - Drinking Water System Components - Health Effects.
6. Occupational Safety and Health Administration (OSHA).
7. Society of Protective Coatings (SSPC):
   a. Glossary - SSPC Protective Coatings Glossary.
   b. Guide 6 - Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations.
   c. PA 1 - Shop, Field, and Maintenance Painting of Steel.
   d. PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   e. PA 9 - Measurement of Dry Coating Thickness Using Ultrasonic Gages.
   f. QP 1 - Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors.
   g. SP 1 - Solvent Cleaning.
   h. SP 3 - Power Tool Cleaning.
   i. SP 5 - White Metal Blast Cleaning.
   j. SP 10 - Near-White Metal Blast Cleaning.
   k. SP 11 - Power Tools Cleaning to Bare Metal.
   l. SP 13 - Surface Preparation of Concrete.
   m. SP 16 - Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   n. SP COM - Surface Preparation Commentary.
   o. SP VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
   p. SP WJ-1 - Waterjet Cleaning of Metals—Clean to Bare Substrate.
   q. SP WJ-2 - Waterjet Cleaning of Metals—Very Thorough Cleaning.
   r. SP WJ-3 - Waterjet Cleaning of Metals—Thorough Cleaning.
   s. SP WJ-4 - Waterjet Cleaning of Metals—Light Cleaning.

1.03 TERMINOLOGY

A. Definitions used in this Section are in accordance with definitions referenced in ASTM D16, ASTM D3960, and SSPC Glossary of Definitions.

B. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Abrasive: Material used for blast cleaning, such as sand, grit, or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed.
   3. Anchor Pattern: Profile or texture of prepared surface(s).
   4. Biogenic Sulfide Corrosion: Corrosion caused by sulfuric acid formed when *Thiobacillus* bacteria metabolizes hydrogen sulfide.
   5. Bug Holes: Small cavities resulting when air bubbles are entrapped in the surface of formed concrete during placement and consolidation.
   6. Coating/Paint/Lining Thickness: Total thickness of primer, intermediate, and/or finish coats after drying or curing.
   7. Dew point: Temperature a given air/water vapor mixture starts to condense.
   8. Dry to Recoat: Time interval between material application and its ability to receive the next coat.
   9. Dry to Touch: Time interval between material application and its ability to tolerate a light ouch without coating damage.
   10. Drying Time: Time interval between application and material curing.
   11. Exposed Surface: Any indoor or outdoor surface not buried or encased.
   12. Feather Edging: Reducing coating thickness at its edge to blend with existing surrounding coating.
   13. Feathering: Tapering off a wet edge with a comparatively dry brush.
   14. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
   15. Field Coat: Application of a surface coating system at the work site.
   16. Finish Coat: Final coat in a paint system, including texture, color, smoothness of surface, and other properties affecting appearance.
   17. Hold Point: A defined point, specified in this Section, at which work shall be halted for inspection.
   18. Holiday: A discontinuity, skip, void, or pinhole in coating or coating system film that exposes the substrate.
   19. Honeycomb: Segregated and porous surface of hardened concrete due to insufficient consolidation.
   20. Hydroblast: High or ultra-high-pressure water jet surface preparation.
   21. Immersed/Immersion: A service condition in which substrate is submerged, is immediately above liquids, or is subject to frequent wetting, splashing, or washdown.
   22. Incompatibility: One coating’s inability to overlay another coating or surface as evidenced by bleeding, poor bonding, or lifting of old coating; inability of a coating to bond to a substrate.
   23. Laitance: A thin, weak, brittle layer of cement and aggregate fines on a concrete surface.
   24. Mil: 0.001 inch.
   25. Overspray: Dry spray, particularly paint bonded to an unintended surface.

26. Pinhole: A small diameter discontinuity in a coating or coating system film, created by offgassing from a void in a concrete or masonry substrate causing a void between coats or exposing the substrate. Usually caused by coating application while temperature is rising.
27. Pot Life: Time interval after components are mixed and coating can be satisfactorily applied.
28. Prime Coat: First full paint coat applied to a surface when using a multicoat system. Primers adhere to a new substrate, protect the substrate, and promote adhesion of subsequent coats of paint. The prime coat on metal surfaces is the first full coat and does not include solvent wash, grease emulsifiers, or other pretreatment applications.
29. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-based material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces.
30. Shelf Life: Maximum storage time a material may be stored without losing its usefulness.
31. Shop Coat: 1 or more coats applied in an off-site shop or plant before shipment to work site where field or finishing coat(s) are applied.
32. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
33. Stripe Coat: A separate brush coat of paint applied to all weld seams, pits, nuts/bolts/washers, and edges. This coat shall not be applied until previous coats have cured. Once applied, the coat shall be allowed to cure before subsequent coats are applied.
34. System: Protective film with 1 or more coats applied in a predetermined order, including surface preparation and quality control requirements.
35. Thick Film Coating System: A coating system applied with a minimum dry film thickness of 25 mils.
36. Tie Coat: An intermediate coat that bonds different types of paint material, improving succeeding coat adhesion.
37. Touch-Up Painting: Application of paint on previously painted surfaces to repair marks, scratches, and deteriorated or damaged areas to restore the appearance and performance of the coating.
38. Water Blast: An alternative to air abrasive blast cleaning that can be used with or without abrasive injection. Water cleaning at pressures up to 5,000 pounds per square inch is called low-pressure water cleaning or power washing. High-pressure water cleaning uses water pressures between 5,000 and 10,000 pounds per square inch. Water jetting is water blasting with added abrasive at pressures between 10,000 and 25,000 pounds per square inch. Ultra-high-pressure water jetting is water blasting at pressures above 25,000 pounds per square inch.
39. Weld Splatter: Beads of non-structural weld metal that adhere to the surrounding surface, removed as part of surface preparation.

1.04 SUBMITTALS

A. As specified in Section 01330 - Submittal Procedures, submit the following:
   1. Schedule of proposed coating materials.
   2. Schedule of surfaces to be coated with each coating material.

3. Dehumidification and heating plan.
4. Product data:
    a. Physical properties of coatings, including the following:
        1) Solids content.
        2) Ingredient analysis.
        3) VOC content.
        4) Temperature resistance.
        5) Typical exposures and limitations.
        6) Manufacturer's standard color chips.
    b. Compliance with regulatory requirements:
        1) VOC limitations.
        2) Lead compounds and polychlorinated biphenyls.
        3) Abrasives and abrasive blast cleaning techniques and disposal.
        4) Methods for tenting blasting areas and methods to protect existing equipment from dust and debris.
        5) NSF certification of coatings for potable water supply systems.
    c. CSM's current printed recommendations and product datasheets for coating systems, including:
        1) Surface preparation recommendations.
        2) Primer type.
        3) Maximum dry and wet-mil thickness per coat and number of coats.
            a) Coating coverage worksheets.
        4) Minimum and maximum curing time between coats, including atmospheric conditions for each.
        5) Curing time before submergence in liquid.
        6) Thinner to be used for each coating.
        7) Ventilation requirements.
        8) Minimum and maximum atmospheric conditions during which the paint shall be applied.
        9) Allowable application methods.
        10) Maximum allowable substrate moisture content.
        11) Maximum shelf life.
        12) Requirements for transportation and storage.
        13) Mixing instructions.
        14) Shelf life.
        15) Material Pot life.
        16) Precautions for applications free of defects.
        17) Method of application.
        18) Drying time of each coat, including prime coat.
        19) Compatible prime coats.
        20) Limits of ambient conditions during and after application.
        21) Required protection from sun, wind, and other conditions.
        22) Touch-up requirements and limitations.
        23) Minimum adhesion of each system submitted in accordance with ASTM D4541 and ASTM D7234.
    d. Samples: Include 8-inch square drawdowns or brushouts of topcoat finish when requested. Identify each sample as to finish, formula, color name and number, sheen name, and gloss units.
    e. Affidavits signed by an officer of the CSM’s corporation attesting to full compliance of each coating system component with current federal, state, and local air pollution control regulations and requirements.

f. List of cleaning and thinner solutions allowed by the CSMs.
g. Storage requirements, including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.
h. Thick film coating systems (greater than 25 mils):
1) CSM's detailed written instructions for coating system treatment and graphic details for coating system terminations in coated structures, including pipe penetrations, metal embedments, gate frames, and other terminations encountered.
2) Include detail treatment for coating system at concrete joints.
3) Manufacturer's Representative's (CTR) Field Reports.

5. Quality assurance Submittals:
a. Quality assurance plan.
b. Qualifications of CSA, including:
1) List of Similar Projects.
a) Name and address of project.
b) Year of installation.
c) Year placed in operation.
d) Point of contact: Name and phone number.
2) Provide a minimum of 5 project references, each including contact name, address, and telephone number where similar coating work has been performed by their company in the past 5 years.
c. CSA Reports:
1) Written daily quality control inspection reports.
d. CTR Reports:
1) Reports on visits to project site to view and approve surface preparation of structures to be coated.
2) Reports on visits to project site to observe and approve coating application procedures.
3) Reports on visits to coating plants to observe and approve surface preparation and coating application on shop-coated items.

1.05 QUALITY ASSURANCE

A. CSA qualifications:
1. Minimum of 5 years of experience applying specified type or types of coatings under conditions similar to those of the Work:
a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 5 years.
2. SSPC-QP 1 certified.
3. Manufacturer-approved applicator when manufacturer has approved applicator program or when required in these specifications.

B. CTR qualifications:
1. Certification, one of the following:
a. NACE Level 2 or 3 Certified Coating Inspector.
b. SSPC Level 3 Protective Coatings Inspector.
2. Minimum of 5 years of experience evaluating application of manufacturer's coatings under conditions similar to those of the Work:
a. Provide CTR qualifications and references listing 5 similar projects completed in the past 5 years.

C. Regulatory requirements: Comply with governing agencies' regulations by using coatings in accordance with to their VOC limits.
   1. Lead-based coatings are not permitted.
   2. Do not use coal-tar epoxy in contact with drinking water or exposed to ultraviolet radiation.

D. Certification:
   1. Certify that applicable pigments resist deterioration when exposed to hydrogen sulfide and other sewage gases.
   2. Product data shall designate coating as being suitable for wastewater service.

E. Pre-installation conference: Conduct as specified in Section 01312 - Project Meetings.
   1. Coordinate Hold Point schedule.

F. Field samples:
   1. Prepare and coat a minimum 100-square-foot area of each system between corners or limits such as control or construction joints.
   2. Approved field sample may be part of the Work.

G. Obtain approval before coating other surfaces. Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

H. CSM services:
   1. CSA shall arrange for CTR to attend pre-installation conferences.
   2. Visit the project site periodically to consult on and inspect specified surface preparation and application Hold Points.
   3. Visit coating plants to observe and approve surface preparation procedures and coating application of items to be shop primed and coated.
   4. CTR shall provide written inspection reports.

I. Quality control requirements:
   1. Contractor shall be responsible for the workmanship and quality of the coating system installation.
      a. Inspections by Owner, Engineer, CSA, or CTR will not relieve or limit Contractor's responsibilities.
   2. In accordance with this specification's requirements and the standards referenced in this Section. Changes in the coating system application requirements will be allowed only with the Engineer's written acceptance.
   3. Specially trained crews with experience applying the specified coating system coating are required for:
      a. Coating application using plural component spray equipment or other specialty equipment.
      b. Coating with specialty linings for severe service conditions, including floor coatings, and with linings for corrosive headspaces or secondary containment areas.
   4. CTR shall specially train personnel for coating systems as specified in Attachment B - Coating Detail Sheets.
      a. CSM shall approve personnel in writing applying the coating system.

5. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
6. Identify inspection access points used by Owner's or Engineer's personnel.
7. Provide ventilation, ingress, egress, or other means as necessary for Owner's or Engineer's personnel to safely access the work areas.
8. Conduct and continually inspect work so the coating system is installed as specified. CSM shall provide written directions to correct coating work not in accordance with the specifications or is otherwise unacceptable.
9. Provide written daily reports summarizing test data, work progress, surfaces covered, ambient conditions, quality control inspection test findings, and other information pertinent to the coating system application.
    a. Determine relative humidity in accordance with ASTM E337. Confirm other conditions, such as proper protective measures for surfaces not to be coated and safety requirements for personnel.
        1) Measure daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
        2) Determine the acceptability of weather and/or environmental conditions within the structure in accordance with the CSM's requirements.
    b. Monitoring surface preparation: Spot check cleanliness, surface profile, and surface pH testing at least 3 times daily. Check each surface at least once. In accordance with:
        1) ASTM D4262.
        2) ASTM D4263.
        3) ASTM D4417.
        4) ICRI 310.2 requirements.
        5) SSPC Surface Preparation Standards.
    c. Confirm that compressed air used for surface preparation or blow-down cleaning is free of oil and moisture.
    d. Monitor surface preparation daily at shift's beginning and end and at intervals not to exceed 4 hours during the shift.
    e. Do not apply coatings when environmental conditions are outside of the CSM's published limits.
    f. Monitoring coatings application: Continuously inspect, measure, and record the wet film thickness and general film quality (visual inspection) for runs, sags, pinholes, holidays, etc., during coating.
        1) Perform WFT measurements in accordance with ASTM D4414.
    g. Post cure evaluation: Measure and inspect the overall dry film thickness on all surfaces.
        1) Conduct a DFT survey and perform adhesion testing, holiday detection, or cure testing as required in this Section and/or the CSM's written instructions.
        2) Perform applicable tests in accordance with ASTM D4541, ASTM D4787, ASTM D5162, ASTM D7234, SSPC-PA 1, SSPC-PA 2, SSPC-PA 9, and other pertinent standards and recommended practices.

J. Inspection at Hold Points:
    1. Conduct inspections at Hold Points during the coating system application and record the results.

2. Coordinate Hold Points with the Engineer so the Engineer can observe Contractor’s inspections on a scheduled basis.
3. Provide the Engineer a minimum of 24 hours of notice before conducting Hold Point Inspections.
    a. Coatings application: At the beginning of coating system application, measure, record, and confirm acceptability of surface and ambient air temperature and humidity. Inspect applicator's equipment for serviceability and suitability for coatings application.
        1) Observe conditions during the pre-application meeting.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products as specified in Section 01601 - Product Requirements.

B. Immediately remove unspecified and unapproved coatings from Project site.

C. Deliver new labeled, unopened containers:
1. Do not deliver materials after manufacturer's expiration date or over 12 months from manufacturing date, whichever is more stringent. Store materials in well-ventilated enclosed structures and protect from weather and excessive heat or cold in accordance with the CSM’s recommendations.
    a. Store flammable materials in accordance with federal, state, and local requirements.
    b. Store rags and cleanup materials appropriately to prevent fire and spontaneous combustion.
2. Store and dispose of hazardous waste in accordance with federal, state, and local requirements. This requirement specifically applies to waste solvents and coatings.
3. Container labels shall show the following:
    a. Brand name or product title.
    b. CSM's batch number.
    c. CSM's manufacture date.
    d. CSM's name.
    e. Generic material type.
    f. Application and mixing instructions.
    g. Hazardous material identification label.
    h. Shelf life expiration date.
    i. Color.
    j. Mixing and reducing instructions.
4. Clearly mark containers to indicate safety hazards associated with the use of or exposure to materials.

1.07 PROJECT CONDITIONS

A. Apply coatings to dry surfaces.
1. Surface moisture: Comply with manufacturer's requirements or as specified in this Section.
    a. Plaster and gypsum wallboard: 12 percent.
    b. Masonry and concrete block: 12 percent.
    c. Interior located wood: 15 percent.

d. Concrete floors: Moisture vapor transmission rate of no more than 3.0 pounds per 1,000 square feet per 24 hours in accordance with ASTM F1869 or relative humidity no greater than 80 percent if tested in accordance with ASTM F2170 unless the CSM's recommendations are more restrictive.
e. Concrete structures: Negative results from Plastic Sheet Test in accordance with ASTM D4263, and maximum of 80 percent relative humidity in accordance with ASTM F2170.

B. Do not apply coatings when the following conditions exist. If such conditions exist, provide containment, covers, environmental controls, and other necessary measures.
1. During rainy, misty, or damp weather, or to surfaces with frost or condensation.
2. When the surface temperature is below 10 degrees Fahrenheit above the dew point.
3. When ambient or surface temperature:
a. Is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
b. Is less than 65 degrees Fahrenheit for clear finishes unless manufacturer allows a lower temperature.
c. Exceeds 90 degrees Fahrenheit unless manufacturer allows a higher temperature.
d. Exceeds manufacturer's recommendation.
4. When relative humidity is higher than 85 percent.
5. Under dusty or adverse environmental conditions.
6. When light on surfaces measures less than 15 foot-candles.
7. When wind speed exceeds 15 miles per hour.

C. Apply coating only under evaporation conditions rather than condensation.
1. Use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain required atmospheric and surface temperature requirements for proper coating application and cure.
2. Measure and record relative humidity and air and surface temperatures at the start and end of each shift to confirm proper humidity and temperature levels inside the work area.
a. Submit test results.

D. Continuously ventilate, dehumidify, and heat enclosed spaces with high humidity during surface preparation, coating application, and curing.
1. Maintain minimum air temperature of 55 degrees Fahrenheit and 10 degrees Fahrenheit above the dew point.
2. Maintain dew point of at least 10 degrees Fahrenheit less than the temperature of the coldest part of the structure where work is performed.
3. Reduce dew point temperature in conditioned space by at least 10 degrees Fahrenheit within 20 minutes.
4. Seal work areas and maintain positive pressure per dehumidification equipment supplier's recommendations.
5. Maintain these conditions before, during, and after application to ensure proper adhesion and cure of coatings for no less than:
a. Entire curing period.
b. 8 hours after coating.

E. Systems:
   1. Site electrical power availability as specified in Section 01500 - Temporary Facilities and Controls.
   2. Internal combustion engine generators may be used.
      a. Obtain required permits and provide air pollution and noise control devices on equipment as required by permitting agencies require.
      b. Comply with state, federal, and local fire and explosion protection measures when locating and operating generator.
      c. Locate engine generator outside hazardous classified areas in accordance with NFPA 820.
      d. Provide daily fuel service for generator for duration of use.
   3. Dehumidification:
      a. Provide desiccant or refrigeration drying.
      b. Use only desiccant types with a rotary desiccant wheel capable of continuous operation.
      c. Liquid, granular, or loose lithium chloride drying systems are not acceptable.
   4. Heating:
      a. Use electric, indirect combustion, or steam coil.
      b. Direct-fired combustion heaters are not acceptable heat sources during abrasive blasting, coating application, or coating cure.
   5. Filters:
      a. Use a filtration system for dust removal designed to not interfere with dehumidification equipment's ability to control dew point and relative humidity inside the reservoir.
      b. Do not allow air from the working area or dust filtration equipment to recirculate through thein dehumidifier during coating application or when solvent vapors are present.
   6. Design and Submittals:
      a. Prepare and submit dehumidification and heating plan, including all equipment and operating procedures.
      b. Suppliers of services and equipment shall have at least 3 years of experience in similar applications.

F. Provide containment and ventilation system components in accordance with SSPC-Guide 6, Level 3 and as required for hazardous materials.

1.08 MAINTENANCE

A. Provide table of products applied organized by surface type. List coating manufacturer, color, color formulation, distributor name, telephone number, and address.

1.09 CTR RESPONSIBILITIES

A. General:
   1. Attend pre-installation conference.
   2. Perform onsite application training.
   3. Periodically inspect coating system application.

B. Coating system installation training:
   1. Provide a minimum of 8 hours of classroom and off-site training for application personnel and supervisory personnel in one of the following ways:
      a. Train a minimum of 2 supervisory personnel and 2 application personnel.
      b. Submit a letter from the CSM stating that CSM approves the supervisory and application personnel, listed by name and responsibility, and no additional training is required.
   2. CTR can train up to 14 application personnel and 3 supervisory personnel at a time.
   3. Minimum training requirements:
      a. Explain in detail the mixing, application, curing, and termination requirements.
      b. Provide hands-on demonstration of coating system mixing.
      c. Explain in detail the ambient condition requirements for temperature and humidity.
      d. Explain in detail the surface preparation requirements.
      e. Explain in detail the re-coat times, cure times, and related ambient condition requirements.
      f. Write a letter stating that training was satisfactorily completed by the personnel, listed by name and responsibility.
   4. Provide special training as specified in the Coating Detail Sheets.

C. Coating system inspection:
   1. CTR inspection is in addition to the CSA's inspection as specified in this Section.
   2. Be on-site to oversee:
      a. Coating application at least once a week.
      b. End of surface preparation.
      c. During coating application.
      d. Post-cure inspection.
   3. Routinely inspect and verify in writing that application personnel have successfully performed surface preparation, filler/surfacer application, coating system application, and Quality Control Inspection in accordance with this Section and to warrantable quality.
   4. Perform the following activities to confirm conformance with the specifications:
      a. Inspect ambient conditions during coating system installation at Hold Points for conformance with the specified requirements.
      b. Inspect each coated surface type and coating system applied to verify the following:
         1) Cleanliness.
         2) Surface pH for concrete substrates.
         3) Confirm surface preparation of substrates where coating system will terminate or will be applied for conformance to the specified application criteria.
      c. Verify surface profile of substrates by completing the following:
         1) Inspect preparation and application of coating detail treatment at terminations, transitions, metal embedments in concrete, and joints and cracks in substrates.
         2) Inspect application of filler/surfacer materials for concrete and masonry substrates.
         3) Verify proper mixing of coating materials.

4) Inspect application of primers and finish coats, including wet and dry film thickness.
5) Inspect coating systems for proper cure times and conditions.

d. Review adhesion testing of cured coating systems.
e. Review coating system continuity testing.
f. Inspect and record representative-localized repairs.
g. Conduct final review of completed coating system installation.
h. Prepare and submit site visit reports after each site visit to document that the coating work is in accordance with the CSM's Recommendations.

D. Final report:
1. Prepare a final report, after coating work ends, summarizing each day's test data, observations, drawings, and photographs.
a. Include substrate conditions, ambient conditions, and application procedures observed during the CTR's site visits.
b. Include a statement that completed work was performed in accordance with the requirements of the CSM's recommendations.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Coating materials shall be formulated for environments encountered in water and wastewater treatment processes.

B. Coating materials that come in contact with water distributed as potable water shall be certified in accordance with NSF 61.

2.02 MATERIALS

A. General:
1. Product requirements: As specified in Section 01601 - Product Requirements.

2.03 COATING SYSTEMS IDENTIFICATION

A. Naming conventions: Coating Systems Identifications contain the elements defined in Table 1.

First Element	Second Element	Third Element	Fourth Element (optional)
3 or 4 alpha characters	1-3 alpha characters	1 number	3 or 4 alpha characters
Coating Type	Substrate	System Number	Additional Substrate or Special Condition
Example: EPX	C	6	BSC

1. First element identifies the coating type using the following abbreviations:
a. ACR: Acrylic.
b. CTE: Coal tar epoxy.
c. ELA: Elastomeric acrylic.
d. EPU: Epoxy-polyurethane.

e. EPX: Epoxy.
f. POL: Polyurethane.
g. SIL: Silicone.
h. SILX: Siloxane or silane.
i. VE: Vinyl ester.

2. Second element identifies the substrate using the following abbreviations:
   a. C: Concrete or masonry.
   b. F: Concrete flooring.
   c. FRP: Fiber-reinforced plastic.
   d. GM: Galvanized metal.
   e. M: Metal.
   f. PVC: Polyvinyl chloride, chlorinated polyvinyl chloride.
3. Third element identifies the sequential system number.
   a. For example, EPX-C-2 is the second standard epoxy coating system for concrete substrates.
4. Fourth element is optional and identifies the additional substrate or special condition with the following abbreviations:
   a. PWS: Potable water service applications (NSF-61 approved).
   b. BSC: Biogenic sulfide corrosion-resistant applications in wastewater.
   c. BG: Below grade or buried.
   d. OZ: Organic zinc primer, epoxy polyurethane system.
   e. SC: Secondary containment.

B. Products: As specified in Attachment B - Coating Detail Sheets.

C. Cleaning solvents:
1. Requirements for solvent wash, solvent wipe, or cleaner used, including, but not limited to, those used for surface preparation in accordance with SSPC-SP 1:
   a. Emulsifying type.
   b. Containing no phosphates.
   c. Biodegradable.
   d. Does not damage zinc.
   e. Compatible with the specified primer.
   f. Complying with applicable air-quality control board requirements.
2. Use clean white cloths and clean fluids in solvent cleaning.

PART 3 EXECUTION

3.01 GENERAL PROTECTION REQUIREMENTS

A. Protect adjacent coated surfaces from coatings and damage associated with coating work. Repair damage resulting from inadequate or unsuitable protection.

B. Use drop cloths and other coverings to protect adjacent surfaces not to be coated against spatter and droppings.

C. Mask off surfaces of items not to be coated or remove items from area.

D. Furnish and deploy sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and, in particular, surfaces within storage and preparation areas.

E. Place coating waste, cloths, and material that may pose a fire hazard in closed metal containers and remove daily from site.

F. Remove electrical plates, surface hardware, fittings, and fasteners before coating application.
   1. Carefully store, clean, and replace items after completing coating in each area.
   2. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finishes.

G. Erect and maintain protective enclosures in accordance with SSPC-Guide 6.

H. Protect the following surfaces from abrasive blasting by masking or by other means:
   1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
   2. Machined surfaces for sliding contact.
   3. Surfaces to be assembled against gaskets.
   4. Surfaces of shafting where sprockets will be fit.
   5. Surfaces of shafting where bearings will be fit.
   6. Machined bronze surfaces, including slide gates.
   7. Cadmium-plated items, except cadmium-plated, zinc-plated, or sherardized fasteners used to assemble equipment requiring abrasive blasting.
   8. Galvanized items, unless scheduled to be coated.

I. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by spent abrasive blast media, dust, or dirt entering such equipment.

J. Schedule cleaning and coating to keep dust and spray from the cleaning process from falling on wet, newly coated surfaces.
   1. Whenever possible, coordinate with other trades and complete surface preparation and coating work before installing hardware, hardware accessories, nameplates, data tags, electrical fixtures, and similar uncoated items that will be in contact with coated surfaces. Mask machined surfaces, sprinkler heads, and other small items that will not be coated.
   2. After completing coating, reinstall removed items.
   3. Disconnect and move equipment adjacent to walls to clean and coat equipment and walls. Replace and reconnect equipment after coating.

3.02 GENERAL SURFACE PREPARATION REQUIREMENTS

A. Prepare surfaces in accordance with CSM's instructions unless more stringent requirements are specified in this Section.

B. Coating detail sheets in Attachment B - Coating Detail Sheets include additional surface preparation requirements.

C. Follow more stringent requirement if information conflicts.

D. Where required by the Owner's representative, a NACE International certified coatings inspector, provided by the Owner, will inspect and approve surfaces to be coated before applying a coating.
   1. CSA shall coordinate coating inspections.
      a. Identify coating inspection Hold Points during the pre-installation conference.
      b. Provide at least 2 days notice before inspection.
   2. Correct surface defects identified by the inspector at no additional cost to the Owner.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

A. Identify equipment, ducting, piping, and conduit as specified in Section 15050 - Common Work Results for Mechanical Equipment, Section 15076 - Pipe Identification, and Section 16075 - Identification for Electrical Systems.

B. Remove grilles, covers, and access panels for mechanical and electrical system and coat separately.

C. Prepare and finish coat equipment primed by the manufacturer using specified intermediate and top coats, as applicable, and color selected by the Owner.

D. Prepare, prime, and coat both insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with material not requiring coating, or with a prefinished coating.

E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.

F. Prepare and coat interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with 1 coat of flat black paint to limit of sight line.

G. Prepare and coat dampers exposed immediately behind louvers, grilles, and convector and baseboard heating cabinets to match face panels.

H. Prepare and coat exposed conduit and appurtenances occurring in finished areas with color and texture to match adjacent surfaces.

I. Prepare and coat sides' front, back, and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.

J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming, and numbering, in accordance with the Contract Documents.

3.04 CLEANING OF NEW AND PREVIOUSLY COATED OR NEW SURFACES

A. Utilize cleaning agent to remove soluble salts, such as chlorides, from concrete and metal surfaces:
   1. Cleaning agent: Biodegradable non-flammable and containing no VOC.
   2. Manufacturers: The following or equal:
      a. CHLOR*RID International, Inc.
         1) Complete soluble salt removal with steam or warm water cleaning.
   3. Test cleaned surfaces to ensure removal of soluble salts. Carry out additional cleaning as needed.
   4. Complete final surface preparation before applying new coating system in strict accordance with CSM's printed instructions.

3.05 BLAST CLEANING

A. Surface preparation requirements:
   1. Do not reuse spent blast abrasive.
   2. Ensure that filter compressed air used for blast cleaning is free of condensed water and oil.
      a. Clean moisture traps at least once every 4 hours or more frequently, as required, to prevent moisture from entering the abrasive blasting equipment air supply.
      b. Check blast air for moisture and oil after each cleaning in accordance with ASTM D4285.
   3. Install oil separators just downstream of compressor discharge valves and at the discharge point of blast pot discharges. Check separators on the same frequency as the moisture traps.
   4. Keep regulators, gauges, filters, and separators on compressor air lines to blasting nozzles operational at all times.
   5. Install an air dryer or desiccant filter drying unit to dry the compressed air before blast pot connections. Use and maintain the dryer throughout surface preparation work.
   6. Use a venturi-type, or other high velocity-type, abrasive blast nozzles supplied with at least 100 pounds per square inch gauge air pressure at the nozzle and enough volume to obtain appropriate blast cleaning production rates and surface cleanliness.
   7. Provide airborne particulate evacuation and filtering that meets OSHA safety standards. Maintain optimal visibility both to clean and provide the specified surface profile and to allow inspection of the substrate during surface preparation work.
   8. If prepared and cleaned metallic substrates become contaminated between final surface preparation work and coating system application, or if the prepared substrate darkens or changes color, re-clean by water blasting, or abrasive blast cleaning as appropriate until the specified degree of cleanliness is restored.

B. Water jetting or water blasting:
   1. Use water jetting or water blasting for recoating or relining where an adequate surface profile exists.
   2. Perform water jetting or water blasting in accordance with SSPC-SP 13 and SSPC-WJ-1, WJ-2, WJ-3, WJ-4.

3.06 PREPARATION REQUIREMENTS FOR CONCRETE SURFACES

A. Cure for at least 28 days before coating.

B. Remove degraded concrete using abrasive blast cleaning or high or ultra-high-pressure water jetting, chipping, or other abrading tools until achieving a sound, clean substrate. Remove bruised or cracked concrete.

C. Prepare substrate cracks and areas requiring resurfacing; perform detail treatment, including, but not limited to, terminating edges in accordance with the CSM's recommendations, and as indicated on the Drawings.
   1. Prepare concrete surfaces in accordance with SSPC-SP 13.

D. Prepare concrete surfaces in accordance with SSPC-SP 13.
   1. Inspect concrete surfaces to select appropriate surface preparation method to provide a suitable substrate for the specified coating system.
   2. Use blast cleaning or other means to expose the complete perimeter of air voids or bug holes. Do not leave shelled over, hidden air voids beneath the exposed concrete surface.
   3. Repair concrete defects and physical damage.
   4. Clean concrete surfaces of dust, mortar, formwork, fins, loose concrete particles, form release materials, oil, and grease.
   5. Fill voids to provide surface as specified in Section 03366 - Concrete Finishes.

E. Provide clean substrate visually free of calcium sulfate, loose, coarse, or fine aggregate, laitance, loose hydrated cement paste, and otherwise harmful substances.
   1. Confirm concrete surface minimum pH of 9.0 with surface pH testing.
   2. If after surface preparation the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.

F. Prepare concrete surface for coating in accordance with SSPC-SP 13.
   1. Provide ICRI 310.2 minimum No. 3 concrete surface profile (CSP) or as specified on Coating Detail Sheets.
   2. Evaluate profile of the prepared concrete using ICRI 310.2 surface profile replicas.

G. Blast clean cementitious repair mortars or grouts to the same profile and degree of cleanliness requirements required for concrete substrates.

H. Blast clean polymer-based surfacers or waterborne modified cementitious surfaces only if they have exceeded the CSM's recommended recoat time.

I. Vacuum concrete surfaces before coating application, leaving a dust free, sound concrete substrate.
   1. Thoroughly clean concrete surfaces to be coated to remove loose dirt and spent abrasive.
   2. Remove debris produced by blast cleaning from the structures to be coated, and legally dispose of it off-site.

J. Test moisture content of concrete to be coated:
   1. Conduct ASTM D4263 plastic sheet test at least once for every 500 square feet of surface area to be coated.
      a. Any moisture on plastic sheet after test period constitutes a non-acceptable test, and the concrete must be dried further.
   2. Conduct ASTM F1869 test at least once for every 1,000 square feet of concrete floor surface area to be coated.
   3. Conduct ASTM F2170 one relative humidity moisture test at least once for each 500 square feet of non-floor concrete surface area where the opposite side is exposed to soil or water.
      a. Waterproof surfaces exposed to soil or water where specified in Section 07110 - Dampproofing.
   4. Comply with specified minimum moisture content and CSM's written recommendations for moisture vapor transmission rates or relative humidity values.

K. Masonry surfaces:
   1. Cure for at least 28 days before coating.
   2. Prepare masonry surfaces to remove chalk, laitance, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
   3. Wash and scrub masonry surfaces with clear water. Do not use muriatic acid.
   4. Seal or fill masonry surfaces with a sealer or block filler compatible with the specified primer after cleaning.
   5. Confirm that masonry surfaces are dry before coating application.
      a. If using pressure washing or low-pressure water blast cleaning for preparation, allow the masonry to dry for at least 5 days under dry weather conditions or until the minimum ambient temperature is 70 degrees Fahrenheit before coating.

3.07 GENERAL PREPARATION REQUIREMENTS FOR METALLIC SURFACES

A. Remove rust, scale, and welding slag and spatter.
   1. Remove and grind smooth excessive weld material and weld spatter on metal surfaces before blast cleaning in accordance with NACE SP0178, Appendix C, Level C.
   2. Grind sharp edges on metal substrate to approximately 1/16-inch radius before abrasive blast cleaning.

B. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the SSPC specified for each coating system.
   1. Remove grease and oil in accordance with SSPC-SP 1.
   2. Use solvent as recommended by the CSM.
   3. Measure profile depth of the surface to be coated in accordance with Method C of ASTM D4417. Select blast particle size and gradation to produce the specified surface profile.
   4. Constantly monitor and maintain ambient environmental conditions to ensure cleanliness and that no "rust back" occurs before coating material application.

C. Prepare metallic surfaces by blast cleaning in accordance with SSPC-VIS 1 (ASTM D2200). Prepare abrasive blast representative areas for the Owner's representative to inspect on the first day of cleaning.

D. Unless otherwise specified, the requirements for blast cleaning steel, ductile iron, and stainless steel substrates are as follows:
   1. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC-SP 10 unless blasting may damage adjacent surfaces, is prohibited, or is specified otherwise. Where abrasive blasting is not possible, clean surfaces to bare metal with power tools in accordance with SSPC-SP 11.
   2. Ferrous metal surfaces to be submerged: Abrasive blast in accordance with SSPC-SP 5, unless specified otherwise, to clean and provide roughened surface profile with a depth between 2 and 4 mils.
   3. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products, or embedded abrasive from substrate before coating application.
   4. When abrasive blasted surfaces rust or discolor before coating, abrasive blast clean surfaces again.

E. Field preparation of shop-primed surfaces:
   1. Smooth welds and prominences with power tools before applying field-applied coatings.
   2. Clean and dry shop-primed ferrous metal surfaces and fabricated assemblies before applying field coats.
   3. Prepare shop epoxy primed surfaces with light abrasive blasting or abrading and then vacuum before applying finish coats.
      a. Follow CSM instructions for surface preparation when the primer recoat limit has been exceeded.
   4. Non-immersion service: Clean in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning) and uniformly roughen.
   5. Immersion, BSC, and SC service: Remove shop primer in accordance with SSPC-SP 5 (Near-White Blast Cleaning).

F. Damaged shop primer or rust bleeding:
   1. Ferrous metals: Clean in accordance with SSPC-SP 1 (Solvent Cleaning) and spot blast in accordance with SSPC-SP 10 (Near-White Metal Blast Cleaning) to achieve a uniform surface profile between 2.0 and 2.5 mils before recoating.
   2. Reject galvanized steel with rust bleeding.

G. Damaged coating: Repair by abrasive blast cleaning surfaces as specified for the coating system; feather to a smooth transition before touching up.

3.08 PREPARATION REQUIREMENTS BY SURFACE TYPE

A. Galvanized steel and non-ferrous metal surfaces:
   1. Degrease or solvent clean (SSPC-SP 1) to remove oily residue.
   2. Abrasive blast clean in accordance with SSPC-SP 16.
      a. If abrasive blast cannot be performed, abrade in accordance with SSPC-SP 3 (Power Tool Cleaning).
   3. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded, such as bolts, nuts, or preformed channels.
   4. Test surface for contaminants using copper sulfate solution.

B. Stainless-steel surfaces:
   1. Abrasive blast clean in accordance with SSPC-SP 16 to leave a clean, uniform appearance with surface profile between 1.5 and 2.5 mils.

C. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.

D. Sherardized, aluminum, copper, and bronze surfaces:
   1. Abrasive blast clean in accordance with SSPC-SP 16.
   2. Prepare in accordance with CSM's instructions.

E. Cadmium-plated, zinc-plated, or sherardized fasteners:
   1. Abrasive blast in the same manner as uncoated metal when assembling equipment designated for abrasive blasting.

F. PVC and FRP surfaces:
   1. Lightly sand surfaces to be coated.
      a. Sand to remove gloss and establish uniform surface profile.
   2. Vacuum to remove loose dust, dirt, and other materials.
   3. Solvent clean with clean white rags and allow solvent to evaporate completely before applying coating materials.

3.09 APPLICATION REQUIREMENTS

A. Apply coatings in accordance with manufacturer's instructions.

B. Empty aboveground piping to be coated of contents when applying coatings.

C. Mechanical equipment shop primed by the manufacturer.
   1. Pumps and valves: Shop coat with manufacturer's highest quality coating system meeting the project specifications.
      a. Provide CTR shop coating reports.
   2. Non-immersed equipment: Touch up shop primer, and coat in the field with specified coating system after installation.
      a. If project requires equipment removal and reinstallation, complete touch-up coating after final installation.
   3. Immersed equipment not shop coated: Remove shop primer before surface preparation and field apply coating.

D. Verify surface preparation immediately before applying coating in accordance with SSPC-SP COM and the SSPC visual standard for the specified surface preparation method.

E. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.

F. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.

G. Do not apply coatings to a surface until it has been prepared as specified.

H. Use equipment designed to apply materials specified.
   1. Use compressors with moisture traps and filters that remove water and oils from the air.
      a. Perform a paper blotter test at the Engineer's request to verify air is sufficiently free of oil and moisture. Do not allow the amount of oil and moisture to exceed CSM-recommended amount.
   2. Equip spray equipment with properly sized mechanical agitators, pressure gauges, pressure regulators, and spray nozzles.

I. Where 2 or more coats are required, tint prime coat intermediate coats as necessary to distinguish each coating and to help indicate coverage.
   1. Do not use color additives with chromium, lead or lead compounds that hydrogen sulfide, other corrosive gases, might destroy or alter. Apply the specified number of coats.

J. Apply coating by brush, roller, trowel, or spray unless a specific application method is required by coating manufacturer's instructions or these Specifications.
   1. Apply primer or first coat by brush to power tool cleaned ferrous surfaces.
   2. Brush or spray-apply coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces.
   3. After prime coat dries, mark, repair, and retest pinholes and holidays before intermediate or top coats are applied.

K. Spray application:
   1. With a brush, stripe coat edges, welds, corners, nuts, bolts, and difficult-to-reach areas, as necessary, before spray application to ensure specified coating thickness along edges.
   2. When using spray application, apply each coat to thickness no greater than recommended in coating manufacturer's instructions.
   3. Use airless spray method unless air spray method is required by CSM's instruction or these Specifications.
   4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.

L. Lightly sand and thoroughly clean surfaces to receive high-gloss finishes unless CSM instructs otherwise.

M. Remove dust on coatings between coats.

N. Shop and field coats:
   1. Prime coat: Shop-apply or field-apply prime coats as specified. Use shop-applied primer compatible with the specified field coating system and apply at the minimum dry film thickness recommended by the finish coat CSM.
      a. Provide datasheets identifying the shop primer to on-site coating application personnel.
      b. Perform adhesion tests on the shop primer.
      c. Remove and recoat damaged, deteriorated, and poorly applied shop coatings.
      d. If shop primer coat meets this Section's requirements, spot prime exposed metal of shop-primed surfaces before spray applying primer over the entire surface.

2. Field coats: Apply field coats with 1 or more prime coats and finish coats to build up coating to dry film thickness specified for the coating system.
    a. Do not apply finish coats until other work in the area is complete and previous coats are inspected.
3. Adhesion confirmation: Perform adhesion tests after proper coating cure in accordance with ASTM D3359. Demonstrate that:
    a. Prime coat adheres to the substrate.
    b. Coatings adhere to the prime and intermediate coats.
        1) Coating 5 mils or more DFT: Achieve adhesion test result of 5A on immersed surfaces and 4A or better on other surfaces.
        2) Coating less than 5 mils DFT: Achieve adhesion test results of 5B on immersed surfaces and 4B or better on other surfaces.

O. Brush, roll, trowel, or spray and back roll coats for concrete and masonry.

P. Plural component coating application:
1. Premix contents of component drums if required by the CSM each day.
2. Before starting application:
    a. Verify gauges are working properly.
    b. Complete ratio checks.
    c. Sample the mix on plastic sheeting to ensure set time is appropriate and complete.
    d. Label and retain spray samples. Submit to Engineer when requested.

Q. Drying and recoating:
1. Provide fans, heating devices, or other means to prevent condensate or dew on substrate surface or between coats and during curing after applying the last coat.
2. Allow each coat to cure or dry thoroughly, in accordance with if required in CSM's printed instructions, before recoating.
3. Use CSM's printed instructions and the requirements specified in this Section to determine minimum required drying time.
    a. Do not allow excessive drying time or exposure, which may impair bond between coats.
    b. Recoat coatings within time limits recommended by CSM.
    c. If time limits are exceeded, abrasive blast clean and de-gloss clean before applying another coat.
4. If limitations on time between abrasive blasting and coating are not met before attaching components to surfaces that cannot be abrasive blasted, coat components before attachment.
5. Ensure primer and intermediate coats of coating are unscarred and completely integral when applying each succeeding coat.
6. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
7. Leave no holidays. Repair holidays in accordance with the requirements on pertinent Coating Detail Sheets or as recommended by the CSM.

8. Sand and feather into a smooth transition and recoat scratched, contaminated, or otherwise damaged coating surfaces so repairs are invisible to the naked eye.
9. For submerged service or highly corrosive headspace service, provide a letter to the Engineer stating that the lining system is fully cured and ready to be placed into service.

R. Workmanship:
1. Ensure that coated surfaces are free from runs, drips, ridges, waves, laps, and brush marks. Coats shall be applied to produce a smooth, even film of uniform thickness completely coating corners and crevices.
2. Coat surfaces without drops, overspray, dry spray, excessive runs, ridges, waves, holidays, laps, or brush marks.
3. Remove splatter and droppings after coating work is completed.
4. Evenly apply each coat of material and sharply cut to a line created with masking tape or other suitable materials.
5. Avoid over spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, vehicles, and other adjacent areas and installations by taping, drop cloths, or other suitable measures.
6. When coating complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces with the primer before overall coating system application.
    a. Brush apply stripe coat to ensure proper coverage.
    b. Do not stripe coat with spray or roller.
7. Ensure that finish coat, including repairs, has a uniform color and gloss.

S. Coating properties, mixing, and thinning:
1. Thin prime coat and apply as recommended by the CSM. Thinned coating must comply with prevailing air pollution control regulations.
2. If maximum recoat time is exceeded, prepare surface with solvent washing, light abrasive blasting, or other procedures in accordance with CSM’s instructions.
3. Allow adequate drying time between coats as instructed by the CSM, adjusted as necessary for the site conditions.
4. Ensure that coatings, when applied, provide a satisfactory film and a smooth even surface. Lightly sand glossy undercoats to provide a surface suitable for proper application and adhesion of subsequent coats. Thoroughly stir and strain coating materials during application and maintain uniform consistency.
5. Mix coatings with 2 or more components in accordance with CSM’s instructions.
6. Where necessary to suit conditions of the surface, temperature, weather, and method of application, thin the coating in accordance with CSM's recommendations.
    a. Ensure that volatile organic content (VOC) of the thinned coating complies with prevailing air pollution control regulations.
    b. Thin coatings to only what is necessary to obtain proper application characteristics.
    c. Use a thinner recommended by the CSM.

T. Film thickness and continuity:
1. Apply coating to the specified thicknesses.
    a. Apply additional coats when necessary to achieve specified thicknesses, especially at edges and corners.

2. Verify WFT of the coating system first coat and after applying each subsequent coat.
3. Do not allow the minimum thickness at any point to deviate more than 25 percent from the required average.
4. Do not allow the surface area covered per gallon of coating for various types of surfaces to exceed those recommended by the CSM.
    a. Provide coating coverage worksheets listing the maximum and minimum coverage for each unit volume of coating for concrete surfaces.
5. Apply additional coats to achieve the specified dry film thickness if brush or roller application methods cannot achieve the specified film thicknesses per coat.

U. Protecting coated surfaces:
1. Do not handle, work on, or otherwise disturb coated items until the coating is completely dry and hard.
2. After installation, recoat shop-coated surfaces with specified coating system as necessary to match surrounding surfaces, and to coordinate with the specified color identification requirements.

V. Special requirements:
1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces inaccessible after assembly. Apply final coat after erection.
2. Coat structural slip-critical connections and high strength bolts and nuts after erection.
3. Areas damaged during erection:
    a. Prepare surface for spot repairs as specified for the coating system.
    b. Recoat with prime coat before applying subsequent coats.
    c. Touch up surfaces after installation.
    d. Clean and dry surfaces to be coated at time of application.
4. Coat underside of equipment bases and supports not galvanized with at least 2 coats of primer specified before setting the equipment in place.
5. Coat aluminum in contact with concrete.

3.10 APPLICATION REQUIREMENTS FOR CONCRETE COATING SYSTEMS

A. Apply filler/surfacer as recommended by CSM to fill bug holes and air voids in concrete or block texture in CMU, leaving a uniformly filled surface that does not produce blowholes or outgassing causing the coating system to pinhole.
1. Allow filler/surfacers to cure sufficiently before applying prime coat as required by the CSM. Use the CSM-recommended drying time between coats.

B. Apply surfacer or filler and let dry before coating application.
1. Use the drying time between filler/surfacer and coating system specified by the CSM for the site conditions.
    a. Let concrete substrate dry before applying filler/surfacers or coating system materials.
2. If the maximum recoat time is exceeded, prepare surfaces by solvent washing, light abrasive blasting, and other procedures in accordance with CSM's instructions.

3. Apply a complete parge coat of the specified filler/surfacer material over the entire substrate before applying the coating system.
    a. Scrub filler/surfacer into the substrate to completely fill open air voids and bug holes.
    b. Completely cover the substrate, unless otherwise specified, above such filled voids by 1/8 inch of thickness.
    c. Provide relatively flat, uniformly even surface before coating application.
4. Secondary containment: Place surfacer or filler 1/16-inch thick above concrete plane to create a monolithic surface free of pinholes.
    a. Floor surfaces: Broadcast with aggregate to create a non-slip surface texture.
    b. Remove excess aggregates and apply base coat to encapsulate embedded non-slip aggregate.

C. Concrete substrate temperatures:
1. Apply filler/surfacers and the coating system when temperatures are falling, typically late afternoon or evening.
    a. Do not coat concrete with rising concrete substrate surface temperatures or substrates in direct sunlight, to minimize outgassing from the substrate and formation of pinholes, and/or blistering.
2. Should bubbles, pinholes, or other discontinuities form in the applied coating system material, they shall be repaired.
    a. Should discontinuities develop in the filler/surfacer material or in the first coat of the coating material, repair them before the next coat.
    b. When discontinuities occur, open the air void behind or beneath the discontinuities and completely fill with specified coating material. Then, abrade the coated area around the discontinuities repair reapply coating over that area.

D. Perform application detail work in accordance with these Specifications, the CSM's current written recommendations, and Drawings, whichever is stricter.

E. Concrete coating systems application requirements:
1. Concrete coating minimum dry film thickness excludes parge coat, block filler, and sealer.

3.11 COATING SYSTEM SCHEDULE

A. Attachment A - Schedule of Surfaces to be Coated specifies surfaces to be coated in the field with the coating systems required.

3.12 SURFACES NOT REQUIRING COATING

A. Stainless steel piping, valves, pipe supports, instrument sunshades.

B. Sliding surfaces on expansion joints, motor and pump shafts, machined surfaces at bearings and seals, grease fittings, etc.

C. Galvanized structural steel framing, galvanized roof decking, galvanized pipe supports.

D. Copper and brass pipe, fittings, valves, etc.

E. Bronze valves, bearings, bushings, and fasteners.

F. Corrosion resistant special alloys: Inconel, Alloy 20, Hastelloy, etc.

G. Exterior concrete.

H. Plastic surfaces except coat PVC, CPVC, and other plastic piping system exposed to sunlight.

I. Buried piping that is encased in concrete or cement mortar.

3.13 QUALITY CONTROL

A. Owner-provided inspection or inspection by others does not limit the Contractor's or CSA's responsibilities for quality workmanship or quality control as specified or as required by the CSM's instructions. Owner inspection is in addition to any inspection required of the Contractor.

B. Owner may perform, or contract with an inspection agency to perform, quality control inspection and testing of the coating work covered by this Section. These inspections may include the following:
   1. Inspect materials upon receipt to ensure that the CSM supplied them.
   2. Verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
   3. Inspect and record findings for substrate cleanliness.
   4. Inspect and record pH of concrete and metal substrates.
   5. Inspect and record substrate profile (anchor pattern).
   6. Measure and record ambient air and substrate temperature.
   7. Measure and record relative humidity.
   8. Check for substrate moisture in concrete.
   9. Verify that mixing of coating system materials is in accordance with CSM's instructions.
   10. Inspect, confirm, and record that coating system materials' "pot life" is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
   11. Perform adhesion testing.
   12. Measure and record the coating system's thickness.
   13. Verify proper curing of the coating system in accordance with the CSM's instructions.
   14. Holiday or continuity testing in accordance with NACE SP0188 for coatings that will be immersed or exposed to aggressively corrosive conditions.

C. Perform holiday testing in accordance with NACE SP0188 to identify holidays or pinholes needing repair for coating over 100 percent of surfaces:
   1. Coated steel that will be immersed or exposed to aggressively corrosive conditions.
   2. Coated concrete.
   3. Perform holiday tests after proper application and coating system cure.

3.14 CORRECTIVE MEASURES

A. Repair pinholes or holidays identified by Holiday Testing as follows:
   1. Remove the coating system with a grinder or other suitable power tool.
   2. Remove coating system at pinholes and holidays at least 2 inches diameter around the defect back to expose substrate.
   3. Concrete voids: Chip back to expose entire cavity in all directions.
      a. Completely fill void with approved filler/surfacer material using a putty knife or other suitable tool and strike off. Cure in accordance with CSM's recommendations.
   4. Aggressively abrade or sand the intact coating system surface at least 3 inches beyond the removal area in all directions to produce a uniform 6- to 8-mil profile in the intact coating system.
   5. Vacuum the prepared area to remove dust, dirt, etc., leaving clean, sound surfaces.
   6. Tape to mask the periphery of the prepared intact coating area to prevent coating repair application onto the prepared area.
   7. Apply the coating system with enough coats to achieve the specified finish coat thickness over the defect and coating removal area. Feather the coating onto the abraded coated surfaces around the removal area to avoid a lip and to achieve a neat repair outline.
   8. Follow curing time between coats as specified by CSM for the site conditions. Solvent wash and abrasive blast in accordance with CSM's instructions if the maximum recoat time is exceeded.
   9. Apply coating at specified dry film thickness.

3.15 CLEANUP

A. Remove surplus materials, protective coverings, and accumulated rubbish after completing coating. Thoroughly clean surfaces and repair overspray or other coating-related damage.

3.16 FINAL INSPECTION

A. Conduct final inspection of coating system work to determine whether it meets specifications requirements.

B. Conduct subsequent final inspection with the Engineer to ensure Work is in accordance with Contract Documents requirements.

C. Mark any rework required.
   1. Re-clean and repair, as specified, at no additional cost to the Owner.

END OF SECTION

ATTACHMENT A - SCHEDULE OF SURFACES TO BE COATED

ATTACHMENT A
Schedule of Surfaces to be Coated

A. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Contact Engineer for clarification.

EPU-M-1	Metals, exterior, non-immersed
EPX-M-2	Metals, interior, non-immersed
EPX-M-3	Metals, immersed
EPX-M-4-BSC	Metals, Wet well and manhole
EPX-C-6-BSC	Concrete, Wet well and manhole, all surfaces existing and new
CTE-C-1	Cast iron soil pipe
ACR-PVC-1	PVC Pipe

Notes:

1: Non-immersed ferrous metal surfaces include:
- a. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports.
- b. Motors and motor accessory equipment.
- c. Valve and gate operators and stands.
- d. Structural steel.
- e. Mechanical equipment supports, drive units, and accessories.
- f. Bare electrical equipment: boxes, exposed conduit, and accessories.
- j. Pumps not submerged.
- k. Other miscellaneous metals.

2: Immersed ferrous metal surfaces include:
- a. Field priming of ferrous metal surfaces with defective shop-prime coat; including non-submerged service.
- b. Bell rings, underside of manhole covers and frames.
- c. Pumps, including underside of base plates and submerged suction and discharge piping.
- d. Exterior of submerged piping and valves other than stainless steel or PVC piping.
- e. Submerged pipe supports and hangers.
- f. Stem guides.
- g. Other submerged iron and steel metal unless specified otherwise.

ATTACHMENT B - COATING DETAIL SHEETS

Attachment B			
Coating Detail Sheet			
Coating System	EPU-M-1		
Coating Material	Two coats epoxy with polyurethane finish coat		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carbothane 134 VOC
International Paint	Devran 224V	Devran 224V	Devthane 379
PPG	Amercoat 385	Amercoat 385	Amercoat 450H
Sherwin Williams	Macropoxy 646	Macropoxy 646	Hi Solids Polyurethane
Tnemec	Series 69	Series 69	Series 1095
Service Condition	Interior or Exterior, subject to direct sunlight. Non-immersion.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP10, Near-White Blast Cleaning. Shop primed surfaces: SSPC-SP2, Hand Tool Cleaning or SSPC-SP3, Power Tool Cleaning. Damaged primer or rust: SSPC-SP10, Near White Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush Blast Cleaning. Test for surface contaminants.		
Surface profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	10 to 13 mils		
Primer	4 to 5 mils		
Intermediate Coat	4 to 5 mils		
Finish Coat	2 to 3 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-2		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 890	Carboguard 890	Carboguard 890
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amerlock 2/400 Series	Amerlock 2/400 Series	Amerlock 2/400 Series
Sherwin Williams	Tank Clad HS	Tank Clad HS	Tank Clad HS
Tnemec	Series 69	Series 69	Series 69
Service Condition	Immersed, non-immersed, moderately corrosive environment.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface profile			
Ferrous Metal	2 to 4 mils		
Nonferrous Metal	1.0 to 1.5 mils		
Galvanized Metal	1.0 to 1.5 mils		
System Thickness (Dry Film)			
Total	12 to 16 mils		
Primer	4 to 6 mils		
Intermediate Coat	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-3		
Coating Material	Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carboguard 891	Carboguard 891	Carboguard 891
International Paint	Bar-Rust 236	Bar-Rust 236	Bar-Rust 236
PPG	Amercoat 240	Amercoat 240	Amercoat 240
Sherwin Williams	Tank Clad HS	Tank Clad HS	Tank Clad HS
Tnemec	Series 104	Series 104	Series 104
Service Condition	Immersed; non-immersed, corrosive environment. Not for Biogenic Sulfide Corrosion areas in wastewater.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Surface profile			
Ferrous Metal	2.5 to 3.0 mils		
Nonferrous Metal	1.5 to 2.0 mils		
Galvanized Metal	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	16 to 20 mils		
Primer	4 to 8 mils		
Intermediate Coat	4 to 8 mils		
Finish Coat	4 to 8 mils		
Application			
Special CTR Training	Not required.		

Attachment B			
Coating Detail Sheet			
Coating System	EPX-M-4-BSC		
Coating Material	Blended Amine Cured Epoxy		
Substrate	Metal		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	CSM recommended	None applied	Plasite 4500S
International Paint	CSM recommended	None applied	Enviroline 222
Neopoxy	CSM recommended	None applied	NPR-5305
Sauereisen	CSM recommended	None applied	Sewergard 210S
Sherwin Williams	CSM recommended	None applied	Duraplate 6100
Tnemec	CSM recommended	None applied	Series 435
Service Condition	Immersed, non-immersed, non-potable, corrosive.		
Surface Preparation			
General			
Ferrous Metal	Bare surfaces: SSPC-SP5, White Metal Blast Cleaning. Shop primed surfaces: SSPC-SP7, Brush-Off Blast Cleaning. Damaged primer or rust: SSPC-SP5, White Metal Blast Cleaning and spot prime.		
Nonferrous Metal	SSPC-SP16, Brush-Off Blast Cleaning.		
Galvanized Metal	Not recommended.		
Ductile Iron Pipe	NAPF 500-03-04 and -05		
Surface profile			
Ferrous Metal	3 to 4 mils		
Nonferrous Metal	2.0 to 2.5 mils		
System Thickness (Dry Film)			
Total	20 to 40 mils		
Primer	2 to 4 mils		
Finish Coat	20 to 40 mils		
Application			

Attachment B			
Coating Detail Sheet			
Coating System	EPX-C-6-BSC		
Coating Material	Blended Amine Cured Epoxy		
Substrate	Concrete		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Plasite 5371	Plasite 4500S	Plasite 4500S
International Paint	Enviroline 222	Enviroline 222	Enviroline 222
Neopoxy	NPR-5305	NPR-5305	NPR-5305
Sauereisen	Sewergard 210T	Sewergard 210G	Sewergard 210G
Sherwin Williams	Duraplate 6100 filled	Duraplate 6100	Duraplate 6100
Tnemec	Series 434	Series 435	Series 435
Service Condition	Immersed, non-potable; non-immersed, corrosive environment, biogenic sulfide corrosion, new or existing construction. Waterproofing in accordance with 07100 for exterior of buried tanks.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Concrete	Apply complete parge coat over all concrete surfaces after surface preparation is accepted. Completely fill all bugholes with the same material. Brush blast clean, if parge coat is non-polymer modified, after adequate cure per CSM's instructions to produce a uniform anchor pattern. Let concrete substrate cure under warm conditions (minimum of 75 degrees F) for at least 5 days before coating application if using wet abrasive or water jet surface preparation. Sawcut 1/4" minimum deep groove and provide coating termination and transition details as shown on the drawings and in accordance with CSM's standard details including terminations, transitions at corners, cracks, pipe penetrations, terminations at metal embedments, and other details. Vacuum all surfaces to be coated after surface preparation and curing to remove all loose dirt, dust, or other loose materials.		
Existing Coated Concrete	Prepare as for new concrete. Apply a skim coat of a surfacer or filler material to restore the substrate to a smooth surface suitable for coating.		
Surface profile			
Concrete	ICRI CSP 5.		
Existing Coated Concrete	ICRI CSP 5.		
System Thickness (Dry Film)			
Parge coat	Completely cover the substrate with concrete repair material above filled voids by 1/8 inch (125 mils) of thickness.		
Total	125 mils dry film in addition to the parge coat.		
Primer	One coat at CSM's recommended dry film thickness.		
Intermediate and Finish Coats	Each coat at CSM's recommended DFT to specified system thickness.		
Application			
Special CTR Training	Required.		

Attachment B			
Coating Detail Sheet			
Coating System	CTE-C-1		
Coating Material	Coal Tar Epoxy		
Substrate	Concrete		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	None applied	300M	300M
International Paint	None applied	Devtar 5A-HS	Devtar 5A-HS
PPG	None applied	Amercoat 78 HB	Amercoat 78 HB
Sherwin Williams	None applied	TarGuard	TarGuard
Tnemec	None applied	Series 46H-413	Series 46H-413
Service Condition	Below grade in contact with soil.		
Surface Preparation			
General	Prepare surfaces as specified in this Section and as follows.		
Surface profile			
Concrete	ICRI CSP 3.		
Existing Coated Concrete	ICRI CSP 3.		
System Thickness (Dry Film)			
Total	16 mils		
Primer	4 to 6 mils		
Intermediate Coat	4 to 6 mils		
Finish Coat	4 to 6 mils		
Application			
General	Fill all bugholes with a filler/surfacer compatible with the coating.		
Special CTR Training	Not Required.		

Attachment B			
Coating Detail Sheet			
Coating System	ACR-PVC-1		
Coating Material	Acrylic		
Substrate	PVC and CPVC pipe		
Products: One of the following or equal:	Primer	Intermediate Coat	Finish Coat
Carboline	Carbocrylic 120	None Applied	Carbocrylic 3359
International Paint	Devcryl 1440	None Applied	Devcryl 1448
PPG	Pitt Tech Primer	None Applied	Pitt Tech
Sherwin Williams	Sher Cryl HPA	None Applied	Sher Cryl HPA
Tnemec	Series 1028 or 1029	None Applied	Series 1028 or 1029
Service Condition	Exterior, exposed to direct sunlight, non-immersed.		
Surface Preparation	Prepare surfaces as specified in this Section and as follows.		
General	Clean to remove loose dirt, dust, or other contaminants. Sand surfaces to achieve a uniform, roughened surface profile. Solvent clean and vacuum to remove loose debris.		
Surface profile	1.5 to 2.0 mils		
System Thickness (Dry Film)			
Total	4 to 8 mils		
Primer	2 to 4 mils		
Finish Coat	2 to 4 mils		
Application			
Special CTR Training	Not Required.		

SECTION 09968

CONCRETE REPAIR AND COATING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Field repair and coating of existing concrete.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

B. Federal Highway Administration (FHWA):
   1. FHWA-RD-86-193 - Highway Concrete Pavement Technology Development and Testing Volume V: Field Evaluation of SHRP C9206 Test Sites (Bridge Deck Overlays).

C. NACE International (NACE):
   1. SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

D. The Society for Protective Coatings (SSPC):
   1. SP-2 - Hand Tool Cleaning.
   2. SP-3 - Power Tool Cleaning.
   3. SP-10 - Near-White Blast Cleaning.
   4. SP-13 - Surface Preparation of Concrete.

E. United States Department of Agriculture (USDA).

1.03 DESCRIPTION OF WORK

A. Furnish all labor, tools, equipment, materials, and other items required to:
   1. Repair damaged/deteriorated concrete as determined necessary and as required by Engineer; if required.
   2. Repair cracks in concrete by epoxy injection, as specified in Section 03931 - Epoxy Injection System as determined necessary and as required by Engineer; if required, it will be added as change order.
      a. Do not include in Total Bid Amount.
   3. Apply coating to all concrete surfaces as specified in this Section.

B. As determined necessary by Engineer, remove piping, fittings, and associated items where work is to be accomplished.
   1. Replace and coat such items upon completion of work.

1.04 AREAS OF WORK

A. Interior surfaces of existing Wet Well as indicated on the Drawings and described in this Section:
   1. Prepare, repair, and coat all interior surfaces.

1.05 SEQUENCE OF WORK

A. Prepare interior surfaces of Wet Well in preparation for viewing by Owner, Engineer, Contractor, and coating manufacturer's technical representative:
   1. Steam clean and degrease all interior surfaces.
   2. Remove any items as required by Engineer, such as piping, brackets, prior to abrasive blast cleaning of concrete surfaces.
   3. Abrasive blast cleaning of concrete surfaces includes cleaning items, such as piping and brackets, that remain in place.
   4. Abrasive blast clean all concrete surfaces to remove loose concrete and provide a "broom" type finish similar to 60-grit sandpaper.
   5. Work shall be completed within 7 days after structure is taken out of service.

B. Complete all modification work in Wet Well as specified in Contract Documents:
   1. Replace all items previously removed and prepare for coating application.

C. Complete all concrete repair work, necessary epoxy injection work, additional abrasive blast cleaning, and coating application as specified and required by Engineer and in this Section.

D. Perform inspection and necessary repairs to coating as specified in this Section.

1.06 SUBMITTALS

A. Shop drawings: Submit prior to start of work.

B. Product data (general): Submit prior to start of work.

C. Product data:
   1. Manufacturer's literature including installation procedure and warranty for coating system.
   2. Test results of product from approved material testing laboratory certifying that product meets or exceeds required physical properties.
   3. Certification of manufacturer's technical services representative.

D. Testing procedure in accordance with ASTM D4263.

E. Coating repair procedures.

F. Coating system applicator certification:
   1. Approval by coating manufacturer for coating applicator to apply the system.

G. Manufacturer's instructions: Submit in accordance with requirements for product data.

H. Manufacturer's technical representative's field reports.

1.07 QUALITY ASSURANCE

A. Qualifications of concrete repair Contractor:
   1. Manufacturer of specified concrete repair products shall have in existence, for a minimum of 10 years, a program of training, certifying, and technically supporting a nationally organized approved Contractor program with annual recertification of its participants.
   2. Provide list of at least 5 job references where Contractor has successfully repaired spalled concrete surfaces.

B. Qualifications of coating system applicator:
   1. At least 5 years of experience applying type of coating under conditions similar to the Work specified in this Section:
      a. Submit list of 5 references for similar projects completed.

C. Qualifications of coating manufacturer's technical services representative:
   1. Minimum 3 years of experience involving applications of the specified coating system.
   2. Shall be available as required to support application of specified product.

D. Regulatory requirements: Include requirements concerning the following:
   1. Abrasives and abrasive blast cleaning techniques and disposal.

E. Pre-installation conference:
   1. Conduct prior to start of work at mutually agreed time by Owner and Contractor.
   2. Coating manufacturer's technical services representative shall attend pre-installation conference.

F. Certification: Certify that coatings to be applied are resistant to deterioration when exposed to hydrogen sulfide and other sewage gases.

G. Field samples: Prepare and coat a minimum 100 square foot area between corners or limits such as control or construction joints of each system.
   1. Accepted field sample may be part of Work.

H. Compatibility of coatings: Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.

I. Services of coatings manufacturer's technical services representative: Arrange for coating manufacturer's technical representative to attend pre-installation conferences and to make periodic visits to the project site to provide consultation and inspection services during surface preparation and application of coatings.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Remove unspecified and unapproved materials from Project site immediately.

B. Deliver containers with labels identifying the manufacturer's name, brand name, product type, batch number, date of manufacturer, expiration date or shelf life, color, and mixing and reducing instructions.

C. Store materials in a well-ventilated facility that provides protection from the sun, weather, and fire hazards.
   1. Maintain ambient storage temperature between 45 and 90 degrees Fahrenheit, unless otherwise recommended by the manufacturer.

D. Take precautions to prevent fire and spontaneous combustion.

1.09 PROJECT CONDITIONS

A. Surface moisture contents: Do not coat surfaces that exceed coating manufacturer specified moisture contents.

B. Do not coat:
   1. Under dusty conditions.
   2. When light on surfaces measures less than 15 foot-candles.
   3. When ambient or surface temperature is less than 45 degrees Fahrenheit.
   4. When relative humidity is higher than 85 percent.
   5. When surface temperature is less than 5 degrees Fahrenheit above dewpoint.
   6. When surface temperature exceeds coating manufacturer's recommendation.
   7. When ambient temperature exceeds 90 degrees Fahrenheit, unless coating manufacturer allows a higher temperature.

C. Provide fans, heating devices, dehumidification equipment, or other means recommended by manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats, and within curing time following application of last coat.

1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Special warranty:
   1. Duration: 3 years warranty on concrete repair and coating work accomplished under this Contract stating that Contractor will provide all labor and materials to repair any defects that occur after completion and acceptance date of work at no cost to Owner.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete repair material:
   1. Suitable for wastewater lift station environment.
   2. Sprayable or trowel applied for vertical and overhead application.
   3. The following or equal:
      a. MasterEmaco S488CI.

B. Concrete coating material:
   1. EPX-C-6-BSC as specified in Section 09960.
      a. Apply total of 125 mils, or as required to be pinhole free.

C. Reinforcing steel coating:
   1. Solvent-free, moisture-tolerant, epoxy-modified, cementitious, corrosion inhibiting product.
   2. Material must be proven to prevent corrosion of reinforcing steel when tested under the procedures as set forth by the FHWA Program Report Number FHWA-RD-86-193. Proof shall be in the form of an independent testing laboratory corrosion report showing prevention of corrosion of the reinforcing steel.
   3. Sika Corp., Sika Armatec 110.

PART 3 EXECUTION

3.01 GENERAL PREPARATION

A. As required, remove all existing piping, pipe hangers, concrete inserts, and other items as necessary from areas where repair and coating of concrete is required to facilitate repair and coating work, and acceptable to Engineer.

B. Steam clean and degrease all surfaces prior to abrasive blasting.

C. Utilize abrasive blast cleaning to remove surface contaminants and loose material for preparation of concrete surfaces.
   1. Remove debris from structure and dispose of material off site:
      a. Compressed air used for blasting or blow downs must be clean and free of oil particles.
      b. Air compressors must be equipped with efficient oil and water traps.

D. Utilize SSPC SP13 standard to remove damaged and deteriorated concrete for repair and coating:
   1. For areas of concrete deterioration between less than 2 inch, provide repair mortar with EPX-C-6 topcoat.
   2. For area with concrete deterioration with exposed reinforcing bars, the concrete must be chipped back to 4-1/2 inches and reinforcing bars repaired as required.

E. Remove loose concrete from spalled areas and cracks:
   1. In areas where concrete deterioration dovetails to original concrete surface, make entire cavity to be repaired at least 1/2-inch deep from original concrete surface by means of saw-cutting.
   2. Provide straight edges, a minimum of 1/2-inch deep in sound concrete 2-inches away from deterioration.
   3. Repair with concrete repair mortar so as to provide a minimum of 1/2 inch of concrete repair material at all locations.
   4. Prepare surface edges of cavity by grinding.
   5. Remove dust, dirt, and loosely bonded material resulting from cleaning.
   6. Ensure cavity surfaces are dry.

F. Use following procedures where reinforcing steel with active corrosion is encountered:
   1. Clean exposed reinforcing bars to SSPC SP10 standard.
   2. Determine reinforcement bar section loss, splice new reinforcing bars where there is more than 15 percent loss as determined by Engineer.
      a. If more than half the diameter of reinforcing steel is exposed, chip out behind reinforcing steel a minimum of 1/2 inch.
      b. Cut reinforcing bars, butt weld new reinforcing bars to undamaged existing reinforcing bars and place repair mortar to original surface.
   3. Coat all exposed reinforcing steel with high solids epoxy immersed service, as specified in Section 09960 - High-Performance Coatings, before installation of final concrete repair material.

G. Restore damaged and deteriorated edges with approved concrete repair material and in accordance with manufacturer's recommendations.

H. For all concrete repair areas:
   1. Provide smooth steel towel finish free from trowel marks and depressions greater than 1/4 inch.
   2. Allow concrete repair areas to cure for minimum of 48 hours before coating application , or as recommended by coating manufacturer's technical services representative.
   3. Sweep blast all concrete repair areas, followed by air blow-down and vacuuming of all areas to remove all dust and debris before the application of coating.
   4. Provide heaters, fans, or dehumidification equipment as required to allow concrete surfaces to cure and be dry, as recommended by coating manufacturer's technical services representative, prior to application of coating.

I. Allow repaired areas to cure for minimum of 7 days before coating application, or as recommended by coating manufacturer's technical services representative .
   1. Provide necessary heaters, fans, or dehumidification equipment to allow concrete to cure and to be surface dry for coating application.

J. Cleanliness:
   1. At the direction of the coating manufacturer's technical services representative or the Owner, all surfaces shall be pressure cleaned with clean, potable water at a minimum pressure of 1,500 pounds per square inch to remove all dust, dirt, and other debris prior to coating application.

K. Expansion joints:
   1. Seal expansion joints with bond breaker tape.
      a. Polyethylene-backed adhesive tape is acceptable.
   2. Prior to installation of bond breaker tape, round-off sharp edges, remove debris/dust, and inspect to assure that joint compound is reasonably flush with top edge of expansion joint.
   3. Apply a tack coat to adjacent areas, followed immediately with installation of the tape.
   4. Install tape centered over the joint and be of sufficient width to extend a minimum of 1 inch onto the concrete on both sides of the joint.
   5. Tape thickness should be no more than 50 percent of the specified coating thickness.
   6. Topcoat bond breaker tape to the minimum specified thickness.

L. Inspection:
   1. After completion of surface preparation Owner, Engineer, and coating manufacturer's technical services representative, will inspect all surfaces to be coated prior to coating.
   2. Specified cleanliness shall be verified through the use of accepted practice in accordance with SSPC or NACE standards.
   3. Utilize visual comparators to verify the specified level of cleanliness.

M. Abrasive-blast and concrete debris:
   1. Remove debris generated from the preparation operations from the structures.
   2. Haul and dispose of debris in accordance with all federal, State, and local regulations.

3.02 COATING APPLICATION

A. Equipment requirements:
   1. Utilize plural component proportioning equipment capable of pumping 2 separate streams of coating components at the required ratio volumetrically.
   2. Have capability to heat the 2 different liquid components to a process temperature range from 100 to 125 degrees Fahrenheit depending on the set-up.
      a. Do not use of band heaters.
   3. Have capability to maintain process temperature to spray through a gun or pour through the nozzle.
      a. The use of insulated heat-trace fluid lines is mandatory.
   4. Have capability to pump at pressures ranging from 1,200 pounds per square inch to 3,000 pounds per square inch.

5. Have capability to bring the 2 separately proportioned streams together as one stream and mix them together to provide a homogenous mixture for reacting into a solid polymer of known properties.
6. Provide spray atomization tip sizes matched to the pumping equipment output which provides a fully atomized spray pattern, free of “fingers” without the addition of solvents of any kind.

B. Before start of application and at such times when long breaks are involved or application of equipment malfunctions, the following 4 material quality tests are recommended:
   1. A ratio check to verify required volumetric proportioning.
   2. A mixed material check to verify proper mixing of components.
   3. Curing cycle test to verify the proper reaction is under way.
      a. At least a pint sample is to be utilized.
      b. First Durometer results should be determined within 15 minutes.

C. All surfaces receiving the coating shall be visually dry and at least 5 degrees Fahrenheit (3 degrees Centigrade) above the dew point prior to starting the installation to prevent moisture entrapment:
   1. The relative humidity must be below 85 percent.
   2. Test surfaces to be coated in accordance with ASTM D4263.
      a. Test method for indicating moisture in concrete is by the plastic sheet method.

D. Compressed air used for coating application shall be clean and free of oil and water.

E. Use primer only at direction of, and as recommended by coating manufacturer’s technical services representative.

F. Materials conditioning:
   1. Perform in accordance with manufacturer’s latest published data.
   2. Control temperature in order to produce a repeatable finished product on each application.

G. Deposition of materials: Apply coating to be monolithic and cohesive in nature and to minimize hand work repair.
   1. Provide a smooth uniform coat without drips or sags.

H. Leading edges: Install a mechanical anchor for the leading edge of the applied coating material:
   1. Leading edge mechanical anchor shall consist of a saw cut to a minimum depth of 1/4 inch and width of 1/8 inch.
   2. Sharp edges of the saw cut shall be rounded, dried, and cleaned of debris.
   3. After cleaning, apply coating into the saw cut, taking care to penetrate to full depth. The use of a trowel or putty knife might be required.
   4. After installation of the leading edge, topcoat the area.
      a. Tape-off adjacent areas not scheduled for coating and protected from overspray.

I. Curing:
   1. Protect finished coating from damage during curing.
   2. Cure coatings as recommended by coating manufacturer for a minimum of 7 days before coated areas are placed in service.

J. Cleanup: Clean spillage and overspray from adjacent surfaces as recommended by coating system manufacturer.

3.03 INSPECTION AND TESTING

A. The following inspection equipment (or engineer accepted equal) shall be provided and utilized for performing quality control testing:
   1. Sling psychrometer.
   2. Surface temperature thermometer.
   3. Ambient temperature thermometer.
   4. Psychrometric charts for determining relative humidity and dew point.
   5. High range wet and dry film thickness gauges.
   6. Micrometer.
   7. Durometer: A scale.
   8. Sample cans.
   9. Inspection glass: 30 power minimum.
   10. High voltage holiday detector.

B. The following quality control tests shall be performed, with results recorded and made available to Engineer:
   1. Compressed air quality in accordance with blotter test.
   2. Environmental conditions prior to coating application, including substrate temperature, ambient temperature, relative humidity, and dew point.
   3. Observation of surface preparation, including anchor pattern prior to coating application.
   4. Results of ratio check of plural component proportioning equipment.
   5. Wet and dry film thickness measurements.

C. Owner, Engineer, and coating manufacturer’s technical representative shall be given sufficient notice so as to be present when the following hold points are reached:
   1. Completion of surface preparation.
   2. Prior to coating application.
   3. During wet and dry film thickness measurements.
   4. During holiday detection testing.
   5. During coating repairs.

D. Surface cleanliness, pH condition:
   1. Use either pH paper or a pH meter to determine the pH of the concrete surface.
   2. A pH range of 5 to 9 is considered acceptable.

E. Enlist the aid of various tests and implement those tests to verify the integrity of the applied coating.
   1. Permit Owner, Engineer, and coating manufacturer's technical representative full access at all times to observe and be satisfied that the specification is being followed.

F. Wet film thickness shall be monitored throughout the coating installation by means of frequent measurements with a high-range wet film thickness gauge.

G. All layers of material shall be applied the same day. This procedure is to ensure minimization of contamination of the coating:
   1. If project is not completed, then at the end of the workday, a 3- to 12-inch "returning edge" of material will be left tapered to the substrate for the start of the next working day.
   2. The "returning edge" shall be cleaned with MEK before proceeding to spray on start up to the following workday.

H. Coating shall be 100 percent electronically tested using high voltage in accordance with NACE procedure SP0188 inspected for discontinuities to include pinholes, voids, and mechanically damaged areas.
   1. Any damaged areas, faulty areas, or discontinuities (pinholes) found during holiday detection within a 24-hour (within recoat window) period of application shall be corrected as follows:
      a. Damaged or faulty areas (i.e., impact damage, off-ratio application):
         1) Clean area thoroughly, extending at least 6 inches beyond damaged area with MEK dampened cloth.
         2) Do not apply excessive MEK to repair area, the intent is to clean only.
         3) Allow MEK to thoroughly dry.
         4) When thoroughly dry to touch, spray area with coating to the specified thickness, feathering material into existing coating.
         5) In the event that the damaged area exhibits a discolored substrate substandard to the specified requirements, these areas shall receive the same degree of surface preparation required by the original project specifications prior to application of the coating material.
      b. Discontinuity (pinhole) repair:
         1) Clean the immediate area around the detected discontinuity with MEK dampened cloth (do not apply excessive MEK to pinhole area, the intent is to clean only), allow MEK to thoroughly dry.
         2) Hand apply (putty knife, etc.) a small amount of mixed material directly to the pinhole.
         3) For pinhole repairs, hand mix and thoroughly blend a small amount (normally 2 or 3 ounces at a time, for each applicator) of Part A and Part B in correct ratios.
   2. Any damaged areas, faulty areas, or discontinuities (pinholes) found during holiday detection inspection after 24 hours of coating installation (exceeding recoat window) shall be corrected as follows:
      a. Damaged or faulty areas (i.e., impact damage, off-ratio application, etc.):
         1) Abrade the surface using a power grinder and/or power steel grinding brush down to and including exposed bare concrete to roughen the surface and to prepare the substrate to the original standard.

2) Abraded areas shall extend at least 6 inches (15 centimeter.) beyond damaged or faulty area.
3) After abrading the surface, vacuum or blow down with clean, dry compressed air thoroughly to remove all loose particles.
4) Clean the area thoroughly, extending at least 6 inches (15 centimeter) beyond the damaged area with MEK dampened cloth (do not apply excessive MEK to pinhole area, the intent is to clean only), allow MEK to thoroughly dry.
5) When thoroughly dry to touch, spray area with coating to the specified thickness, feathering the material into the existing prepared coating.

b. Discontinuity (pinhole) repair:
1) Abrade (hand sand or power tool clean) the immediate areas around the detected pinhole (1/2-inch radius from edge of discontinuity) to establish a roughed surface, and to prepare the substrate to the original standard, followed with vacuuming or blow down with clean, dry compressed air to remove loose particles.
2) After dust removal, wipe abraded area with MEK dampened cloth.
3) Do not apply excessive MEK to pinhole area.
4) The intent is to clean only. Allow MEK to thoroughly dry.
5) Hand apply (putty knife, etc.) a small amount of mixed material directly to the pinhole.
6) For pinhole repairs, hand mix and thoroughly blend a small amount (normally 3 ounces at a time for each applicator) or Part A and Part B in correct ratios.

3.04 REPLACEMENT OF REMOVED ITEMS

A. Clean and recoat items removed from work areas prior to commencing work such as piping, pipe hangers, and associated equipment replace in like manner as removed.

3.05 FINAL INSPECTION AND ACCEPTANCE

A. Final inspection:
1. Following replacement of previously removed items, a final inspection of the repaired and coated structures shall be made by Engineer, Owner, Contractor, and the coating manufacturer’s technical representative.
2. Any damage that has occurred to the coating shall be repaired in accordance with the coating manufacturer’s instructions.

END OF SECTION

SECTION 11312K

SUBMERSIBLE MEDIUM CAPACITY CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Submersible pump with features scheduled in the Pump Schedule.
   2. Fiberglass pump base, pump discharge elbows, and guide rail brackets.
   3. Tag numbers: As specified in Pump Schedule.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
   5. B148 - Standard Specification for Aluminum-Bronze Sand Castings.
   6. B505 - Standard Specification for Copper Alloy Continuous Castings.
   7. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
   8. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   9. F594 - Standard Specification for Stainless Steel Nuts.

C. CSA International (CSA).

D. FM Global (FM).

E. Food and Drug Administration (FDA).

F. Hydraulic Institute (HI):
   1. 9.1-9.5 - Pumps - General Guidelines.
   2. 11.6 - Rotodynamic Submersible Pump Tests.
   3. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
   4. 14.3 - Rotodynamic Pumps for Design and Application.

G. Insulated Cable Engineer’s Association (ICEA).

H. National Electrical Code (NEC).

I. National Electrical Manufacturers Association (NEMA).

J. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
   1. Allowable Operating Region (AOR): The region over which the service life of the pump is not seriously compromised by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
   2. Preferred Operating Region (POR): The region over which the service life of the pump will not be significantly affected by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
   3. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 9.1-9.5, 11.6,14.1-14.2, 14.3, and as modified in this Section.
   4. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; when multiple suction pressure taps are used, average pressure shall be suction head regardless of variation in individual taps.
   5. Tolerances: As stipulated in the listed HI standards, unless specified more restrictively.

1.04 DELEGATED DESIGN

A. Anchoring and bracing.

B. Rotordynamic analysis.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

C. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer's representative qualifications.
      b. Certificates:
         1) Requirements as specified in this Section.

c. Test Plans:
    1) Test requirements as specified in this Section.
d. Test Reports.
e. Manufacturer's representatives field notes and data.
f. Owner Training.

D. Product Submittals:
1. As specified in Section 01601 - Product Requirements.
2. Product data.
3. Shop Drawings.
4. Manufacturer's instructions.
5. Calculations.
6. Schedules.

E. Operation and maintenance manuals:
1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01601 - Product Requirements, Section 15050 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Submersible pumps: One of the following, no equal:
1. Xylem Flygt: NP series.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Submersible sump pumps with components: Pumps, drivers, motors, base elbows, guide rails and lifting devices, electrical devices internal to pump housing, submersible cabling for power and control conductors, and other items as required for a complete and operational system.

B. Design requirements:
1. Pump performance characteristics:
    a. As specified in the Pump Schedule.
    b. Rotordynamic analysis level: As scheduled and as specified in Section 15050 - Common Work Results for Mechanical Equipment.
    c. Required conditions (flow/head) shall be within the pump manufacturer's Allowable Operating Range (AOR).
    d. Performance tolerances shall be the same as the test tolerances specified in Section 15958 - Mechanical Equipment Testing.

2. Motor characteristics: As specified in Pump Schedule.

C. Product requirements: As specified in Section 01601 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 MATERIALS

A. General: When materials are referenced in this Section or on the pump schedule, the compositions shall be the UNS Alloys, Types, or Grades in this Article unless specified or scheduled otherwise.

B. Cast iron: ASTM A48, Class 35 B minimum.

C. Nickel cast iron: ASTM A48, Class 35 minimum with 3 percent nickel added.

D. Steel: ASTM A108, Grade or UNS Alloy as specified or scheduled.

E. Stainless steel: ASTM A276 or ASTM A582, Type or UNS Alloy as specified or scheduled.

F. Bronze: ASTM B505 or ASTM B584, UNS Alloy C83600.

G. Zincless bronze: ASTM B505 or ASTM B584, Leaded Tin Bronze, UNS Alloy C92700.

H. Aluminum bronze: ASTM B148, ASTM B505 or ASTM B584, UNS Alloy C95200.

I. Fasteners: Stainless steel, ASTM F593 or ASTM F594, type or grade as specified.

2.04 GENERAL PUMP CONSTRUCTION

A. Pump shall be an overhung impeller, close-coupled, single-stage, volute-style, end-suction submersible unit, capable of handling raw unscreened sewage, stormwater and other solids-laden fluids without clogging.

2.05 PUMP AND MOTOR CASING

A. Type: Watertight, air-filled.

B. Material: Cast iron (minimum).

C. Design working pressure: Minimum 1.10 times maximum shutoff total dynamic head with maximum diameter impeller at maximum operating speed plus maximum suction static head or minimum 20 pounds per square inch gauge.

D. O-ring seals: Capable of sealing mated surfaces (major components) watertight; with the following features:
   1. Machined surfaces and grooves.
   2. O-ring contact on 4 surfaces and O-ring compression on 2 surfaces.

3. Does not require specific fastener torque or tension to obtain watertight joint.
4. Does not require secondary sealing compounds, gasket, grease, or other devices.

E. Testing: Perform 5-minute hydrostatic test of pump casing at minimum 1.5 times Design Working Pressure.

2.06 IMPELLERS

A. General:
   1. Water passages: Smooth enough to prevent clogging by stringy or fibrous materials.
   2. Passage sizes: Large enough to pass solids with sphere size of 3 inches or smaller for motors larger than 2 horsepower.
   3. Casting: 1 piece, free of cracks and porosity.
   4. Balance vanes: On impeller back shrouds.
   5. Method for securing impeller to shafts:
      a. For pumps 5 horsepower and less, secured by bronze nut or Allen head bolt locked in place, but readily removable without the use of special tools.
      b. For pumps greater than 5 horsepower, keyed to the shaft and secured by bronze nut or Allen head bolt locked in place, but readily removable without the use of special tools.

B. Rotation: As indicated on the Drawings; clockwise looking from top when not indicated.

C. Balance: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

D. Vibration criteria: As specified in Section 15958 - Mechanical Equipment Testing.

E. Type: As specified in the Pump Schedule:
   1. Standard impeller and insert ring:
      a. Material: A 532 alloy III A (25% chrome).
      b. Dynamically balanced, double-shrouded, multi-vane, non-clog design.
   2. Flygt-supplied pumps:
      a. N-style impeller:
         1) Material: Cast iron, Class 35B.
         2) Dynamically balanced, semi-open, multi-vane, backswept, non-clog design.
         3) Impeller vane leading edges shall mechanically self-clean as they pass a spiral groove located on the volute section.
         4) Impeller vanes shall have a screw-shaped leading edge hardened to Rockwell HRc 45.

2.07 WEAR RINGS

1. Impeller wear ring:
   a. Material: Type 316 stainless steel.
   b. Heat-shrunk fitted onto the suction inlet of the impeller.
   c. Flygt N impeller: Part of replaceable suction cover.

2. Wear plate system:
    a. Material: Cast iron, ASTM A48, Class 40, with a minimum Brinell Hardness of 250.
    b. Attached to the pump volute to prevent rotation.
    c. Replaceable and adjustable to maintain proper clearances between the wear plate and the impeller.

2.08 PUMP SHAFTS

A. Material: Type 420 stainless steel; turned, ground, and polished.

B. Features:
    1. Strength: Able to withstand minimum of 1.5 times maximum operating torque and other loads.
    2. Resonant frequency: As specified in Section 15050 - Common Work Results for Mechanical Equipment and Section 15958 - Mechanical Equipment Testing.
    3. Maximum deflection: Minimum 0.002 inches under operating conditions.

C. Tapered to fit at impeller with key and bolt for securing impeller.

D. Pump and motor shaft shall be a solid continuous shaft.

2.09 BEARINGS

A. Pump shaft shall rotate on a minimum of 2 permanently sealed, grease-lubricated bearings:
    1. Upper bearing for radial forces shall be self-aligning spherical roller type.
    2. Lower bearing for combined axial and radial forces shall be angular contact ball type.

B. Bearing type: Anti-friction in accordance with ABMA standards.

C. Bearing lubrication system shall be sized to safely absorb heat energy normally generated in bearing under maximum ambient temperature of 60 degrees Celsius.

D. Bearing life: One of the following, whichever provides longer bearing life in intended service:
    1. Minimum ABMA 9 or 11, L10 bearing life of 50,000 hours at rated design point.
    2. Minimum 24,000 hours at bearing design load imposed by pump shutoff with maximum sized impeller at rated speed.

2.10 SHAFT SEALS

A. Upper seal unit material: 1 stationary tungsten-carbide ring and 1 positively driven rotating carbon ring or tungsten-carbide ring.

B. Lower seal unit material: 1 stationary and 1 positively driven rotating tungsten-carbide ring.

C. Features:
   1. Tandem arrangement running in an oil chamber.
   2. Design oil chamber to ensure that air is left in the oil chamber to absorb the expansion of the oil due to temperature variations.
   3. Oil in oil chamber shall be FDA approved, paraffin-type, colorless, odorless, and non-toxic.
   4. Independent spring system between seal interfaces able to withstand maximum suction submergences.
   5. Does not require pressure differential to effect sealing.
   6. Does not use pumped media for lubrication.
   7. Lower mechanical seal effectively lubricated from oil chamber housings.
   8. Not damaged when pump is run dry (unsubmerged) for extended periods.
   9. Springs and other hardware: Stainless steel, Type 300 or 400 series.

2.11 DISCHARGE BASE AND ELBOW

A. Materials: Same as pump casing.

B. Features:
   1. Structurally capable of firmly supporting guide rails, discharge piping, and pumping unit under operating conditions.
   2. Integral support legs or pads with bolting to sump floor provisions: 1 or more.
   3. Incorporates 90-degree flanged elbow that receives horizontal flow from pump and discharges flow vertically.
   4. Discharge interface:
      a. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal-to-metal watertight contact.
      b. Self-aligning without having to enter the wet well.
      c. Discharge elbow to mate to pump discharge and transition to discharge piping.

2.12 GUIDE RAIL BRACKETS, FASTENERS, AND LIFTING CHAIN FOR EACH PUMP

A. Dual pipes that extend from discharge base to upper bracket unless scheduled otherwise.
   1. Provided and installed by Contractor.
   2. Material: 316 stainless steel.
   3. Diameter: 2-inch.
      a. Coordinate with pump manufacturer prior to purchasing.
   4. Wall Thickness: Schedule 40.

B. Integral, self-aligning, guide rail sliding brackets that seal pump to discharge base under operating conditions.
   1. Provided by pump manufacturer.
   2. Installed by Contractor.
   3. Material: Type 316 stainless steel.

C. Upper guide rail bracket.
   1. Provided by pump manufacturer.
   2. Installed by Contractor.
   3. Material: Type 316 stainless steel.

D. Intermediate guide rail brackets where indicated on the Drawings or at 10-foot maximum intervals.
   1. Provided by pump manufacturer.
   2. Installed by Contractor.
   3. Material: Type 316 stainless steel.

E. Lifting chain of sufficient strength and length to permit safe removal of pump unit from sump.
   1. Provided by pump manufacturer.
   2. Installed by Contractor.
   3. Material: Type 316 stainless steel.
   4. Length: As recommended by pump manufacturer to accommodate for pump installation depth and recommended slack.

2.13 DRIVERS

A. Horsepower:
   1. As scheduled.
   2. Listed driver horsepower is the minimum to be supplied.
      a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
      b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
      c. Make structural, mechanical, and electrical changes required to accommodate increased horsepower.

B. Motors:
   1. Revolutions per minute (rpm): As scheduled:
   2. Enclosure: As scheduled.
   3. Electrical characteristics: As scheduled.

C. Motor construction:
   1. Squirrel cage induction motor, shell type design.
   2. If explosion-proof motor is scheduled, provide motor that is UL or FM listed for NEC Class I, Division 1, Groups C and D service, whether submerged or unsubmerged.
   3. NEMA design type: B.
   4. Motor insulation, either one:
      a. Class F, moisture resistant, rated for 155 degrees Celsius.
      b. Class H, moisture resistant, rated for 185 degrees Celsius.
   5. Designed for continuous duty handling pumped media of 40 degrees Celsius and capable of a minimum of 15 evenly spaced starts per hour.
   6. Capable of continuous operation under load with the motor submerged, partially submerged, or exposed, without derating the motor.
   7. Motor cooling, one of the following:
      a. Motor cooled by the surrounding media.
      b. Cooling jacket:
         1) Non-clogging ports and channels that use pumped fluid as the cooling media.

2) Functional with motor submerged, partially submerged, or exposed.
3) Provide capability to relieve entrapped air from the system.

c. Spray systems, air moving equipment or other secondary cooling systems are not acceptable.

8. Motor sealing: Design motor case and seals to withstand 65 feet of submergence.
9. Coordinate motors with the variable frequency drive manufacturer to ensure compatibility between the motor and variable frequency drive. Other drivers: As scheduled and as specified in sections listed in the Pump Schedule.

D. Power and control cables:
1. Submersible to same water depth as motor casing.
2. Type SPC with Hypalon/Buna N or chloroprene rubber jacket.
3. Insulation rated for 90 degrees Celsius.
4. Non-wicking fillers.
5. Length: Sufficient to connect to surface junction box (without the need of splices) as indicated on the Drawings or 30 feet, whichever is greater.
6. Power and control conductors shall terminate at terminal blocks in the local control panel or junction box.
7. Sized in accordance with NEC, ICEA, and CSA specifications.
8. Provide stainless steel cable and stainless steel wire braid sleeve to support power cable from underside of wet well roof slab or access frame.

E. Cable entry/junction chamber:
1. Cable entry seal design shall not require specific torque requirements to insure a watertight and submersible seal.
2. Cable entry seal shall consist of a single cylindrical elastomer grommet, flanked by stainless steel washers.
3. Entry body shall perform compression and strain relief that is separate from the sealing function.
4. Cable entry junction chamber shall be separate from the motor chamber to prevent foreign material from gaining access to the motor interior through the top of the pump.

F. Control/protection module:
1. Each pump shall be supplied with its own self-contained control/protection module to provide for the direct connection to internal pump monitoring devices, including:
a. Thermal protection: Provide automatic reset motor stator temperature detectors, 1 switch in each phase winding. If any detector is activated, the sensor shall activate an alarm and shut down the motor. Thermal detectors shall activate when the stator temperature exceeds 125 degrees Celsius.
b. Moisture detection: One of the following:
1) Provide capacitive type leakage sensor for the detection of water in the oil chamber or a moisture sensor in the lower motor chamber to detect any fluid in the motor. Sensor shall have an explosion-proof rating.
2) Provide a small float to detect the presence of water in the stator chamber.

2. Module shall signal an alarm condition if any of the internal monitoring devices is activated.
3. Furnish the modules to Contractor for installation in control panels not provided by the manufacturer.

2.14 INSTRUMENTATION

A. If explosion-proof motor is scheduled, provide intrinsically safe level sensor system.

B. Type:
1. Capacitance level switch as specified in Section 17201 - Level Measurement: Switches.

2.15 ACCESSORIES

A. Fiberglass Reinforced Plastic Pump Base:
1. Fiberglass reinforced plastic self-cleaning pump base for a Flygt pump to be installed in pump station wet well. Pump base shall be coordinated with pump supplier and shall accommodate their specifications for a fully functioning system. The flat surface area shall be minimized to an area that is directly influenced by the pump suction and must be free of obstacles. The bottom surface area must have a preferred ratio of 1:4 as it relates to the cross-sectional area of the pump station. Sloping of the walls of the base shall facilitate self-cleaning by directing all solids, trash, and sludge to the suction of the submersible pumps to facilitate removal and effectively clean the bottom.
2. Manufacturer: One of the following, no equal.
   a. Xylem – Flight
3. Material: Fiberglass reinforced plastic.
4. Wet well interior diameter: 7 feet.
   a. Pump base shall be modified as necessary to accommodate the wet well diameter.
5. Hardware: Stainless steel.

2.16 FINISHES

A. Pump manufacturer to factory prime and coat pump/motor and discharge elbow as specified in Section 09960 - High-Performance Coatings.

B. Contractor to provide touch-up field coatings as specified in Section 09960 - High-Performance Coatings.

2.17 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts: Deliver the following as specified in Section 01601 - Product Requirements:
1. Thrust bearing set.
2. Radial bearing set.
3. Mechanical seal: 1 each size and type.
4. O-ring set.

5. Power cable entry seal set.
6. Wear ring set (rotating and stationary).

B. Deliver 1 set of special tools required for complete assembly or disassembly of pump system components for each type or size of pump specified.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
2. Install anchors of type and material indicated on approved anchoring designs.
3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. Fiberglass reinforced plastic pump base shall be installed per manufacturer's requirements.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing (Factory Acceptance Tests):
1. Not witnessed.
2. Furnish test reports and Manufacturer's Certificate of Source Testing.
3. Equipment Testing:
a. Pump:
1) Performance test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
2) Vibration test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
3) Noise test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
4) Pump casing: Hydrostatic pressure tests if specified in this Section.

C. Installation Verification:
1. Furnish Manufacturer's Certificate of Installation Verification.

D. Functional Testing:
1. Equipment testing:
a. Pump:
1) Performance test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.

2) Vibration test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
3) Noise test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.

E. Owner Training:
1. Perform Owner training as specified in Section 01756 - Commissioning.
2. Number of sessions:
a. Operations and Maintenance: 1.

3.04 PUMP SCHEDULE

Tag Numbers	PMP-101 and 102
General Characteristics:	
Service	Wastewater
Quantity	2
Maximum Noise, dBA at 3 Feet	Not required
Minimum Pumped Fluid, Degrees Fahrenheit	55
Normal Pumped Fluid, Degrees Fahrenheit	70
Maximum Pumped Fluid, Degrees Fahrenheit	80
Rotordynamic Analysis Level	None
Vibration Analysis Expert	Not required
Installation Configuration	Wet Pit
Pump Characteristics:	
Impeller Type	N
Pass Minimum Sphere Size, Inch	3
Speed Control	Fixed
Maximum Pump Speed, rpm	3,600
Minimum Pump Speed, rpm	N/A
Rated Design Point (at Maximum rpm):	
Flow, gpm	123
Head, Feet	51
Minimum Hydraulic Efficiency, Percent	45
Maximum active input horsepower	4
Required Condition 2 (at Maximum rpm):	
Flow, gpm	80
Head Range, Feet	62
Minimum Hydraulic Efficiency, Percent	N/A

Tag Numbers	PMP-101 and 102
Required Condition 3 (at Maximum rpm):	
Flow Range, gpm	160
Head, Feet	44
Minimum Hydraulic Efficiency, Percent	N/A
Other Conditions:	
Maximum Shutoff Head, Feet	79
Maximum NPSHr at Every Specified Flow, Feet	25
Minimum Suction Static Head, Feet	0.5
Maximum Suction Static Head, Feet	10
Minimum Discharge Size, Inches	3
Motor Characteristics:	
Minimum Submergence	Exposed
Maximum Driver Speed, rpm	3,600
Motor Horsepower, Minimum	4
Voltage/Phases/Hertz	460/3/60
Service Factor	1.15
Starting Current, Amperes	20.7
Rated Current, Amperes	9.9
Motor Efficiency (At 100-Percent Load), Minimum	92
Enclosure Type	Submersible, Explosion-Proof
NEMA Design Type	B
Accessories:	
Fiberglass Reinforced Plastic Pump Base	Required
Hoist	Not required
Source Testing:	
Performance Test Level	1
Vibration Test Level	Not required
Noise Test Level	Not required
Functional Testing:	
Performance Test Level	1
Vibration Test Level	Not required
Noise Test Level	Not required

END OF SECTION

SECTION 13446

MANUAL ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve actuators.
   2. Handwheel actuators.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45 - Designation System for Aluminum Finishes.

B. American Water Works Association (AWWA).

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

D. National Electrical Code (NEC).

1.03 SUBMITTALS

A. Shop drawings: Include shop drawings and product data with associated valve as an integrated unit.

1.04 QUALITY ASSURANCE

A. Provide valve actuators integral with valve, except for valve actuators utilizing T-wrenches or keys, and portable gate actuators intended to operate more than 1 valve.

B. Provide similar actuators by 1 manufacturer.

C. Provide gates and hand operating lifts by 1 manufacturer.

D. Provide hydraulic gate lifts by 1 manufacturer.

E. Provide hydraulic valve actuators and motorized actuators by 1 manufacturer.

1.05 MAINTENANCE

A. Extra materials:
   1. Key operated valve keys or wrenches: Furnish a minimum 4 keys with 4-foot shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot handles for operating key operated valves.

PART 2 PRODUCTS

2.01 VALVE ACTUATORS

A. Valve actuators:
   1. Manual actuators:
      a. Material: Type 316 stainless steel.
      b. Design: Hand lever.
      c. Spring release handle: 12-inch.
      d. Notch plate: 10 position.
      e. Secure with mounting bolts.
      f. Locking device so that valve can be locked in any position with a wing nut.
   2. Stem and cover:
      a. For submerged valves, provide extension stem as indicated on the Drawings.

B. Stem covers:
   1. Aluminum pipe:
      a. Threaded cap on top.
      b. Bolted aluminum flange on bottom.
      c. Slots cut 1 inch by 12 inch at 18 inches on center in front and back of pipe.
      d. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
   2. Ultraviolet light resistant, clear butyrate plastic or polycarbonate pipe:
      a. Capped on the upper end.
      b. Either threaded into the top of the gate operators or held in place by bolt-down aluminum brackets.
      c. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
   3. Staff gauges:
      a. Adhesive-backed mylar, suitable for outdoor service.
      b. Calibrated in hundredths of feet.
      c. Read the weir crest elevations directly.
      d. Gauge range: 1.5 feet minimum.
      e. Indicate the following elevations on each staff gauge:
         1) -0.75, -0.50, -0.25, 0.0, 0.25, 0.50, 0.75.
      f. Supplement with a stem-mounted pointer or indicator that permits direct observation of the weir gate crest elevation.
      g. Apply staff gauges to each stem cover after installation of the cover and after calibration and testing of the weir gates.
      h. Set gauges precisely by a survey crew using instruments acceptable to the Engineer.

C. Stem cover flanges, pipes and caps:
   1. After fabrication, etch and anodize to produce the following chemical finishes in accordance with AA publication DAF-45:
      a. A 41 - Clear Anodic Coating.
      b. C 22 - Medium Matte Finish.

D. Gate stem covers: Concentric with stem.

E. Position indicators:
   1. For all aboveground worm gear or traveling nut manual actuators, provide position indication on the actuator enclosure.
   2. Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.

F. Manual or power actuator size:
   1. Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.

G. Actuator size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.

H. Provisions for alternate operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve actuators or lifts for alternate operation with tripod mounted portable gate actuators.

I. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.

J. Open direction indicator: Cast arrow and legend indicating direction to rotate actuator on handwheel, chain wheel rim, crank, or other prominent place.

K. Buried actuator housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between actuator housing and valve body so that no moving parts are exposed to soil; provide actuators with 2-inch square AWWA operating nut.

L. Worm gear actuators: Provide gearing on worm gear actuators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.

M. Traveling nut actuators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual actuators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

2.02 HANDWHEEL ACTUATORS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   2. Waterman Industries, Inc.

B. Coating: Handwheel as specified in Section 09960 - High-Performance Coatings.

C. Bearings above and below finished threaded bronze operating nut: Ball or roller.

D. Wheel diameter: Minimum 24 inches.

E. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.

F. Pull to operate: Maximum 40 pounds pull at most adverse design condition.

G. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.

H. Grease fittings: Suitable for lubrication of bearings.

2.03 ACCESSORY EQUIPMENT

A. Stems: Stainless steel; sized to match output of actuator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.

B. Stem couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.

C. Stem stuffing boxes: Cast-iron, with adjustable gland and packing.

D. Fasteners: Type 316 stainless steel.

E. Anchor bolts: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry except that the material shall be Type 316 stainless steel.

F. Geared valve actuators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.

G. Geared valve traveling nut actuators: Acceptable only where specified or indicated on the Drawings.

H. Accessory equipment for valves and gates requiring remote actuators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

PART 3 EXECUTION

3.01 SCHEDULES

A. Geared actuators: Provide geared actuators for following valves:
   1. Plug valves 6 inches, nominal size, and larger.

B. Handwheel actuators: Provide handwheel actuators for valves mounted 6 feet or less above floors.

C. Chain wheel actuators: Provide chain wheel actuators for valves mounted more than 6 feet to centerline above floors.

END OF SECTION

SECTION 15050

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mechanical equipment requirements for:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation requirements.

1.02 REFERENCES

A. American Bearing Manufactures Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. American Gear Manufacturer's Association (AGMA) Standards.

C. ASTM International (ASTM):
   1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   2. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   3. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   4. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   5. F594 - Standard Specification for Stainless Steel Nuts.

D. Hydraulic Institute (HI):
   1. 9.6.8 - Guideline for Dynamics of Pumping Machinery.

E. International Concrete Repair Institute (ICRI):
   1. Guideline No. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

F. International Organization for Standardization (ISO):
   1. 21940 - Mechanical Vibration - Rotor Balancing - Part 1: Introduction.

G. National Electrical Manufacturers Association (NEMA):
   1. MG-1 - Motors and Generators.

H. Society for Protective Coatings (SSPC):
   1. SP-1-Solvent Cleaning.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Definitions used in this specification and equipment Submittals for terms related to rotor-dynamic pumps shall be in accordance with HI 9.6.8, Appendix A, as clarified below.
   2. These definitions shall be applied to equipment other than pumps, unless otherwise specified in Technical Sections.
   3. Rotordynamic Analysis Level:
      a. The level of detail required for rotordynamic analysis is indicated in the Technical Sections schedules as None (no analysis required), Analysis Level 1, Analysis Level 2, or Analysis Level 3, which correlate to increasing levels of required detailed equipment design analysis. Analysis Levels 1, 2, and 3 are based on HI 9.6.8.
      b. Where these specifications differ from HI the more stringent shall apply.
   4. Resonant Frequency:
      a. The frequency of a periodic excitation force that is close to the natural frequencies of an object. Also known as critical frequency, critical speed, or resonant speed.
      b. An undamped resonant frequency within the separation margin is always considered harmful under Level 1 analysis.
      c. A resonant frequency that occurs within a separation margin of 15 percent above or below the operating speed range and has a log decrement greater than +0.3 is considered harmful under Level 2 and Level 3 analysis.
   5. Separation Margin:
      a. The span of operating speeds within which interference between excitation orders and resonant frequencies indicate the possibility of harmful vibrations.
      b. The separation margin for a specific application extends 15 percent above and 15 percent below the span of operating speed required for the specified performance conditions.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination.
   1. Show roof penetrations for mechanical equipment on roof drawing Submittal and include mechanical equipment information:
      a. Type.
      b. Size.
      c. Location.
      d. Configuration of penetration and the surround.
      e. Weight.
      f. Anchoring and support details.

1.05 SUBMITTALS

A. Items in this Section are components of equipment or systems specified in other sections.
   1. Include data for this Section’s components with the equipment or system Submittal.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General:
   1. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries to provide a complete, operable unit.
   2. Manufacturer shall analyze all rubber-bearing vertical-column pumps, and equipment identified as non-reversing in the Technical Sections for reverse rotation and provide non reversing motor ratchets.
   3. Equipment that prevents reverse rotation shall be capable of both:
      a. Handling 150 percent of the maximum torque at maximum operating speed.
      b. 150 percent of torque that will be generated in reverse direction due to equipment shutoff head as calculated by the manufacturer.
   4. The motor shall be designed to run safely in the reverse direction at up to 140 percent times the reverse runaway speed under shutoff head conditions.

B. Rotordynamic analysis and vibration testing:
   1. Submit information for the Rotordynamic Analysis Level specified for each piece of equipment as shown in the Technical Sections prior to manufacture of the equipment.
   2. Rotordynamic analysis shall be performed on “like-new” and “as-worn” conditions, representing conditions when first installed and conditions when parts wear to the manufacturer's maximum allowable operating tolerances. Conditions assumed for the “as-worn” condition shall be 2 times the “like-new” tolerances unless specified otherwise.
   3. Rotordynamic analysis criteria:
      a. Torsional excitation forcing function magnitudes shall be no less than 1 percent of the maximum transmitted torque at given speed.
      b. Motor mass elastic information in accordance with NEMA MG-1 shall be obtained from the original equipment manufacturer and included in the analysis. Motors shall be precision balanced to ISO 21940 grade G2.5.
      c. Bearings:
         1) At maximum bearing loads an L-10 life of 100,000 hours in accordance with ABMA 9-11 to be proven.
   4. Submit factory and field testing requirements as specified in the Technical Sections and specified in Section 15958 - Mechanical Equipment Testing after manufacture and installation respectively.
   5. Repair, replace, and modify equipment exhibiting vibration performance that does not meet criteria specified in this Section at no additional cost to Owner.
      a. Acceptable remedies include adjustments to equipment component geometry, materials, energy absorbing couplings, etc.
      b. Locking out speed interval(s) within equipment specified operating range is unacceptable.
   6. Vibration analysis expert:
      a. Provide vibration analysis expert when specified in the equipment Technical Sections.
         1) The vibration analysis expert must be a 3rd party, unaffiliated with the equipment vendor or Contractor.

b. The vibration analysis expert, and analysis shall be provided by one of the following or equal:
    1) Mechanical Solutions, Inc. (MSI, New Jersey).
    2) Engineering Dynamics Inc. (EDI, Texas).
c. The analysis shall be:
    1) Stamped by a registered professional mechanical Engineer.
    2) Verified in-situ by the vibration analysis expert including certification that installation conforms to field conditions assumed in the reports.
    3) Verified in-situ by the vibration analysis expert including witness of at least 1 field vibration test, and certification that vibration measurements corroborate the rotordynamic analysis.
    4) Supplemented with additional field investigation and analysis should conditions during field vibration testing activity indicate non-compliance with these specifications; supplemental field investigation and analysis shall indicate remedies to comply with the specifications and shall be stamped by a registered professional mechanical Engineer.

7. Rotordynamic Analysis Level 1:
    a. Before the equipment is released for manufacture it shall be determined that the equipment/motor structures do not have any harmful resonant frequencies in the lateral and torsional modes. Representative analysis results for identical equipment may be submitted.
    b. Calculate rotor lateral and torsional and equipment structural components' lateral frequencies with a spreadsheet calculation or finite element analysis software.
        1) Equipment structure lateral frequency shall include the motor.
        2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
    c. Determine the equipment system components (rotor and structure) resonant frequencies.
    d. An intersection of an equipment component resonant frequency with the 1x run speed excitation order that occurs within separation margin is unacceptable.
8. Rotordynamic Analysis Level 2:
    a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
    b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
        1) Equipment structure lateral frequency shall include the motor.
        2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
        3) The rotational inertia of water within the impeller, in the wet well and inside the equipment structure, e.g., the column of a vertical pump, shall be included in the calculation at both the high level and low level conditions.
    c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.

d. Forced damped analysis:
    1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
    2) Forced torsional analysis shall include not less than 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
    3) The equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
        a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
        b) Variable torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
        c) Submit documentation of material fatigue limit.

e. Report Submittals:
    1) Confirmation of compliance with this Section, or detailed exceptions taken.
    2) Software used for analysis.
    3) Results with interpretation.
    4) Preparer's professional engineering stamp and seal.
    5) Input data including component properties, materials and connectivity to other components.
    6) Schematic diagram of model mode shapes, nodes and elements.
    7) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.
    8) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
        a) Campbell diagram shall include equipment operating range; excitation lines at 1x, 2x run speed, and vane pass (or equivalent); and critical speeds associated with equipment system components including the rotor, each major equipment structural component and the motor.
    9) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.

9. Rotordynamic Analysis Level 3:
    a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
    b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
        1) Equipment structure lateral frequency shall include the motor.
        2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
        3) The rotational inertia of water within the impeller, in the wet well and inside the equipment structure, e.g., the column of a vertical pump,

shall be included in the calculation at both the high level and low level conditions.

c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.

d. Forced damped analysis:
   1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
   2) Forced torsional analysis shall include 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
   3) The equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
      a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
      b) Variable Torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
      c) Submit documentation of material fatigue limit.

e. Report Submittals:
   1) Report 1: Executive Summary including:
      a) Confirmation of compliance with this specification section, or detailed exceptions taken.
      b) Software used for analysis.
      c) Results with interpretation.
      d) Preparer's professional engineering stamp and seal.
      e) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
         (1) Campbell diagram shall include equipment operating range; excitation lines at 1x, 2x run speed, vane pass (or equivalent), line- and twice-line frequency, motor-pole frequency, torsional harmonics from reciprocating drivers (including up to 6 times operating speed), control pulse frequencies induced by VFDs (with certification from VFD manufacturer of frequencies up to 24 times motor running speed), any torque harmonic greater than 1 percent of steady torque at primary excitation, and synchronous motor requirements; and critical speeds associated with equipment system components including the rotor and each major equipment structural component.

f) Report 1 shall not include detailed analysis elements listed for Submittal under Report 2 below, Submittal of full analysis details in Report 1 is unacceptable.
g) Following Submittal of Report 1, submit Report 2: Detailed Analysis including responses to comments made on Report 1: Rotor-dynamic Executive Summary.

2) Report 2: Rotor-dynamic Detailed Analysis including:
a) Input data including component properties, materials and connectivity to other components.
b) Schematic diagram of model mode shapes, nodes and elements.
c) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.
d) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.
e) Synchronous motor information including time-integration study results showing transient peak stresses at startup, shutdown and motor control transient events. Provide tomographic diagrams including root and keyway stress concentration locations and the corresponding speeds that result in reported peak stresses.

2.02 POWER TRANSMISSION SYSTEMS

A. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints:
1. Rated for 24 hour-a-day continuous service, or for intermittent service with frequent stops-and-starts, whichever is most severe.
2. Sized with a service factor of 1.5 or greater:
a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
b. Apply service factors in accordance with AGMA or as specified in the Technical Sections.

2.03 BEARINGS

A. Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
1. Design lubrication system based on the equipment location to operate in the temperatures as specified in Section 01850 - Design Criteria.
a. Design lubrication system to safely start after being shut off for 24 hours and operate safely:
1) Suitable for the outdoor winter temperature as specified in Section 01850 - Design Criteria.

B. Oil-lubricated bearings:
1. Provide either pressure lubricating system or separate oil reservoir splash-type system as specified in the Technical Section.

2. Design oil-lubrication system to safely absorb heat energy generated in bearings when equipment is operating in the following conditions:
    a. With the highest load and the temperature 15 degrees Fahrenheit above the outdoor summer temperature as specified in Section 01850 - Design Criteria.

C. Grease lubricated bearings, except those specified to be factory sealed:
    1. Fit with easily accessible grease supply, flush, drain, and relief fittings.
    2. Lubrication lines and fittings:
        a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
        b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
        c. Use standard hydraulic-type grease supply fittings:
            1) Manufacturers: One of the following or equal:
                a) Alemite.
                b) Zerk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.04 BELT DRIVES

A. Sheaves:
    1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
    2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
    3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
    4. Key bushings to drive shaft.

B. Belts:
    1. Anti-static type when explosion-proof equipment or environment is specified.
    2. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
        a. Where 2 or more belts are involved, furnish matched sets.
        b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
        c. Package in boxes labeled with identification of contents.

C. Manufacturers: One of the following or equal:
    1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
    2. T. B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.05 FLANGED PIPING CONNECTIONS

A. Unless otherwise in the Technical Sections or indicated on the Drawings, provide flat face flanges.

2.06 ASSEMBLY FASTENERS

A. General service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM F593, Alloy Group 2.
   2. Nuts: In accordance with ASTM F594, Alloy Group 2.
   3. Washers: Alloy group matching bolts and nuts.

B. High-temperature service or high-pressure service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM A193, Grade B8M, Class 1, heavy hex.
   2. Nuts: In accordance with ASTM A194, Grade 8, heavy hex.
   3. Washers: Alloy group matching bolts and nuts.

C. Low-temperature service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM A320, Grade B8M, Class 1, heavy hex.
   2. Nuts: In accordance with ASTM A194, Grade B8M, heavy hex.
   3. Washers: Alloy group matching bolts and nuts.

2.07 GUARDS AT HIGH-TEMPERATURE SURFACES

A. Exposed surfaces having an external surface temperature of 120 degrees Fahrenheit or higher and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps or fixed ladders.

B. Cover with a thermal insulating material unless otherwise guarded against contact.
   1. Insulation thickness such that the insulation exterior temperature is below 120 degrees Fahrenheit.

2.08 GUARDS AT MOVING COMPONENTS

A. Provide guards on rotating components that are within 7.5 vertical feet of an operating floor or platform.

B. Allow visual inspection of moving parts without removal.

C. Allow access to lubrication fittings.

D. Easily removable for maintenance.

E. Prevent entrance of rain or dripping water for outdoor locations.

F. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.

G. Materials:
   1. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
   2. Fasteners: Type 316 stainless steel.

2.09 SHOP FINISHES

A. Manufacturer’s standard primer and finish coatings.
   1. Primer only if field coatings are to be applied.

2.10 GEAR MOTORS

A. Parallel shaft drives: Helical gearing.

B. Right-angle drives: Worm gearing.

C. Manufacturers: One of the following or equal:
   1. Baldor Electric Company.
   2. Bodine Electric Company.

2.11 GEAR REDUCTION UNITS

A. Design and performance criteria:
   1. Gear type:
      a. Helical or herringbone.
   2. AGMA Class II service:
      a. Use more severe service condition when such is recommended by unit's manufacturer.
   3. Cast-iron housing with gears running in oil.
   4. Anti-friction bearings.
   5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.

2.12 MOUNTING AND LIFTING PROVISIONS FOR EQUIPMENT

A. Equipment bases and base plates:
   1. Provide equipment bases with machined support pads, dowels for alignment for mating of adjacent items, openings for electrical conduits, and openings to facilitate grouting.
   2. Provide jacking screws in bases and supports for equipment and for equipment weighing 500 pounds or more.
   3. Materials:
      a. Match equipment material or steel.
      b. Coating: Match equipment.

B. Steel support frames:
   1. Carbon steel:
      a. At exterior locations, and at interior wet or moist locations, provide continuous welds on both sides to close seams and edges between steel members.
      b. Grind closure welds smooth.

C. Lifting lugs or eyes:
   1. Equipment units weighing 50 pounds or more:
      a. Provide with lifting lugs or eyes to allow removal with lifting device.

2.13 NAMEPLATES

A. Fastened to equipment at factory in an accessible and visible location.

B. Metal engraved or stamped with text, holes drilled or punched for fasteners.

C. Material: Aluminum or stainless steel.

D. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.

E. Text:
   1. Manufacturer's name, equipment model number, equipment serial number, and identification tag number.
   2. Additional items indicated in the Technical Sections.
   3. Indicate the following additional information as applicable:
      a. Maximum and normal rotating speed.
      b. Service class in accordance with applicable standards.
   4. Include for pumps:
      a. Rated total dynamic head in feet of fluid.
      b. Rated flow in gallons per minute.
      c. Impeller, gear, screw, diaphragm, or piston size.
   5. Include for motors:
      a. Drive speed.
      b. Motor horsepower with rated capacity.
   6. Include for gear reduction units:
      a. AGMA class of service.
      b. Service factor.
      c. Input and output speeds.

2.14 PUMP SHAFT COUPLINGS

A. General:
   1. Type and ratings: Non-lubricated designed for not less than 50,000 hours of operating life.
   2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, balance, and type of service.
   3. Suitable for an ambient temperature range between -40 degrees to +200 degrees Fahrenheit.

B. Close-couplings for electric-motor-driven equipment:
   1. Manufacturers: One of the following or equal:
      a. Lovejoy.
      b. T.B. Woods.
   2. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
   3. Manufacture flexible component of coupling from synthetic rubber or urethane.
   4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
   5. Do not allow metal-to-metal contact between driver and driven equipment.

C. Flexible couplings for direct connected electric-motor-driven equipment:
   1. Manufacturers: One of the following or equal:
      a. Rexnord.
      b. T.B. Woods.
   2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
   3. Provide flexible connecting element of rubber and reinforcement fibers.

4. Provide service factor of 2.0.
5. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer couplings:
1. Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment.

2.15 PUMP SEAL CHAMBER AND SEALS

A. Seal chamber (stuffing box):
1. Large enough to retrofit with double mechanical seal.

B. Seal Types: Based on the following and as specified in the Technical Section:
1. Type 1: Packing:
a. Provide when specified in the Technical Section for wastewater, non-potable water, and sludge applications:
1) Asbestos free.
2) PTFE (Teflon™) free.
3) Braided graphite.
4) Manufacturers: One of the following or equal:
a) Chesterton, 1400.
b) John Crane.
b. Provide when specified for drinking water service:
1) Asbestos free.
2) Material: Braided PTFE (Teflon™).
3) Manufacturers: One of the following or equal:
a) Chesterton, 1725.
b) John Crane.
c. Design:
1) Packing gland to allow adjustment and repacking without dismantling pump except to open up stuffing box.
2) Seal chamber (stuffing box) large enough to retrofit with double mechanical seal.
3) Manufacturers: One of the following or equal:
a) Chesterton, 1725.
b) John Crane.
2. Type 2: Mechanical seal, flushing, cartridge, single O-ring.
a. Manufacturers: One of the following or equal:
1) Chesterton, S10.
2) John Crane, 5610 Series.
3. Type 3: Mechanical seal, flushing, cartridge, double O-ring:
a. Manufacturers: One of the following or equal:
1) Chesterton, S20.
2) John Crane, 5620 Series.
4. Type 4: Mechanical seal, flushing, cartridge, double split-ring:
a. Manufacturers: One of the following or equal:
1) Chesterton, S20.
2) John Crane, 5620 Series.

5. Type 5: Mechanical seal, flushing, cartridge, single split-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 442.
        2) John Crane, 5860.
6. Type 6: Mechanical seal, flushless, cartridge, single split-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 156.
        2) John Crane, 3740 Series.

C. Mechanical seals, Types 2 to 6:
1. Balanced hydraulically.
2. Spring:
    a. Stationary, out of pumping fluid.
    b. Material as specified in the Technical Section. Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
3. O-ring: Viton™ 747.
4. Gland: Type 316L stainless steel.
5. Set screws: Type 316L stainless steel.
6. Faces: Reaction bonded, silicon carbide/carbon.
7. Minimum differential pressures in either direction: 300 pounds per square inch gauge.
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 1400.
        2) John Crane, equivalent product.
8. Drinking water service:
    a. Asbestos free.
    b. Material: Braided PTFE (Teflon™).
    c. Manufacturers: One of the following or equal:
        1) Chesterton, 1725.
        2) John Crane, equivalent product.

D. Flushing system:
1. Provide flushing connections:
    a. 3/4-inch size.
    b. Provide API Standard 682 seal water plan arrangement as specified in the Technical Section:
        1) Plan 11 - Product stream seal water from discharge thru seal.
        2) Plan 13 - Product stream seal water thru seal to suction.
        3) Plan 23 - Closed loop seal water with cooler and pumping ring.
        4) Plan 32 - Production seal water discharged to product stream.
        5) Plan 54 - Production Seal Water Excluded from Product Stream.

2.16 SHIPPING

A. Prior to shipment of equipment:
1. Bearings (and similar items):
    a. Pack separately or provide other protection during transport.
    b. Greased and lubricated.

2. Gear boxes:
    a. Oil filled or sprayed with rust preventive protective coating.
3. Fasteners:
    a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 PRE-INSTALLATION

A. Field measurements:
    1. Prior to Shop Drawings preparation, take measurements and verify dimensions indicated on the Drawings.
    2. Ensure equipment and ancillary appurtenances fit within available space.

B. Sequencing and scheduling:
    1. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
    2. Equipment anchoring: Obtain anchoring material and setting drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

3.02 LUBRICATION LINES AND FITTINGS

A. Support and protect lines from source to point of use.

B. Fittings:
    1. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
    2. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
    3. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.

3.03 ALIGNMENT OF DRIVERS AND EQUIPMENT

A. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after driven equipment has been leveled on its foundation.

B. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
    1. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
    2. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.

C. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.

D. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.

E. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
   1. Allow minimum 48 hours for grout to harden.
   2. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
   3. Correct alignment as required.

3.04 EQUIPMENT SUPPORT AND ANCHORING TO STRUCTURES

A. Anchor equipment to structures as indicated on the Drawings and as specified.

B. Obtain final anchor bolt layouts for equipment prior to:
   1. Detailing reinforcement for equipment pads.
   2. Preparation of Shop Drawings for metal structures supporting equipment.

C. Anchor bolt templates:
   1. Provide templates as specified in the Technical Sections.
   2. Use final anchor bolt layout to construct templates for setting anchor bolts.
   3. Make templates:
      a. Rigid, and non-deformable during use.
      b. With longitudinal axes of anchors parallel.
      c. With longitudinal axes of anchors perpendicular to surface supporting the equipment.
   4. Templates may be reused for multiple locations of the same equipment only if:
      a. Templates are in "like-new" condition prior to each reuse.
      b. The anchor layout has not been deformed or damaged by previous installation, removal, or handling of templates.
   5. Sequence:
      a. Set and support templates prior construction of structures surrounding anchors.
      b. Position anchors in templates to provide designated embedment in supporting structure, with required projection for installation of grout, base plates, and hardware for tightening.
      c. Construct concrete or masonry around anchors using methods that preserve required anchor positions and alignment, and clearances to edges of supports or structures.

D. Anchor adjustment sleeves:
   1. Use of adjustment sleeves around anchors:
      a. Is at the option of the Contractor.

b. Does not relieve Contractor of obligation to construct and use templates for setting of anchors.
c. May required increased anchor embedment length to develop the strength of the anchor in the embedded length below the adjustment sleeve.

2. Submittal requirements for anchor adjustment sleeves:
a. Provide within sufficient time for Engineer approval and not less than 10 working days before setting those items.
b. Proposed locations of sleeves.
c. Details and dimensions of sleeves.
d. Sleeve materials of construction, and coatings.
e. Information on sleeve filler material and means of filler removal.
f. Type, details, and dimensions of anchor bolts or anchor rods to be used with sleeves.
g. Calculations showing development of anchor load capacity below the bottom of the sleeve.
h. Plan for removal of sleeve fillers, if any.
i. Plan for placement and consolidation of flowable grout inside sleeves and to a level equal to top of concrete slab or equipment pad surrounding the sleeve.

3.05 GROUTING UNDER EQUIPMENT BASES, BASE PLATES, SOLE PLATES, AND SKIDS

A. General:
1. Comply with equipment manufacturer's installation instructions including:
a. Tolerances for level.
b. Tolerances for vertical and horizontal alignment.
c. Requirements or recommendations for grouting spaces and grout installation.
d. Recommendations for tightening of equipment anchors after grout has cured.
2. Install equipment over grout as indicated on the Drawings or specified only after:
a. Equipment is leveled and in proper alignment.
b. Piping connections are complete and in alignment with no strain transmitted to equipment.
3. Install flowable grout, as specified in Section 03600 - Grouting, placed with forms and head boxes.
a. Use flowable, non-shrink grout.
b. Use flowable, non-shrink epoxy grout, only where indicated on the Drawings, where specified in Technical Sections, or when approved in advance by the Engineer.
c. Grouting with dry-pack materials is not permitted.

B. Prepare equipment bases, base plates, soleplates, and skids for grouting:
1. Concrete equipment bases:
a. Roughen surface in accordance with ICRI, Guideline No. 310.2R, Surface Preparation Profiles CSP-3 and CSP-4.
b. Clean roughened concrete surfaces.

2. Base plates, soleplates, and skids:
    a. Clean surfaces in accordance with SSPC-SP-1-Solvent Cleaning, to remove dirt, dust, oil, grease, paint, and other material.

C. Level equipment for grouting:
1. Use removable jack screws, or removable steel wedges and shims to support and level equipment bases, base plates, sole plates, and skids.
    a. Do not use leveling nuts placed on equipment anchors to support or level equipment bases, base plates, sole plates, and skids.
2. Removable jack screws:
    a. Provide number, size, and locations of jack screws required to support and level equipment in accordance with manufacturer's recommendations.
    b. Drill and tap equipment base plates, sole plates, and skids for jack screws.
    c. Support jack screws on circular steel plates that have been epoxy bonded to the equipment foundation.
        1) Provide plates fabricated from Type 316 stainless steel where edges of support plates will have grout side cover of 3 inches or less in the finished work.
    d. Make provision for removal of jack screws after grouting:
        1) Prevent grout from bonding to jack screws by wrapping jack screw threads that will be in contact with grout with multiple layers of tape or other material acceptable to the Engineer.
    e. Place and cure grout.
    f. After grout is placed and cured:
        1) Remove jack screws and material used to prevent grout from bonding to jack screws.
        2) Provide jack screws to Owner for future use.
        3) Fill jack screw holes with grout.
        4) Cure grout as specified.
3. Removable steel wedges and shims:
    a. Use for equipment bases, base plates, sole plates, and skids where it is not practical to use jack screws.
    b. Provide number, size, and locations of wedges and shims required to support and level equipment in accordance with manufacturer's recommendations.
    c. Make provision for removal of wedges and shims after grouting:
        1) Prevent grout from bonding to wedges and shims by wrapping wedges and shims that contact grout with multiple layers of tape or other material acceptable to the Engineer.
        2) Locate and orient wedges and shims to allow for removal after grouting, and to facilitate placement of grout in the remaining voids.
    d. Place and cure grout.
    e. After grout is placed and cured:
        1) Remove wedges and shims, and material used to prevent grout from bonding to them.
        2) Fill jack screw holes with grout.
        3) Cure grout as specified.

D. Construct grout forms:
    1. Provide forms:
        a. Rigid with adequate strength to withstand placement of grout.
        b. With surfaces that will produce a smooth, uniform finish for grout edges exposed in the finished work.
        c. That allow grout to flow horizontally beyond the perimeter of the equipment base plate a distance not less than the thickness of the grout, and not less than 1 inch.
    2. Install forms:
        a. Seal form cracks and joints with elastomeric sealant to make form watertight.
        b. Line form surfaces in contact with grout with polyethylene film, or coat with 2 coats of heavy-duty paste wax.
    3. Construct grout “head box” over entire length of one side of form.
        a. Make head box height sufficient to force grout to flow under full dimensions of equipment base and to the surrounding form faces.

E. Pre-grouting procedures:
    1. Concrete surfaces receiving flowable, non-shrink grout:
        a. Saturate concrete surface in contact with grout and concrete surfaces extending not less than least 6 inches beyond limits of grout with clean water for a minimum of 24 hours prior to grouting.
        b. Just prior to grout placement, remove standing water using clean rags or oil-free compressed air. Provide “saturated surface dry” (SSD) concrete for grout placement.
    2. Concrete surfaces receiving flowable, non-shrink epoxy grout:
        a. Do not saturate concrete prior to grout placement.

F. Grout placement and curing:
    1. Place and cure grout as specified in Section 03600 - Grouting, and in this Section.
    2. Grouting:
        a. Keep level of grout in head box above bottom of equipment bases, base plates, sole plates, and skids always to drive flow under base.
        b. Maintain continuous grout flow from head box to opposite sides of forms without trapping air or forming voids.
        c. Vibrate, rod, or chain grout to facilitate grout flow, to consolidate grout, and to remove entrapped air.
    3. After grout sets, remove forms and trim grout edges at 45-degree angle from bottom edge of equipment bases, base plates, sole plates, and skids.
    4. Cure grout as specified in Section 03600 - Grouting.

G. After grout is cured:
    1. Remove jack screws or wedges and shims, and material used to prevent grout from bonding to leveling devices.
    2. Fill pockets from removed leveling devices with grout.
    3. Cure filled voids as specified in Section 03600 - Grouting.
    4. Tighten equipment anchors in accordance with equipment manufacturer requirements.

3.06 FIELD FINISHES

A. When touchup or repair is required, apply primer and coating systems as recommended by the equipment manufacturer.

END OF SECTION

SECTION 15052

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Basic materials and methods for metallic and plastic piping systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.

B. American Water Work Association (AWWA):
   1. C11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   4. C151 - Ductile-Iron Pipe, Centrifugally Cast.
   5. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 inch Through 144 inch.

C. ASTM International (ASTM):
   1. A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   4. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
   5. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   6. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   7. B88 - Standard Specification for Seamless Copper Water Tube.
   8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
   9. D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings.
   10. F37 - Standard Test Methods for Sealability of Gasket Materials.
   11. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

12. F594 - Standard Specification for Stainless Steel Nuts.
13. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

1.03 DEFINITIONS

A. Buried Pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.

B. Exposed Pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.

C. Pipes Adjacent to a Wet Wall: Pipe centerline within 10 inches of the wet wall.

D. Underground Pipes: Buried pipes - see A. above.

E. Underwater Pipes: Pipes below the top of walls in basins or tanks containing water.

F. Wet Wall: A wall with water on at least 1 side.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials as specified in Section 01601 - Product Requirements.

B. Coatings and linings requirements stated in the Pipe Schedule as modified in the individual pipe Technical Sections and Section 09960 - High-Performance Coatings.

2.02 LINK TYPE SEALS

A. Characteristics:
   1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   2. Links to form a continuous rubber belt around the pipe.
   3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
   4. Hardware to be Type 316 stainless steel.
      a. Provide anti-galling lubricant for threads.

B. One of the following or equal:
   1. Link-Seal.
   2. Pipe Linx.

2.03 FLANGE BOLTS AND NUTS

A. General:
   1. Washer:
      a. Provide a washer for each nut.
      b. Washer shall be of the same material as the nut.
   2. Nuts: Heavy hex-head.
   3. Cut and finish flange bolts to project:
      a. Face of the bolt shall exceed face of nut by 1/8 inch minimum.
      b. A maximum of 1/4 inch beyond outside face of nut after assembly.
   4. Tap holes for cap screws or stud bolts when used.
   5. Lubricant for stainless steel bolts and nuts:
      a. Chloride-free.
      b. Manufacturers: One of the following or equal:
         1) Huskey FG-1800 Anti-Seize.
         2) Weicon Anti-Seize High-Tech.

B. Ductile iron pipe:
   1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
      a. Bolts: In accordance with ASTM A307, Grade B.
      b. Nuts: In accordance with ASTM A563, Grade A.
      c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
   2. On exposed pipes with pressures greater than 150 psig:
      a. Bolts: In accordance with ASTM A193, Grade B7.
      b. Nuts: In accordance with ASTM A194, Grade 2H.
      c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
   3. On underwater pipes and pipes adjacent to wet walls:
      a. Bolts: In accordance with ASTM A193, Grade B8M.
      b. Nuts: In accordance with ASTM A194, Grade 8M.

2.04 MECHANICAL JOINTS BOLTS AND NUTS

A. Bolts including T-Bolts:
   1. High strength low alloy steel in accordance with AWWA C111.
      a. Fluoropolymer coated.

B. Heavy Hex Nuts:
   1. High strength low alloy steel in accordance with AWWA C111.
      a. Fluoropolymer coated.

2.05 GASKETS

A. General.
   1. Gaskets shall be suitable for the specific fluids, pressure, and temperature conditions.
   2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.

B. Gaskets for flanged joints in ductile iron and steel piping for sewage service:
   1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and raw sewage service.
   2. Gasket material:
      a. SBR or neoprene elastomer with minimum Shore A hardness value of 70.
      b. Reinforcement: Cloth or synthetic fiber.
      c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.
   3. Manufacturers: One of the following or equal:
      a. Pipe less than 48 inches in diameter:
         1) Garlock, Style 7797.
         2) John Crane, similar product.
      b. Pipe 48 inches in diameter and larger:
         1) Garlock, Style 3760.
         2) John Crane, similar product.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Piping drawings:
      a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
      b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
         1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
   2. Piping alternatives:
      a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
      b. Alternative pipe ratings:
         1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
         2) Piping of different material may not be substituted in lieu of specified piping.

c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
d. Flanged joints: where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.

3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:
1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings**.**
3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
4. Core drilled openings:
a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by Engineer.
b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
c. Remove dust and debris from hole using compressed air.

C. Exposed piping:
1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
1) Slope plumbing drain piping with a minimum of 1/4-inch per foot downward in the direction of flow.
2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.
3. Support piping: As specified in Section 15061 - Pipe Supports:
a. Do not transfer pipe loads and strain to equipment.
4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.

5. Assemble piping without distortion or stresses caused by misalignment:
    a. Match and properly orient flanges, unions, flexible couplings, and other connections.
    b. Do not subject piping to bending or other undue stresses when fitting piping.
    c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
    d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
    e. Alter piping assembly to fit when proper fit is not obtained.
    f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Buried piping:
1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
    a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
3. Laying piping:
    a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
    b. Place piping with top or bottom markings with markings in proper position.
    c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
    d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
    e. At the end of each day's construction, plug open ends of piping temporarily to prevent entrance of debris or animals.

E. Venting piping under pressure:
1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
2. Install plug valves as air bleeder cocks at high points in piping.
    a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.

F. Restraining buried piping:
1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
    a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
    b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.

2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
    a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
3. Place concrete thrust blocks against undisturbed soil.
4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
5. Provide underground mechanical restraints where specified in Attachment A - Piping Schedule.

G. Restraining above ground piping:
1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
    a. When piping is aboveground or underwater, use mechanical or structural restraints.
    b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
    c. During testing, provide suitable temporary restraints where piping does not require permanent restraints.

H. Connections to existing piping:
1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
    a. Protect domestic water/potable water supplies from contamination:
        1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
        2) Provide devices approved by Owner of domestic water supply system to prevent flow from other sources into the domestic supply system.
2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

I. Connections between ferrous and nonferrous metals:
1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
2. Nonferrous metals include aluminum, copper, and copper alloys.

J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 CLEANING

A. Piping cleaning:
   1. Upon completion of installation, clean piping interior of foreign matter and debris.
   2. Perform special cleaning when required by the Contract Documents.

B. Conduct pressure and leak test, as specified.

C. As specified in Attachment A - Pipe Schedule.

END OF SECTION

ATTACHMENT A - PIPE SCHEDULE

Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Comments
D	Drain									
	Underground	All	CISP		15400 - Plumbing Systems	Bell and Spigot	15 feet/GR	Per 15400	CTE-M-1	
RS	Raw Sewage									
	Underground	All	DIP	150	15211 - Ductile Iron Pipe: AWWA C151	Mech Rest. Mechanical Joint	50 psig/HH	CM	2 layers PEE	
	Aboveground (valve vault)	All	DIP	CL 53	15211 - Ductile Iron Pipe: AWWA C151	Flanged	50 psig/HH	CM	EPX-M-2	Marker Color ID 9
	Aboveground (wet well)	All	DIP	CL 53	15211 - Ductile Iron Pipe: AWWA C151	Flanged	50 psig/HH	CM	EPX-M-6-BG	Marker Color ID 9
SD	Storm Drain									
	Underground	All	PVC	SDR 35	15247 – Polyvinyl Chloride PVC Pipe: Gravity	Bell and Spigot	5 feet/ GR	None	None	
SS	Sanitary Sewer									
	Underground	All	DIP	150	15211 - Ductile Iron Pipe: AWWA C151	Push On or Mech Joint	20 feet/GR	CM	2 layers PEE	

Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Comments
V	Vent									
	Underground	All	PVC	SCH 40	15249 – Polyvinyl Chloride PVC Pipe: Schedule Type	Solvent Welded	5 feet/GR	None	None	
	Aboveground	All	SST	SCH 10	15286 – Stainless Steel Pipe and Tubing	Weld, Flanged where shown	5 feet/GR	None	None	

Abbreviations:

1. The following abbreviations used in the column of test method refer to the respective methods as specified in Section 15956 - Piping Systems Testing.
   - AM Air method
   - GR Gravity method
   - HH High head method
   - LH Low head method
   - SC Special case
2. Abbreviations to designate piping include the following:
   - B&SP Bell and spigot
   - BSP Black Steel Pipe
   - CE Ceramic epoxy lining
   - CI Cast iron
   - CISP Cast iron soil pipe
   - CL Class, followed by the designation
   - CM Cement mortar
   - CTP Coal tar pitch
   - DIP Ductile iron piping
   - EPP Epoxy polyurethane coating
   - FL Flange

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Supports for pipe, fittings, valves, and appurtenances.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   3. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

B. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures

B. Product data.
   1. Design features.
   2. Load capacities.
   3. Material designations by UNS alloy number or ASTM Specification and Grade.
   4. Data needed to verify compliance with the Specifications.
   5. Catalog data.
   6. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01601 - Product Requirements.

2.02 MATERIALS

A. General:
   1. Hot dip galvanized:
      a. Fabricate as specified in Section 05120 - Structural Steel Framing.
      b. Hot dip after fabrication of support in accordance with ASTM A123.
      c. Repair galvanized surface as specified in Section 05120 - Structural Steel Framing.
   2. Stainless steel.
      a. Fabricate as specified in Section 05120 - Structural Steel Framing.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
      c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or A967.
         1) Passivation treatments using citric acid are not allowed.
      d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.

B. Outdoor areas: Areas exposed to the natural outdoor environment:
   1. Hot Dip Galvanized.

C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
   1. Hot Dip Galvanized.

D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
   1. Type 316L Stainless Steel.

E. Stainless steel piping system:
   1. Type 316L Stainless Steel.

F. Fasteners:
   1. As specified in Section 05120 - Structural Steel Framing.

2.03 PIPE SUPPORTS

A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 133.
         2) Nibco-Tolco, Figure 103.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 140.
         2) Bergen-Power, Figure 133.
         3) Cooper B-Line Systems, Inc., Figure B3205.

B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 94.
         2) FM Stainless Fasteners.
      b. For steel and ductile iron piping:
         1) Anvil International, Figure 146.
         2) Bergen-Power, Figure 94.

C. Eye bolts:
   1. For stainless steel piping:
      a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
   2. For all other piping, unless indicated on the Drawings:
      a. Welded and rated equal to full load capacity of rod.

D. Welded eyebolt rod:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 101.
         2) FM Stainless Fasteners.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 278.
         2) Bergen-Power, Figure 93.
         3) Cooper B-Line Systems, Inc., Figure B3210.

E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1C.I.
         2) Bergen-Power, Figure 100SS.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 69.
         2) Cooper B-Line Systems, Inc., Figure B3172.

F. Adjustable clevis hangers: MSS SP-58, Type 1:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
         2) FM Stainless Fasteners, Figure 60.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 260 or Figure 590.
         2) Bergen-Power, Figure 100.
         3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

G. Adjustable clevis hangers for insulated pipe: Oversize:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 1A.

b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 300.
2) Bergen-Power, Figure 100EL.
3) Cooper B-Line Systems, Inc. Figure B3108.

H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 324.
2) Cooper B-Line Systems, Inc., Figure B3110.
3) FM Fasteners, Figure 81.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 181.
2) Cooper B-Line Systems, Inc., Figure B3110.

I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) FM Stainless Fasteners, Figure 71.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 171.
2) Cooper B-Line Systems, Inc., Figure B3114.

J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 30M.
2) Cooper B-Line Systems, Inc., Figure B3066.
3) FM Stainless Fasteners, Figure 98.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 195.
2) Cooper B-Line Systems, Inc., Figure B3066.

K. Standard U-bolt: MSS SP-58, Type 24:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 110.
2) Cooper B-Line Systems, Inc., Figure B3188.
3) FM Stainless Fasteners, Figure 37.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 137.
2) Bergen-Power, Figure 283.
3) Cooper B-Line Systems, Inc., Figure B3188.

L. Riser clamps: MSS SP-58, Type 8:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Cooper B-Line Systems, Inc., Figure B3373.
2) FM Stainless Fasteners, Figure 61.

b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 261.
2) Bergen-Power, Figure 126.
3) Cooper B-Line Systems, Inc., Figure B3373.

M. Pipe clamps: MSS SP-58, Type 4:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 4.
2) Cooper B-Line Systems, Inc., Figure 3140.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 212.
2) Bergen-Power, Figure 175.
3) Cooper B-Line Systems, Inc., Figure B3140.

N. Adjustable offset pipe clamp:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 4.
2) Cooper B-Line Systems, Inc., Figure B3149.
3) FM Stainless Fasteners, Figure 63.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 100.
2) Cooper B-Line Systems, Inc., Figure B3149.

O. Offset pipe clamp:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 8.
2) Cooper B-Line Systems, Inc., Figure 3148.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 103.
2) Cooper B-Line Systems, Inc., Figure B3148.

P. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 318.
2) FM Stainless Fasteners, Figure 59.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 259.
2) Bergen-Power, Figure 125.
3) Cooper B-Line Systems, Inc., Figure B3090.
c. Threaded pipe stand support stanchion. Match pipe support material.
1) Anvil International, Figure 63T.
2) Bergen-Power, Figure 138.
3) Cooper B-Line Systems Inc., Figure B3088ST.

Q. Spring hangers:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 920.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure B-268, Type G.
         2) Bergen-Power, Figure 920.

R. One hole pipe clamps:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping: Engineer knows of no product.
      b. For all other piping:
         1) Anvil International, Figure 126.
         2) Carpenter & Paterson, Figure 237S.

S. Welded beam attachment: MSS SP-58, Type 22:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 304.
         2) Cooper B-Line Systems, Inc., Figure 3083.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 66.
         2) Bergen-Power, Figure 113A or 113B.
         3) Cooper B-Line Systems, Inc., Figure B3083.

T. Heavy pipe clamp: MSS SP-58, Type 4:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 4H.
      b. For all other piping, unless called out otherwise on the drawings:
         1) Anvil International, Figure 216.
         2) Bergen-Power, Figure 298.

U. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Nibco-Tolco, Figure 426.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 257, Type 3.
         2) Cooper B-Line Systems, Inc., Figure B3893.

V. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120 - Structural Steel Framing.

PART 3 EXECUTION

3.01 INSTALLATION

A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1-inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods and secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers or adjustable clevis hangers for 4-inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
   1. For stainless steel piping, use stainless steel U-bolts.
   2. For all other piping, use galvanized U-bolts.

L. Support spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
   5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.

M. Install supports at:
   1. Any change in direction.
   2. Both sides of flexible pipe connections.
   3. Base of risers.
   4. Floor penetrations.
   5. Connections to pumps, blowers, and other equipment.
   6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.

R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01410 - Regulatory Requirements.

T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

U. Where pipe is insulated, install over-sized supports and hangers.

V. Install riser clamps at floor penetrations and where indicated on the Drawings.

W. Coat support system components as specified in Section 09960 - High-Performance Coatings.

END OF SECTION

SECTION 15076

PIPE IDENTIFICATION

1.01 SUMMARY

A. Section includes: Pipe identification including the following:
   1. Pipe identification markers, flow direction arrows, tags, and bands.
   2. Underground warning tape.
   3. Tracer wire.
   4. Witness markers.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01770 - Closeout Procedures:
      a. Operation and Maintenance Data.
      b. Warranty.

PART 2 PRODUCTS

2.01 EXPOSED AND IN-CHASE PIPE IDENTIFICATION

A. For piping with outer diameter greater than or equal to 3/4-inch, provide lettered pipe markers and flow direction arrows:
   1. General requirements:
      a. Pipe markers shall include the following, minimum:
         1) Printed text identifying the pipe fluid.
            a) The text shall be all capital letters matching the text listed in the "Service" column of the Piping Schedule for the corresponding piping system.
         2) An arrow identifying the direction of fluid flow.
            a) The arrow can either be integral to the text marker or provided separately. If provided separately, the arrow must be placed immediately adjacent to each text marker, with the arrow aligned with the text such that the text and arrow are both visible from the same viewpoint.
            b) The arrow color shall match the text color, and the arrow background color shall match the text background color.

b. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
c. Lettering:

Outside Pipe Diameter Including Covering	Lettering Height
Less than 0.75 inches	N/A
0.75 to 1.5 inches	1/2-inch
1.5 inches to 2 inches	3/4-inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

d. Marker colors:

Marker Color System ID(1)	Fluid Service	Text/Arrow Color	Background Color
1	Flammable and oxidizing fluids	Black	Yellow
2	Potable, cooling, boiler feed, and other waters	White	Green
3	Compressed air	White	Blue
4	Fire quenching fluids	White	Red
5	Toxic and corrosive fluids	Black	Orange
6	Combustible fluids	White	Brown
7	Not Used	White	Purple
8	Not Used	Black	White
9	Raw sewage, sewer vent	White	Gray
10	Not Used	White	Black

Notes:
(1) See Piping Schedule.

2. Self-adhesive type markers:
   a. Manufacturers: One of the following or equal:
      1) Seton, (of Brady Corporation), Opti Code Pipe Markers.
      2) Marking Services, Inc.
   b. Materials:
      1) Self-adhesive vinyl.
3. Snap-on markers:
   a. Manufacturers: One of following or equal:
      1) Brady Snap-On.
      2) Seton (of Brady Corporation) Setmark.

B. For piping with outer diameter less than 3/4-inch, provide identification tags and flow direction arrows:
   1. Manufacturer: One of the following or equal:
      a. Seton (of Brady Corporation).
   2. Tag and chain materials:
      a. Copper piping: Brass.
      b. Ferrous piping: Type 316 stainless steel.
      c. Plastic piping: Stainless steel.
   3. Flow direction arrow colors shall adhere to the same requirements as for piping with outer diameter greater than or equal to 3/4 -inch, as specified in this Section.

C. Pipe bands:
   1. When bands are required by the Piping Schedule for a specific piping system, provide solid-colored 4-inch wide bands.
      a. Color as specified in the Piping Schedule.
   2. Self-adhesive type.
   3. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit.

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
   1. Manufacturer: One of the following or equal:
      a. Seton (of Brady Corporation).
      b. T. Christy Enterprises, Inc.
   2. Material:
      a. Polyethylene tape for prolonged underground use.
      b. Minimum tape thickness: 4 mils.
      c. Overall tape width: 4 inches.
      d. Message: “CAUTION” with the name of the service followed by “LINE BURIED BELOW.” in black lettering on colored background in accordance with approved American Public Works Association colors.

Service	**Color**
Potable water	Blue
Reclaimed water, irrigation, and slurry lines	Purple
Sewers and drain lines	Green
Gas, oil, steam, petroleum, chemicals, or other service	Yellow

B. Tracer wire:
   1. Manufacturers: One of the following or equal:
      a. Kris-Tech Wire.
      b. Aegion Corrpro.
   2. Materials: One of the following or equal:
      a. Solid copper conductor.
      b. Thickness minimum: 10 gauge.
      c. Insulation:
         1) Match insulation color to the color of the pipe being installed.

2) UF type, direct bury.
3) 30 mil HMWPE.

3. Splicing kit:
   a. Manufacturers: One of the following or equal:
      1) 3M, Model 82 A1N.
4. Station box:
   a. Lid and collar materials: Cast iron.
   b. Lid type: Locking.
   c. Able to withstand heavy traffic loading.
   d. Manufacturers: One of the following or equal:
      1) CP Test & Valve Products, Inc., Glenn Test Station.
      2) Farwest Corrosion Control.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01601 - Product Requirements.

3.02 PREPARATION

A. Prepare and coat piping with the coating systems defined in the Piping Schedule.

B. Prepare surface in accordance with identification product manufacturer's instructions.

3.03 EXPOSED AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed and in-chase piping with flow direction arrows and lettering (for piping with outer diameter greater than or equal to 3/4-inch) or tags (for piping with outer diameter less than 3/4-inch).

B. Provide lettering (or tags for pipes with outer diameter less than 3/4-inch) and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.
   1. Label all chemical tank fill pipelines at locations that are visible from chemical fill stations.
   2. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers along horizontal centerline of pipe, unless better visibility is achieved elsewhere.
   3. Do not apply markers, arrows, or tags to piping that is regularly submerged.

C. Where scheduled in the Piping Schedule, space solid-color bands along piping at 10-foot intervals.
   1. Do not apply bands to piping that is regularly submerged.

3.04 BURIED PIPING IDENTIFICATION

A. Underground warning tape:
   1. Non-detectable warning tape:
      a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.

B. Tracer wire:
   1. Install on all non-metallic pipe.
   2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
   3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
   4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
      a. Twisting the wires together is not acceptable.

END OF SECTION

SECTION 15110

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
   3. A536 - Standard Specification for Ductile Iron Castings.

C. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

D. Society for Protective Coatings (SSPC):
   1. SP7 - Brush-Off Blast Cleaning.
   2. SP10 - Near-White Blast Cleaning.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      d. Certified drawings with description of component parts, dimensions, weights, and materials of construction.
      e. Certifications of reference standard compliance:
         1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
      f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
      g. Factory test data.

C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals.
   1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.05 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Pressure rating:
   1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
   2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Metallic valves:
      a. Valves 3 inches nominal size and larger: Flanged ends.
      b. Valves less than 3 inches nominal size: Screwed ends.
   2. Plastic valves in plastic piping systems:
      a. Up to 4 inches: Provide solvent or heat welded unions, except for plastic butterfly valves.
      b. 6 inches and above: Provide solvent or heat-welded flanges.

2.02 MATERIALS

A. Stainless steel: In accordance with ASTM A480, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts (not including flange bolts and nuts, which are specified in Section 15052 - Common Work Results for General Piping):
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Cast iron valve bodies: In accordance with ASTM A126, Class 30 minimum.

E. Ductile iron valve bodies: In accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

2.03 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: The following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.
      c. Apply in accordance with manufacturer's published instructions.
      d. Lining thickness: 0.010 to 0.012-inch, except that:
         1) Lining thickness in grooves for gaskets: 0.005-inch.
         2) Do not coat seat grooves in valves with bonded seat.
      e. Quality control:
         1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
         2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
         3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
         4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
         5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2. High solids epoxy:
    a. Product equivalent to high solids epoxy EPX-M-1 as specified in Section 09960 - High-Performance Coatings.
        1) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy EPX-M-1 as specified in Section 09960 - High-Performance Coatings.
    b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
    c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
        1) Repair holidays and other irregularities and retest coating.
        2) Repeat procedure until holidays and other irregularities are corrected.

2.04 UNDERGROUND VALVES

A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.

B. Coating and wrapping:
    1. After installation, encase valves in polyethylene wrap as specified for ductile iron piping in Section 15211 - Ductile Iron Pipe: AWWA C151.
        a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.05 VALVE BOXES

A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.

B. Do not support boxes on valve, valve operator, or pipe.

C. Boxes:
    1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
    2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.

D. Manufacturers: One of the following or equal:
    1. Tyler Pipe Industries, Inc.
    2. Neenah Foundry Co.

2.06 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels, as indicated on the Drawings.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
   2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
   2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inches square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

PART 3 EXECUTION

3.01 EXAMINATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.
   2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.

C. Valve and actuator orientation:
   1. Contractor shall coordinate with valve supplier final orientation of valve and actuator assembly based on Contractor's selection of equipment manufacturers and the valve and piping arrangement as indicated on the Drawings.
      a. Contractor shall rotate valve and/or actuator mounting orientation as specified in this Section unless otherwise indicated on the Drawings.
   2. Install valves with their stems in vertical position above the pipe, except as follows:
      a. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
      b. Install buried plug valves with geared operators with their stems in a horizontal position.
   3. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

D. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.

E. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon™ tape on external (male) threads to prevent forcing compound into valve seat area.

F. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

G. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

3.03 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer’s coating system and as specified in Section 09960 - High-Performance Coatings.
   1. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services from each manufacturer for all valves supplied:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

C. As specified elsewhere for specific valve types, sizes or actuators.
   1. Source testing.
   2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION

SECTION 15114

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:
   1. Swing Check Valves:
      a. General Swing Check Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch NPS.

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A276: Standard Specification for Stainless Steel Bars and Shapes.
   3. A313 - Standard Specification for Stainless Steel Spring Wire.
   4. A536 - Standard Specification for Ductile Iron Castings.
   5. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
   6. B16 - Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines.
   7. B61 - Standard Specification for Steam or Valve Bronze Casting.
   8. B62 - Standard Specification for Composition Bronze or Q=Ounce Metal Castings.
   9. B582 - Standard Specification for Nickel-Chromium-Iron-Molybdenum-Copper Alloy Plate, Sheet, and Strip.
   10. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

D. National Electrical Manufacturers Association (NEMA).

E. NSF International (NSF):
   1. Standard 61 – Drinking Water Components Health Effects.
   2. 372 - Drinking Water System Components - Lead Content.

F. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 01601 - Product Requirements.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation Compliance as specified in Section 01756 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in 01601 - Product Requirements and 15110 - Common Work Results for Valves.

B. Provide check valves as shown on the Check Valve Schedule and suitable for service:
   1. In either horizontal or vertical position.
   2. For working pressures up to 150 pounds per square inch.

C. Check valve materials as follows unless otherwise specified:
   1. Cast iron conforming to ASTM A126 Grade B.
   2. Ductile iron conforming to ASTM A536 Grade 65-45-12.
   3. T-303 stainless steel conforming to ASTM A582 (UNS S30300).
   4. Type 316 stainless steel conforming to ASTM A313.

D. Flanges: Drilled per ASME B16 Class 125/150 unless otherwise specified or indicated on the Drawings.

2.02 GENERAL SWING CHECK VALVES (CKV00)

A. Valves 4 inches through 24 inches:
   1. Manufacturers: One of the following or equal:
      a. Kennedy, Figure 106LW or M&H, Model 159.
      b. Mueller Co., Model A-2600.
      c. APCO Model 250.
      d. Crispin SWL Series.
   2. Valve design:
      a. In accordance with AWWA C508.
      b. Constructed to permit top entry and removal of internal components without removing the valve.
      c. Equipped with outside lever and weight.

3. Materials:
    a. Body: Cast iron, ASTM A126 Class B or ASTM A536 Grade 65-45-12 Ductile Iron.
    b. Disc:
        1) Valve disc shall be ASTM A126 cast iron, ASTM A536 ductile iron, or ASTM B584 bronze.
        2) 4-inch valves: Bronze or stainless steel rings and seats.
        3) 6 inches and larger valves: Bronze-faced or stainless steel rings and seats.
        4) Rubber seat Buna-N or EPDM.
    c. Hinge pins: Stainless steel.

2.03 INTERIOR PROTECTIVE LININGS

A. As shown in the valve schedules and in accordance with Section 15110 - Common Work Results for Valves.

PART 3 EXECUTION

3.01 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
    1. Provide certificates:
        a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
    1. Test witnessing: Witnessed.
    2. Conduct pressure and leak test, as specified in Section 15956 - Piping Systems Testing.

END OF SECTION

SECTION 15116

PLUG VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Non-lubricated plug valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C517 - Resilient-Seated Cast Iron Eccentric Plug Valves.
   2. C606 - Grooved and Shouldered Joints.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A536 - Standard Specification for Ductile Iron Castings.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and 15110 - Common Work Results for Valves.

A. Product data as defined in 01601 - Product Requirements.

B. Shop drawings showing installation arrangement of major component assemblies.

C. Calculations.

D. Vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Data.

E. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning:
      a. Interior coating.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01601 - Product Requirements and Section 15110 - Common Work Results for Valves.

2.02 NON-LUBRICATED PLUG VALVES (PV00)

A. Manufacturers: One of the following or equal:
   1. DeZurik, "PEC".
   2. Clow Valve.
   3. Milliken Valve, Model 600/601.

B. Design:
   1. Type: Non-lubricated eccentric type, in accordance with AWWA C517.
   2. Plug face: Resilient material that operates satisfactorily at a temperature of 180 degrees Fahrenheit continuous and 215 degrees Fahrenheit intermittent, except for valves in compressed air or digester gas service.
      a. Valves in compressed air service: Resilient material suitable for continuous duty at 250 degrees Fahrenheit.
      b. Valves in digester gas service: Resilient material suitable for petroleum or digester gas at continuous duty at 180 degrees Fahrenheit.
   3. Compression washer: Provide flat compression washer made of Teflon™, or of a material having equal physical characteristics on valve stem between plug and bonnet.
   4. Stem seals: Provide stem seals serviceable without unbolting the valve bonnet assembly.
   5. Grit excluders: Provide PTFE grit excluders at upper plug journals to prevent entry of foreign solids in bearing area.
   6. Clearly mark valves to indicate their open and closed positions.
   7. Provide valves with ends as required by piping details indicated on the Drawings.
      a. Grooved end body valves:
         1) Usage: Plug valves with grooved ends may be used in piping systems specified in the Piping Schedule to have grooved end joints and as indicated on the Drawings.
         2) Grooved end joint design: In accordance with AWWA C606.

C. Materials:
   1. Body and plug: ASTM A126, Class B, cast-iron or ASTM A536, Grade 65-45-12, ductile iron, with plug face of neoprene material suitable for the intended service as specified under paragraph "Design" above.
   2. Body seats in valves 3 inch size and larger: Provide with overlay of not less than 90-percent nickel and minimum thickness of 1/8-inch on surfaces contacting the plug face.
   3. Stem bearing and bottom bearing: Type 316 stainless steel.
   4. Internal parts, except the body and plug: Type 316 stainless steel.
   5. Exposed nuts, bolts, and washers: Zinc plated. Exception: Exposed nuts, bolts, and washers for buried service: Stainless steel.

2.03 VALVE OPERATORS

A. Furnish valves with an operating wrench or worm gear operator:
   1. Equip valves 4-inch nominal size and smaller with a lever operator.

2.04 COATING

A. Coat and test interior metal surfaces as specified in Section 15110 - Common Work Results for Valves.

B. Field applied coating of valve exterior:
   1. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
      a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
      b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

2.05 SHIPMENT, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01601 - Product Requirements.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves as specified in Section 15110 - Common Work Results for Valves and the manufacturer's instructions.
   1. Unless differently indicated on the Drawings install valves so that in the closed position the pressure in the pipeline applies a seating head on the valves.
   2. Install valves so that in the open position the plug is located in the top half of the valve body.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15120

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Piping specialties including:
      a. Pipe saddles.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   4. A536 - Standard Specification for Ductile Iron Castings.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
   2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 01601 - Product Requirements.

B. Product data:
   1. For each piping product in this Section as applicable:
      a. Design features.
      b. Load capacities.
      c. Material designations by UNS alloy number or ASTM Specification and Grade.

d. Data needed to verify compliance with the Specifications.
e. Catalog data.
f. Clearly mark Submittal information to show specific items, materials, and accessories or options being furnished.

C. Installation instructions:
1. Provide manufacturer's installation instructions.

D. Calculations:
1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

E. Manufacturer's Certificate of Installation as specified in Section 01756 - Commissioning:
1. Provide as specified in this Section.

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01601 - Product Requirements.

B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

2.02 PIPE SADDLES

A. For ductile iron pipe:
1. Double strap brass type.
2. Manufacturers: One of the following or equal:
a. A.Y. McDonald, Style 3825.
b. The Ford Meter Box Company, Style 202B.
c. Mueller Company, Style BR2B.
3. Materials:
a. Pipe saddle body, straps, and nuts: Brass or silicon bronze.
b. Gaskets: Rubber.

B. For PVC C900 or C905 pipe:
1. Manufacturers: One of the following or equal:
a. Romac Industries, Inc., Style 202S.
b. Smith-Blair, Inc., Style 317.
2. Materials:
a. Pipe saddles: Ductile iron with fusion bonded epoxy finish.
b. Straps, bolts, and nuts: Type 304 stainless steel with Teflon™ coating on nuts.
c. Gaskets: Rubber.

2.03 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01601 - Product Requirements.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01601 - Product Requirements.

B. Drawings supersede conflicts with this Section.

3.02 INSTALLATION

A. Pipe saddles:
   1. Coat threads on bolts with anti-gall coating prior to installation.

3.03 FIELD QUALITY CONTROL

A. Manufacturer services:
   1. Provide Manufacturer’s Certificate of Installation.

B. Field testing:
   1. As specified in Section 15052 - Common Work Results for General Piping.

END OF SECTION

SECTION 15121

PIPE COUPLINGS

1.01 SUMMARY

A. Section includes:
   1. Pipe couplings for ductile iron piping.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 inch. Through 144 inch.
   3. C213 - Standard for Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   4. C606 - Standard for Grooved and Shouldered Joints.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   4. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   5. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
   6. A536 - Standard Specification for Ductile Iron Castings.
   7. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   8. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
   9. C425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
   10. C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
   11. C564 - Standard Specification for Rubber Gasket for Cast Iron Pipe and Fittings.
   12. C1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.
   13. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.

14. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
15. D5926 - Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
16. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
1. For each product in this Section as applicable:
a. Design features.
b. Load capacities.
c. Material designations by UNS alloy number or ASTM Specification and Grade.
d. Data needed to verify compliance with the Specifications.
e. Catalog data.
f. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Calculations:
1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01601 - Product Requirements:
1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

B. Known acceptable manufacturers are listed by specific products.

C. Provide references as specified in this Section by specific product.

D. Manufacturer’s representatives requirements as specified in Section 01756 - Commissioning and this Section by specific product.

E. Gaskets for flexible couplings and flanged coupling adapters:
   1. Provide gasket materials for piping applications as follows:
      a. All other piping applications: Neoprene rubber or Buna-N

F. Exterior coatings for underground and submerged applications:
   1. Manufacturers: One of the following or equal:
      a. Tapecoat Co., Inc., T.C. Mastic.
      b. Kop-Coat Co., Inc., Bitumastic Number 50.
   2. Thickness: Minimum 0.040 inch.

2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Dismantling joints:
   1. Manufacturers: One of the following or equal:
      a. Romac Ind., Inc., Style DJ400.
      b. Smith-Blair, Inc., Series 975.
   2. Materials:
      a. Flanged spool: AWWA C207 steel pipe:
         1) ASTM A53 for sizes 3 inches to 12 inches.
         2) ASTM A36 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
         2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36 or A53.
      c. Follower ring: Ductile iron in accordance with ASTM A536.
      d. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
      e. Tie rods: High tensile steel in accordance with ASTM A193 Grade B7.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

B. Flanged coupling adapters: 12-inch size and smaller:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 227.
      b. Romac Ind., Inc., Style FCA501.
      c. Smith-Blair, Inc., Series 912.
   2. Materials:
      a. Flanged body: Ductile iron in accordance with ASTM A536.
      b. Follower ring: Ductile iron in accordance with ASTM A536.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.

3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

C. Flexible couplings:
1. Manufacturers: One of the following or equal:
   a. Dresser, Inc., Style 253.
   b. Romac Ind., Inc., Style 501.
   c. Smith-Blair, Inc., Series 441.
2. Materials:
   a. Center rings: Ductile iron in accordance with ASTM A536.
   b. Follower rings: Ductile iron in accordance with ASTM A536.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size	Sleeve Length
3 inch and smaller	Manufacturer's standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inches	Use steel flexible coupling per Pipe Couplings for Steel Piping

D. Flexible couplings (Gravity Flow):
1. Manufacturers: One of the following or equal:
   a. Fernco Flexible Coupling.
2. Materials:
   a. In accordance with ASTM D5926, C1173 and applicable portions of ASTM C443, C425, C564, and D1869.
3. Requirements:
   a. In underground and underwater installations, couplings shall be corrosion resistant or coated with a fusion applied epoxy coating in accordance with AWWA C213.
   b. Bolts and hardware shall be stainless steel 18-8 type 316 epoxy coated alloy hardware.

E. Restrained flange coupling adapter:
1. Manufacturers: One of the following or equal:
   a. Romac Ind., Inc., Style RFCA.
   b. Star Pipe Products, 3200 StarFlange™.
2. Materials:
   a. Flange and flanged body: Ductile iron in accordance with ASTM A536.

b. Follower ring: Lug type restraint system.
    1) Follower ring: Ductile iron in accordance with ASTM A536.
    2) Restraining lugs: Ductile iron in accordance with ASTM A536.
        a) Designed to contact the pipe and apply forces evenly.
    3) Restraining bolts:
        a) Ductile iron in accordance with ASTM A536.
        b) Bolt heads shall be designed to twist off when the proper torque has been applied.
c. Bolts and hex nuts:
    1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
    2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.

3. Flange design: Class D steel ring flange in accordance with AWWA C207 compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.

PART 3 EXECUTION

3.01 INSTALLATION

A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with manufacturer's instructions.

B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.

C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
    1. Install flexible coupling with pipe gap located in middle of center sleeve.
    2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

Center Ring Length	Gap Dimension and Tolerance
4 inch through 6 inch	3/8 inch
7 inch	5/8 inch
10 inch and greater	7/8 inch

D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
    1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.

END OF SECTION

SECTION 15211

DUCTILE IRON PIPE: AWWA C151

1.01 SUMMARY

A. Section includes: Ductile iron pipe, joints, connections, fittings, and pipe linings and coatings.

B. As specified in Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C104 – Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
   6. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
   7. C153 - Standard for Ductile-Iron Compact Fittings for Water Service.
   8. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   9. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   10. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
   11. C606 - Standard for Grooved and Shouldered Joints.

C. American Welding Society (AWS):
   1. D11.2 - Guide for Welding Iron Castings.

D. ASTM International (ASTM):
   1. A536 - Standard Specifications for Ductile Iron Castings.
   2. B1000 - Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-Lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry.
   3. C33 - Standard Specification for Concrete Aggregates.
   4. C150 - Standard Specification for Portland Cement.
   5. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
   6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   7. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

E. Ductile Iron Pipe Research Association (DIPRA):
   1. Thrust Restraint Design Manual.

F. International Organization for Standardization (ISO):
   1. 8179 - Ductile iron pipe, fittings, accessories and their joints - External zinc-based coating –Part 1: Metallic zinc with finishing layer.

G. National Association of Pipe Fabricators, Inc. (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

H. Society for Protective Coatings (SSPC):
   1. SP 5 - White Metal Blast Cleaning.
   2. PA-2 - Measurement of Dry Coating Thickness With Magnetic Gages.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data.

C. Manufacturer's qualifications.
   1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.

D. Manufacturer's Quality Assurance Manual:
   1. Submit manufacturer's coating and lining application quality assurance manual to Engineer prior to beginning coating application.
      a. Strict conformance to the requirements of the manual will be required.
      b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

E. Shop drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
   2. Thrust restraint systems.
   3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings.

F. Calculations:
   1. Calculations for thrust restraint system design.

G. Manufacturer's Certificate of Source Testing for ceramic epoxy, glass lined, plural component polyurethane, and zinc materials:
   1. Certify successful performance of holiday detection tests on 100 percent of lining in accordance with ASTM B1000.
   2. Identify each test piece by mark designation and show the actual test results during the final inspection by manufacturer prior to shipment.
   3. Zinc coating: Regular measurements in accordance with ISO 8179 Part 4.4.
   4. Include Coating Manufacturer’s Technical Representative’s reports.

1.04 QUALITY ASSURANCE

A. Ductile iron pipe shall be supplied by a single manufacturer.

B. Hydrostatically test each joint of ductile iron pipe in accordance with AWWA C151.

C. Pre-installation meeting:
   1. Arrange for Coating Manufacturer's Technical Representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

B. Carefully handle piping and associated fittings during loading, unloading, and installation:
   1. Do not drop piping material from cars or trucks.
   2. Lower piping by mechanical means.
   3. Do not drop or pound pipe to fit grade.

C. Handle pipe from the outside if lined with ceramic epoxy, glass or plural component polyurethane.
   1. No forks, chains, straps, hooks, or other lifting device shall be placed inside the pipe or fittings for lifting, positioning, or laying.

D. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.

E. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Ductile iron piping:
   1. Manufacturers: One of the following or equal:
      a. American Cast Iron Pipe Co.
      b. McWane Ductile.
      c. SIP Industries.
      d. U.S. Pipe.

2.02 THRUST RESTRAINT SYSTEM DESIGN

A. The length of pipe that must be restrained on each side of the focus of a thrust load as specified in the Pipe Schedule.

B. Design pressure: 50 pounds per square inch.

C. Laying condition: Type 5 in accordance with AWWA C150.

D. Soil type: Silt 1.

E. Unit friction resistance for polyethylene encasement of pipe: DIPRA factor multiplied by a safety factor of 1.5.

2.03 DUCTILE IRON JOINTS AND CONNECTIONS

A. General:
   1. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 15052 - Common Work Results for General Piping.
   2. In accordance with AWWA C150 and AWWA C151.
   3. Joints:
      a. Flanged.
      b. Grooved.
      c. Mechanical.
      d. Push-on Rubber Gasket.
      e. Integrally Restrained Mechanical.
      f. Mechanical Wedge Action.
      g. Integrally Restrained Push-On.
      h. Push-On Joint Restraint Harness.
   4. Connections:
      a. Tapping saddle.
      b. Tapping sleeve.
      c. Welded outlet.
   5. Fittings.
   6. Flanged joints:
      a. Screw-on flanges:
         1) Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1.
         2) Ductile iron.
         3) Long hub, threaded, and specially designed for ductile iron pipe.
         4) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
      b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
      c. Cap screw or stud bolt holes: Tapped.
      d. Bolts and nuts:
      e. Gaskets:
         1) Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052 - Common Work Results for General Piping.
   7. Mechanical joints:
      a. In accordance with AWWA C111.
      b. Gaskets:
         1) As specified in Section 15052 - Common Work Results for General Piping.
      c. Bolts and nuts, including T-bolts:
         1) As specified in Section 15052 - Common Work Results for General Piping.

8. Push-on rubber gasket joints:
    a. In accordance with AWWA C111.
    b. Gaskets:
        1) As specified in Section 15052 - Common Work Results for General Piping.
9. Integrally restrained mechanical joints:
    a. Manufacturers: Where restrained mechanical joints are required, use one of the following or equal:
        1) American Cast Iron Pipe Co., MJ Coupled Joint.
        2) U.S. Pipe, Bolt-Lok.
        3) U.S. Pipe, Mech-Lok.
    b. Application:
        1) Where designated mechanical restraint.
        2) Mechanical joint is specified in the Piping Schedule provided in Section 15052 - Common Work Results for General Piping, supply a restrained mechanical joint piping system, which includes restrained mechanical joints where necessary based upon thrust calculations.
        3) Standard mechanical joints as specified above can be used where thrust calculations demonstrate restraint is not required.
    c. Design:
        1) Integral retainer weldment type or lugged type joint with Type 304 stainless steel rods and nuts.
        2) Restrained mechanical joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
    d. Gaskets:
        1) As specified in Section 15052 - Common Work Results for General Piping.
    e. Bolts and nuts, including T-bolts:
        1) As specified in Section 15052 - Common Work Results for General Piping.
10. Integrally restrained push-on joints:
    a. Application:
        1) Where designation restrained push-on is specified in the Piping Schedule provided in Section 15052 - Common Work Results for General Piping, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
        2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
    b. Design:
        1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
        2) Suitable for the following working pressures:
            a) For 4- through 24-inch pipe: 350 pounds per square inch gauge.
            b) For 30- through 54-inch pipe: 250 pounds per square inch gauge.
    c. Gaskets:
        1) As specified in Section 15052 - Common Work Results for General Piping.

d. Manufacturers: One of the following or equal:
    1) U.S. Pipe, TR Flex.
    2) McWane Ductile, TR Flex.
    3) American Cast Iron Pipe Co., Flex Ring or Lok-Ring.
e. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

B. Connections:
1. Tapping saddle as specified in Owner standard specification.
    a. If Owner does not have a standard specification, provide tapping saddles as specified in Section 15120 - Piping Specialties.
2. Tapping sleeve as specified in Owner standard specification.
    a. Not allowed without Engineer approval.

C. Fittings:
1. Ductile iron in accordance with AWWA C110.
2. Joint type:
    a. Same as that of the associated piping as specified in Section 15052 - Common Work Results for General Piping.
3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

2.04 ASPHALT VARNISH

A. Coating:
1. Factory apply.

B. Primer:
1. Factory applied for field coating.

C. Compatible with materials as specified in Section 09960 - High-Performance Coatings.

2.05 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C104 and as specified in this Section.

B. Cement:
1. Cement: In accordance with ASTM C150, Type II.

C. Water:
1. In accordance with AWWA C104 and as specified in this Section.

D. Sand and aggregate:
1. In accordance with AWWA C104.
2. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

E. Lining:
   1. Minimum lining thickness: Standard in accordance with AWWA C104.
   2. Apply cement mortar on clean bare metal surfaces.
   3. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
   4. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
      a. Extend to faces of flanges and ends of spigots.
      b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
      c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
   5. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
   6. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C104 and approved by the Engineer.
      a. Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
         1) No. 12 gage spaced at maximum 1-inch centers.
         2) No. 14 gage steel wire at maximum 1/2-inch centers.

2.06 POLYETHYLENE ENCASEMENT

A. General:
   1. Polyethylene encasement shall be supplied by the pipe manufacturer.

B. Materials: Supply one of the following polyethylene encasements:
   1. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105; or,
   2. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.
   3. Single layer of V-Bio® enhanced polyethylene encasement (3 layers of coextruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface), meeting all requirements of AWWA C105.

2.07 SEAL COAT

A. Asphaltic seal coat:
   1. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating.
   2. Apply in accordance with AWWA C151.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section 15052 - Common Work Results for General Piping.

2. For underground piping, the trenching, backfill, and compaction:
    a. Inspect coating prior to backfill.
    b. As specified in Section 02318 - Trenching.

B. Joints:
1. Install types of joints as specified in the piping schedule provided in Section 15052 - Common Work Results for General Piping.
2. Mechanical joints are not acceptable in above ground applications.
3. Field closure for restrained push-on pipe:
    a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
4. Grooved joints:
    a. Install piping with grooved joints where specified in the piping schedule as specified in Section 15052 - Common Work Results for General Piping.
    b. Assemble grooved joints in accordance with manufacturer's published instructions.
    c. Support grooved-end pipe in accordance with manufacturer's published instructions.
        1) Install at least 1 support between consecutive couplings.

C. Connection:
1. Tapping ductile iron pipe:
    a. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
        1) Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	**Pressure Class**				
	150	**200**	**250**	**300**	**350**
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2
16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

b. The maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
c. 2 layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

2. Direct tapping of glass lined ductile iron pipe may be performed only when approved in writing by the Engineer. Direct tapping of glass lined pipe shall be performed in accordance with the above conditions for tapping ductile iron pipe in addition to the following conditions:
   a. Drilling and tapping shall be performed using a hole saw.
      1) Use of a large drill bit is not acceptable.
   b. As the hole saw approaches the glass lining, lessen the inward pressure to avoid excess chipping or cracking of the lining.
   c. Minor chipping or spalling of the glass lining shall be repaired using an epoxy resin “glass repair kit” provided by the fabricator.
      1) Manufacturers: One of the following or equal:
         a) Devoe - Devran 224 HS.
         b) Sherwin-Williams Co. - Sher-Tile High Solids Epoxy.
      2) Repair kit use is only allowed for areas of damage less than 1/2 inch in diameter.
         a) Larger areas of damage will require replacement.
      3) Surface shall be prepared and repair kit shall be applied in accordance with manufacturer and/or fabricator’s instructions.
3. When direct tapping of ductile iron pipe is not possible due to limited wall thickness, a saddle tap shall be used.

3.02 DEFECTS IN COATINGS EXCEPT TAPE WRAP AND CEMENT MORTAR COATING

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
   1. Pipe joints exceeding the following defect maximum will be rejected.
      a. Minor defects:
         1) No more than 1.5 per 100 square feet of surface area.
         2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
         3) Repairs for adhesion testing will not be included in the total number of repairs.
         4) Repair in accordance with manufacturer's requirements.
      b. Major defects:
         1) No more than 3 major repairs on each pipe joint.
         2) No more than 30 percent repairs on the pipe surface area with defects.
   2. Minor repairs:
      a. Repairs less than 8-inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.
   3. Major repairs:
      a. Repairs that exceed 8-inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.

3.03 POLYETHYLENE ENCASEMENT

A. Wrap buried ductile iron pipe and fittings in 2 layers of loose low-density polyethylene wrap or a single layer of high-density polyethylene wrap, or a single layer of V-Bio polyethylene wrap in accordance with AWWA C105 and as specified in this Section.

B. Wrap polyethylene encasement to be continuous and terminated neatly at connections to below grade equipment or structures.

C. At wall penetrations, extend encasement to the wall and neatly terminate.

D. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.

E. When rising vertically in unimproved areas, extend encasement on pipe 6 inches above existing grade and neatly terminate.

F. Repair tears and make joints with 2 layers of plastic tape.

G. Work shall be inspected prior to backfilling of pipe and associated items.

3.04 FIELD QUALITY CONTROL

A. Testing ductile iron piping:
   1. Test as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
   1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

C. Verify that interior surfaces of ceramic epoxy and glass lined pipe and fittings have continuous coverage:
   1. Test random samples, as directed by Engineer, in accordance with ASTM B1000.
   2. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 15247

POLYVINYL CHLORIDE (PVC) PIPE: GRAVITY

1.01 SUMMARY

A. Section includes: Gravity sewer pipe and fittings in accordance with ASTM D3034 and ASTM F679 standards.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
   2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   4. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   5. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
   6. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
   7. F679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.

1.03 ABBREVIATIONS

A. PVC: Polyvinyl chloride.

B. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 PIPE

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. PVC compound: Cell classification 12454-C in accordance with ASTM D1784.

C. Stabilizers, antioxidants, lubricants, colorants, and other additives and fillers not to exceed 10 parts by weight per 100 of PVC resin in the compound.

D. Pipe less than or equal to 15-inch diameter:
   1. In accordance with ASTM D3034.
   2. Wall thickness SDR as specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
   3. Joints: Push-on in accordance with ASTM D3212.
      a. Integral bell.
      b. Factory installed gaskets meeting the requirements in accordance with ASTM F477.

2.02 FITTINGS

A. Same material as the pipe.

B. Minimum wall thickness: Same as the minimum wall thickness of the equivalent size pipe as specified in Table 1 of ASTM F679.

C. Supplied by the pipe manufacturer.

D. Factory molded with joints and gaskets equal to those of the pipe.

E. Gasket:
   1. In accordance with ASTM F477.
   2. Manhole adapter gasket: Stainless steel clamp with gasket or similar device to seal the penetration.

F. Flexible gaskets for precast bases with a flexible pipe connection: In accordance with ASTM C923:
   1. Manufacturer: One of the following or approved equal:
      a. Press-Seal Gasket Corp.: PSX.
      b. A-Lok Premium.

G. Waterstop grouting rings:
   1. Manufacturer: One of the following or approved equal:
      a. NPC.
      b. Press-Seal Gasket Corp.

2.03 SOURCE QUALITY CONTROL

A. Mark pipe and fittings in accordance with ASTM D3034 and ASTM F679 as appropriate.

B. Mark the production control code on pipe and fittings.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install piping in accordance with ASTM D2321 and manufacturer's published installation instructions.
   2. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
   3. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
   4. Trenching and backfill as specified in Section 02318 - Trenching.
   5. Install pipe with tracer wire as specified in Section 15076 - Pipe Identification.

B. Connections to manholes:
   1. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations using 1 of the following methods:
      a. Precast bases with a flexible pipe connection:
         1) Pipe connectors shall be cast into the base.
            a) Pipe openings shall contain flexible gaskets.
         2) Follow manufacturer's recommendation for lubrication to prevent damage to the gasket during pipe insertion.
         3) When PSX gaskets are used, the take-up screws for the gasket clamps shall be positioned a minimum of 90 degrees apart.
         4) Install and grout in place per manufacturer's instructions.
      b. Cast in place or precast bases using grouting rings:
         1) Provide opening for connection large enough to allow subsequent grouting around the grouting ring.
         2) Grout around the pipe penetration manhole gasket and seal the opening.

3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 15956 - Piping Systems Testing.

B. Mandrel tests:
   1. Perform initial mandrel test:
      a. After cleaning and completion of other tests.
      b. After placement and compaction of backfill.
      c. Before construction of pavement or surfacing.
      d. Not sooner than 30 days after pipe installation.
      e. Not later than 60 days after installation.

2. Perform final verification mandrel test:
   a. Not sooner than 30 days before the end of the warranty period.
   b. Not later than 10 days before the end of the warranty period.
   c. Consider the final verification mandrel test a warranty service, and include the costs related to final verification mandrel test in the Contract Price.
3. Utilize a 9 rod mandrel with minimum length equal to NPS and diameter as follows:

Nominal Pipe Size (NPS)	Mandrel Diameter (in) (SDR 35/PS46)	Mandrel Diameter (in) (SDR 26/PS 115)
6	5.45	5.33
8	7.28	7.11
10	9.08	8.87
12	10.79	10.55
15	13.20	12.90
18	16.13	15.76
21	19.00	18.57
24	21.36	20.87
27	24.06	23.51
30	27.68	27.04

4. Test procedure: Pull the mandrel through the line under test by 1 person, by hand, with reasonable effort, without the aid of mechanical equipment.
5. Failing test: Where the mandrel test is not successful, remove and replace the section of piping with the obstruction; test the piping again, including visible leaks test, pressure test with maximum leakage allowance, mandrel tests, and other specified tests:
   a. Correction of excessive deflection or obstructions by methods other than removal of the affected piping and replacement of the removed piping with new piping will not be accepted.

END OF SECTION

SECTION 15249

POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

1.01 SUMMARY

A. Section includes: Schedule type PVC pipe and fittings.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   2. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   3. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   4. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   5. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   6. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
   7. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.

B. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   1. Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
      b. Schedule 40 unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
   2. Fittings: In accordance with ASTM D2466.
      a. Same material as the pipe and of equal or greater pressure rating.
      b. Supplied by pipe manufacturer.
      c. Unions 4 inches and smaller:
         1) Use socket end screwed unions.
      d. Unions 6 inches and larger:
         1) Use socket flanges with 1/8-inch full-face soft gasket.
            a) Gasket material: As indicated on the Piping Schedule.
   3. Solvent cement:
      a. In accordance with ASTM D2564.
      b. Manufacturers: The following or equal:
         1) IPS Corp.
            a) Primer: Type P70.
            b) Cement: Type 724.
      c. Certified by the manufacturer for the service of the pipe.
      d. In potable water applications: Provide solvent cement listed by NSF for potable water applications.

2.02 SOURCE QUALITY CONTROL

A. Meets or exceeds all quality assurance test requirements stated in ASTM D1785.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable.

B. Provide molded transition fittings for transitions from plastic to metal pipe.
   1. Do not thread pipe.
   2. Do not use flanged transition fittings unless specifically indicated on the Drawings.

C. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.

D. Provide serrated nipples for transition from pipe to rubber hose.

E. Solvent weld joints in accordance with ASTM D2855.

3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

END OF SECTION

SECTION 15286

STAINLESS STEEL PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Stainless steel piping and tubing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
   2. B16.11 - Forged Fittings, Socket-Welding and Threaded.
   3. B31.3 - Process Piping.
   4. B36.19 - Stainless Steel Pipe.

B. ASTM International (ASTM):
   1. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   9. A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
   10. A774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
   11. A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
   12. A790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.

13. A928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
14. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

C. American Welding Society (AWS):
1. D1.6 - Structural Welding Code - Stainless Steel.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Shop Drawings:
1. Detailed layout drawings:
   a. Dimensions and alignment of pipes.
   b. Location of valves, fittings, and appurtenances.
   c. Location of field joints.
   d. Location of pipe hangars and supports.
   e. Connections to equipment and structures.
   f. Location and details of shop welds.
2. Thickness and dimensions of fittings and gaskets.
3. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
4. Material specifications for pipe, gaskets, fittings, and couplings.
5. Data on joint types and components used in the system including stub ends, backing flanges, flanged joints, grooved joint couplings and screwed joints.

D. Field welding references:
1. Welder and weld operator qualification certificates and welding procedures.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized.
1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
2. Where joints and couplings are specifically indicated on the Drawings, design and shop-fabricate piping sections utilizing the joint or coupling illustrated at the locations shown.
3. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field assembly:
   1. Field welding is prohibited.
   2. Assemble shop-fabricated piping in the field using the joints designed into the piping layout or by using flexible couplings.

2.02 STAINLESS STEEL PIPE

A. General:
   1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.

B. Wall thickness:
   1. As specified in Section 15052 - Common Work Results for General Piping.

C. Piping material and manufacturing:
   1. Comply with the requirements outlined in the following table:

Service	Stainless Steel Grade	Pipe Manufacturing Process
For low chloride water service with chloride concentrates below 200 parts per million and/or free chlorine less than 2 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A778
Piping less than 3 inches in nominal diameter	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A312
Digester Gas, Oxygen and Ozone Service, Membrane and Reverse Osmosis Filtration Systems with chloride concentrations less than 1,000 parts per million and/or free chlorine less than 4 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 316L or LDX 2101 stainless steel in accordance with ASTM A240	Type 316L in accordance with ASTM A778
		Type LDX 2101 in accordance with ASTM A790
Piping less than 3 inches in nominal diameter	Type 316L or LDX 2101 stainless steel in accordance with ASTM A240	Type 316L in accordance with ASTM A312
		Type LDX 2101 in accordance with ASTM A790
Brackish water Membrane and Reverse Osmosis Membrane Filtration Systems with chloride concentrations between 1,000 and 10,000 parts per million.		
All piping diameters	Austenitic or duplex grades of material with PREN greater than 33	In accordance with ASTM A312, ASTM A778, ASTM A790, or ASTM A928
Brackish and Seawater Membrane and Reverse Osmosis Membrane Filtration Systems with chloride concentrations between 10,000 to 20,000 parts per million		
All piping diameters	Austenitic and duplex grades of material with PREN greater than 40	In accordance with ASTM A312, ASTM A790 or ASTM A928

Service	Stainless Steel Grade	Pipe Manufacturing Process
Brackish and Seawater Reverse Osmosis Concentrate (i.e., Brine) with chloride concentrations greater than 20,000 parts per million		
All piping diameters	Austenitic and duplex grades of material with PREN greater than 45	In accordance with ASTM A312, ASTM A778, ASTM A790, or ASTM A928
PREN: Pitting Resistance Equivalency Number PREN = Cr% + (3.3 x Mo%) + (16 x N%)		

UNS #	Alloy	Cr%	Mo%	N%	Other	PREN
N10276	C-276	14.5-16	15-17	-	W 3-4.5	64
S32750	Alloy 2507	24-26	6-8	0.24-0.32	-	48
S32654	654SMO	24-25	7-8	-	-	47
N06625	Alloy 625	20-23	8-10	-	Cb 3.25-4.15	46
N08366	AL6XN	20-22	6-7	-	-	40
N06985	Alloy G	21-23.5	5.5-7.5	-	-	39
S32760	Zeron 100	24-26	3-4	0.2-0.3	W 0.5-1.0	37
S32205	Alloy 2205	22-23	3-3.5	0.14-0.20	-	34
N08904	904L	19-23	4-5	-	-	32
S31726	317LNM	17-20	4-5	0.1-0.2	-	32
N08825	Alloy 825	19-23.5	2.5-3.5	-	-	27
S32101	LDX-2101	21.5	0.3	0.22	-	26
S31603	316L	16-18	2-3	-	-	23
S30403	304L	18-20	-	-	-	18

D. Fittings for piping 3 inches in nominal diameter and greater:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A774.
   3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Dimensional standards:
      a. Fittings with weld ends: In accordance with ASME B16.11.
      b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.

E. Fittings for piping less than 3 inches in diameter:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A403, Class WP.

3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.
4. End configuration: As needed to comply with specified type of joint.
5. Forgings in accordance with ASTM A182, or barstock in accordance with ASTM A276. Match forging or barstock material to the piping materials.

F. Piping joints:
   1. Joint types, piping greater than 2 inches in diameter, general:
      a. Where type of joint is specifically indicated on the Drawings or specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.
      b. Where type of joint is not specifically indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping, Piping Schedule, design and shop-fabricate piping sections utilizing any of the following joint types:
         1) Welded joints.
         2) Flanged joints.
      c. Joints at valves and pipe appurtenances:
         1) Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends.
         2) Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using flanged coupling adapters or flanged joints.
            a) Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system and in accordance with requirements as specified in Section 15121 - Pipe Couplings.
      d. Joints in digester gas, ozone and oxygen piping systems, membrane and reverse osmosis filtration systems:
         1) Aboveground piping: Welded or flanged.
         2) Underwater piping: Welded or flanged.
         3) Buried piping: Welded or mechanically restrained.
   2. Joints in piping 2 inches in diameter and smaller: Flanged, welded,.
   3. Welded joints:
      a. Piping 4 inches through 12 inches in diameter: Double butt welded joints.
      b. Piping less than 4 inches in diameter: Single butt-welded joints.
      c. Mark each weld with a symbol that identifies the welder.
   4. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150.
   5. Flanges for Schedule 40S and Schedule 80S pipe:
      a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150.
      b. Material: In accordance with ASTM A182.

G. Gaskets:
   1. Ozone and oxygen service: TFE sheet.
   2. Aeration air service: As specified in Section 15052 - Common Work Results for General Piping.
   3. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.

H. Bolts for flanges:
   1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A193 heavy hex head.
      a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
      b. Nuts: In accordance with ASTM A194 heavy hex pattern.

I. Fabrication of pipe sections:
   1. Welding: Weld in accordance with ASME B31.3.
   2. Weld seams:
      a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.
      b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
      c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
      d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

J. Cleaning (pickling) and passivation:
   1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
   2. Clean (pickle) and passivate in accordance with ASTM A380 or ASTM A967.
      a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible.
         1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
      b. Passivation treatments with citric acid are not allowed.
   3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

2.03 STAINLESS STEEL TUBING

A. Stainless steel tubing:
   1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A269, wall thickness not less than 0.035 inch.

B. Fittings: Swage ferrule design:
   1. Components made of:
      a. Type 316 stainless steel.
   2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
   3. Flare type fittings are not acceptable.
   4. Manufacturers: One of the following, or equal:
      a. Crawford Fitting Co., Swagelok.
      b. Hoke, Gyrolok.
      c. Parker, CPI.

C. Valves for use with stainless steel tubing:
   1. Ball type valves with swage ends to match tubing diameter.
   2. Constructed from:
      a. Type 316 stainless steel with TFE seats.
   3. Manufacturers: The following or equal:
      a. Crawford Fitting Co., Swagelok.

2.04 SOURCE QUALITY CONTROL

A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

B. Provide written certification that the pipe as supplied are in accordance with ASTM A778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied are in accordance with ASTM A774.
   1. Supplementary testing is not required.

D. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

E. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.

F. Shipment to site:
   1. Protect flanges and pipe ends by encapsulating in dense foam.
   2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
   3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
   4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
   5. Notify Engineer when deliveries arrive so Engineer may inspect the shipping conditions.
   6. Engineer may reject material due to improper shipping methods or damage during shipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping in such a manner as not to impart strain to connected equipment.

B. Slope horizontal lines so that they can be drained completely.

C. Provide valve drains at low points in piping systems.

D. Install eccentric reducers where necessary to facilitate draining of piping system.

E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.02 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

3.03 FIELD QUALITY CONTROL

A. Test piping to pressure and by method as specified in Section 15052 - Common Work Results for General Piping.
   1. If pressure testing is accomplished with water:
      a. Use only potable quality water.
      b. Piping: Thoroughly drained and dried or place immediately into service.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

3.04 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
   1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
   2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
   3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without projection from bad weather is prohibited.
   4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION

SECTION 15400

PLUMBING SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for materials and installation of plumbing systems.

1.02 REFERENCES

A. Abbreviations:
   1. gpf - gallons per flush.
   2. gph - gallons per hour.
   3. gpm - gallons per minute.
   4. psig - pounds per square inch, gauge.

B. Definitions:
   1. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.
   2. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.
   3. Flame Spread and Smoke Density: Burning characteristics determined in accordance with ASTM E84.
   4. Interior: Piping that is installed inside a building.
   5. K Factor: Thermal conductivity determined in accordance with ASTM C177 or C518.
   6. Mineral Fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.
   7. Water Vapor Permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

C. Standards:
   1. American Concrete Institute (ACI).
   2. American Gas Association (AGA).
   3. American Society of Mechanical Engineers (ASME).
      a. B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300.
      b. B16.12 - Cast Iron Threaded Drainage Fittings.
   4. American Society of Sanitary Engineering (ASSE):
      a. 1070 - Performance Requirements for Water Temperature Limiting Devices.
   5. American Water Works Association (AWWA):
      a. C511 – Reduced-Pressure Principle Backflow Prevention.
      b. C700 - Standard for Cold-Water Meters -- Displacement Type, Bronze Main Case.
      c. C702 - Standard for Cold-Water Meters -- Compound Type.
   6. Americans with Disabilities Act (ADA).

7. ASTM International (ASTM):
    a. A48 - Standard Specification for Gray Iron Castings.
    b. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
    c. A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
    d. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
    e. A888 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
    f. B32 - Standard Specification for Solder Metal.
    g. B88 - Standard Specification for Seamless Copper Water Tube.
    h. B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
    i. B828 - Standard Specification for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
    j. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
    k. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
    l. C547 - Standard Specification for Mineral Fiber Pipe Insulation.
    m. C552 - Standard Specification for Cellular Glass Thermal Insulation.
    n. C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
    o. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
    p. D256 - Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
    q. D297 - Standard Test Methods for Rubber Products—Chemical Analysis.
    r. D395 - Standard Test Methods for Rubber Property—Compression Set.
    s. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
    t. D638 - Standard Test Method for Tensile Properties of Plastics
    u. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
    v. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
    w. D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride (CPVC) Compounds.
    x. D1785 - Standard Specification for Poly (Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.
    y. D2240 - Standard Test Method for Rubber Property—Durometer Hardness.
    z. D2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
    aa. D2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
    bb. D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
    cc. D2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

dd. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
ee. E96 - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.
ff. F438 - Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
gg. F439 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
hh. F441 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
ii. F493 - Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
jj. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
kk. F594 - Standard Specification for Stainless Steel Nuts.
ll. F645 - Standard Guide for Selection, Design, and Installation of Thermoplastic Water- Pressure Piping Systems.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination:
1. Provide plumbing equipment roof penetrations information required in the preparation of roofing drawings including, but not limited to:
a. Location.
b. Diameter.
c. Configuration of penetration and the surround.
2. Provide roof mounted plumbing equipment information required in the preparation of roofing drawings including, but not limited to:
a. Location.
b. Size.
c. Weight.
d. Anchoring and support details.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Manufacturer's instructions.

C. Shop drawings: and as applicable:
1. System layout, mechanical, electrical power, and control diagrams.
2. Nameplate information.
3. Materials.
4. Coatings and linings.
5. Rough-in drawings.
6. Supports, vibration isolators, and details.
7. Primary and ancillary equipment.
8. Proposed cutting and patching.
9. Maximum recommended equipment vibration levels and field-testing method.
10. Copy of factory test results.

D. Certificates: As specified in Section 01601 - Product Requirements:
   1. American Backflow Prevention Association for backflow prevention assembly.
   2. National Science Foundation for products when specified.

E. Field testing documentation.

F. Warranties.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 PLUMBING AND DRAINAGE PRODUCTS

A. Drains:
   1. Drains shall be the type, shape, and size as indicated on the Drawings with connections suitable for the piping system.
      a. Provide all drains of one type from the same manufacturer.
   2. Type FD1: Floor drain, finished floors, pedestrian traffic:
      a. Manufacturers: One of the following or equal:
         1) Josam, 30000-A.
         2) Zurn.
      b. Round, adjustable strainer head, floor level grate.
      c. Body material: Coated cast iron.
      d. Strainer:
         1) Material: Nickel bronze.
         2) Size:
            a) 6-inch diameter for 3-inch drain.
            b) 8-inch diameter for 4-inch drain.

2.02 PLUMBING PIPING SYSTEMS

A. As indicated on the Drawings in the Piping Schedule specified in Section 15052 - Common Work Results for General Piping.

B. Cast iron soil pipe piping system:
   1. In accordance with ASTM A74.
   2. Bell-and-spigot, service weight.
      a. Above ground: Hubless per CISPI 310.
   3. Joints underground: positive double seal compression type gaskets in accordance with ASTM C564.
   4. Joints aboveground:
      a. American standard taper screw threads, cut clean and made up with Teflon™ tape or an acceptable paste thread compound applied to the male threads only.
      b. Slip joints permitted only in trap seals or on the inlet side of the traps.
         1) Do not use long screws or bushings.
   5. Cast iron drainage pattern fittings.

6. Couplings for "No Hub": Stainless steel corrugated shield and clamp assembly over a molded 1-piece neoprene sealing sleeve, in accordance with ASTM A888.
7. Line pipe and fittings inside and coat outside with bituminous coating.
8. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish and install vents required in drainage piping as part of the plumbing system, in accordance with Laws and Regulations.

B. Use anti-seize lubricant for stainless steel treads on fittings and fasteners.

3.02 INSTALLATION

A. Plumbing and drainage products:
   1. Sizes of equipment drains and of floor drains shall be as indicated on the Drawings.

B. Plumbing piping systems:
   1. Cast iron soil pipe, PVC, polypropylene piping systems:
      a. Where not specified otherwise, install horizontal piping with a grade of 1/4 inch per foot.
      b. Provide vents, roof drains, and pipes flashed and made watertight at the roof with lead sheet flashings.
         1) Minimum 4-pound lead sheet.
      c. Extend flashing not less than 6 inches up the pipes, and counter flash with standard cast iron or malleable iron recessed roof couplings.
      d. Extend flashing for vents up to the top of the vent and turn down into the pipe.
      e. Extend flashing shields not less than 8 inches from vent and pipe in all directions.

3.03 FIELD QUALITY CONTROL

A. Test drain, waste, and vent lines as specified and in accordance with the plumbing code as specified in Section 01410 - Regulatory Requirements.

3.04 CLEANING

A. Upon completion of installation, clean piping interior of foreign matter and debris.

END OF SECTION

SECTION 15956

PIPING SYSTEMS TESTING

1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

1.02 REFERENCES

A. National Fuel Gas Code (NFGC).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.3 - Process Piping.
   3. B31.8 - Gas Transmission and Distribution Piping Systems.

C. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

A. General requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 15052 - Common Work Results for General Piping; are specified in the specifications covering the various types of piping; and are specified in this Section.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01410 - Regulatory Requirements, and UL requirements.
   4. Test natural gas or digester gas piping:
      a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01410 - Regulatory Requirements, or the National Fuel Gas Code, whichever is more stringent.
      b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
   5. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
      a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for testing, cleaning, and disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01500 - Temporary Facilities and Controls.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water disposal: Dispose of testing water as directed by Owner in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site. All requirements and costs associated with notifications and obtaining any discharge permit or approvals shall be responsibility of Contractor.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Schedule and notification of tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
   3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection test:
   1. Pull a mandrel through the clean piping section under test.
   2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
   3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
   4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.02 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
   1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Piping Schedule in Section 15052 - Common Work Results for General Piping:
   1. Provide temporary pressure relief valve for piping under test:
      a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
   2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASME B31.8, or the pipe manufacturer's stated maximum working pressure.
   3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.
   4. Perform initial check of joints and fittings for leakage.
   5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage; at each step increase until test pressure reached.
   6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
   7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.03 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. Pressure test piping with maximum leakage allowance after backfilling.
   5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
         1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
            a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
               (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
            b) For vitrified clay piping: 500 gallons per day per inch of diameter per mile of piping under test.
            c) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.

B. General:
   1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.
   2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
   3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.

4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
6. When test results indicate failure of selected sections, limit tests to piping:
    a. Between valves.
    b. Between a valve and the end of the piping.
    c. Less than 500 feet long.
7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing procedures:
1. Fill piping section under test slowly with water while venting air:
    a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
    a. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
2. Pressure test piping after completion of visible leaks test.
3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
    a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
    b. Successful completion of the pressure test with maximum leakage allowance shall be achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
    c. When leakage is allowed, calculate the allowable leakage by the following formula:

$$L = S \times D \times P^{1/2} \times 148{,}000^{-1}$$

wherein the terms shall mean:

L = Allowable leakage in gallons per hour.

S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
   1. Test pressures shall be as scheduled in Section 15052 - Common Work Results for General Piping.
   2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
   3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
   4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible leaks test:
   1. Subject piping under test to specified pressure measured at the lowest end.
   2. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
   4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Pressure test piping after completion of visible leaks test.
   2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
      b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:
   1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
      a. Joint testing will be allowed only for low head pressure piping.
      b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.

2. Joint testing may be performed with water or air.
3. Joint test piping after completion of backfill and compaction to the top of the trench.
4. Joint testing with water:
    a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
    b. Maintain test pressure for 1 minute.
    c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
    d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
    e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
5. Joint testing with air:
    a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
    b. Maintain test pressure for 2 minutes.
    c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Testing of mechanical equipment and systems.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

C. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

A. Provide Source Test Plans as specified in Section 01756 - Commissioning.

B. Provide Installation and Functional Testing Plans as specified in Section 01756 - Commissioning.

C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals.
   1. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

PART 2 EXECUTION

2.01 GENERAL

A. Commissioning of equipment as specified in:
   1. This Section.
   2. Section 01756 - Commissioning.
   3. Equipment sections:
      a. If testing requirements are not specified, provide Level 1 Tests.

B. Test and prepare piping as specified in Section 15956 - Piping Systems Testing.

C. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
   1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
   2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

D. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
      a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy.
      a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

2.02 VARIABLE SPEED EQUIPMENT TESTS

A. Establish performance over the entire speed range and at the average operating condition.

B. Establish performance curves for the following speeds:
   1. The speed corresponding to the rated maximum capacity.
   2. The speed corresponding to the minimum capacity.
   3. The speed corresponding to the average operating conditions.

2.03 PUMP TESTS, ALL LEVELS OF TESTING

A. Test in accordance with the following:
   1. Applicable HI Standards.
   2. This Section.
   3. Equipment sections.

B. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
   1. From 0 to plus 5 percent of head at the rated design point flow.
   2. From 0 to plus 5 percent of flow at the rated design point head.
   3. No tolerance for head and flow when ranges are specified.
   4. No negative tolerance for the efficiency at the rated design point, and other specified conditions.
   5. Use of specified test tolerances shall not result in motor overload while operating at any point on the supplied pump operating head-flow curve, including runout.
   6. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

2.04 DRIVERS TESTS

A. Test other drivers as specified in the equipment section.

2.05 NOISE REQUIREMENTS AND CONTROL

A. Perform noise tests in conjunction with vibration test analysis.

B. Make measurements in relation to reference pressure of 0.0002 microbar.

C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

D. Set sound level meter to slow response.

E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

2.06 PRESSURE TESTING

A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

2.07 INSPECTION AND BALANCING

A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.

C. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

D. Critical speed of rotating equipment:
   1. Satisfy the following:
      a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
      b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
      c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

E. Vibration tests:
   1. Definitions:
      a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
      b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.
      c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
      d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.

e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
    1) Manufacturers: One of the following or equal:
        a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
        b) CSI, "PeakVue."
f. Rotor bar pass frequency (RBF), for detecting loose rotor bars.
g. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
h. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
i. Preferred operating range: Manufacturer’s defined preferred operating range (POR) for the equipment.
j. Allowable operating range: Manufacturer’s defined allowable operating range (AOR) for the equipment.

2. Vibration instrumentation requirements:
    a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
        1) Manufacturers: One of the following or equal:
            a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
            b) Pruftechnik, VIBXPERT II.
    b. Analyzer settings:
        1) Units: English, inches/second, mils, and gravitational forces.
        2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
        3) Sample averages: 4 minimum.
        4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
        5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
        6) Fast fourier transform windowing: Hanning Window.
        7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.
    c. Accelerometers:
        1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity,

10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.

a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 797L.
(2) PCB, Model 393C.

2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.

a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 793.
(2) Entek-IRD Model 943.

3. Accelerometer mounting:
   a. Use magnetic mounting or stud mounting.
   b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
   c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.
4. Vibration acceptance criteria:
   a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
   b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field, mils	Factory, mils
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

   c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type) Vertical Solids Handling Centrifugal Pumps	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
	Below 33 hp	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps (solids-handling type pumps)	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	Below 268 hp	0.15	0.19
	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	
	268 hp and above	0.17	
Slurry Pumps		0.25	0.30
Motors		See Applicable Motor Specification	See Applicable Motor Specification
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

e. Additional criteria:
   1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.
   2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.

3) For motors, the following shall be cause for rejection:
a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.
b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

5. Vibration testing results presentation:
a. Provide equipment drawing with location and orientation of measurement points indicated.
b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
c. When Vibration Spectra Data required:
1) Plot peak vibration velocity versus frequency in cycles per minute.
2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
4) Plot motor spectra on a log amplitude scale versus frequency.
d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

2.08 TESTING LEVELS

A. Level 1 Tests:
1. Level 1 Performance Test:
a. General:
1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.

2) Operate at rated design load conditions.
3) Confirm that equipment is properly assembled.
4) Confirm the equipment moves or rotates in the proper direction.
5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Pumps:
1) Comply with general performance test requirements as specified in this Section.
2) Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture.
b) Use actual driver for field tests.
3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.

2. Level 1 Vibration Test:
a. Test requirement:
1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
b. Equipment operating condition: Test at specified maximum speed.

3. Level 1 Noise Test:
a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 Tests:
1. Level 2 Performance Test:
a. General:
1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
2) Operate at rated design load conditions.
3) Confirm that equipment is properly assembled.
4) Confirm the equipment moves or rotates in the proper direction.
5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Pumps:
1) Comply with general performance test requirements as specified in this Section.

2) Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
    a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture.
    b) Use actual driver for field tests.
3) Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

2. Level 2 Vibration Test:
    a. Test requirement:
        1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
        2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
    b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
    c. Natural frequency test of field installed equipment:
        1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
        2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
        3) Perform with equipment and attached piping full of intended service or process fluid.
3. Level 2 Noise Test:
    a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Tests:
1. Level 3 Performance Tests:
    a. General:
        1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
        2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
        3) Confirm that equipment is properly assembled.

4) Confirm the equipment moves or rotates in the proper direction.
5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
8) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

b. Pumps:
1) Comply with general performance test requirements as specified in this Section.
2) Test 4 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test at full speed.
a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture.
b) Use actual driver for field tests.
3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
5) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
b) Perform efficiency testing with test fluids at maximum rated speed.
c) Perform priming time testing with test fluids at maximum rated speed.

2. Level 3 Vibration Test:
a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
b. Perform High Frequency Enveloping Analysis for gears and bearings.
1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a

smooth surface and direct path to the bearing to detect bearing defects.

2) Report results in units of acceleration versus frequency in cycles per minute.

c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).

d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.

3. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plain view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Tests:

1. Level 4 Performance Test:

a. General:

1) For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.

2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.

3) Confirm that equipment is properly assembled.

4) Confirm the equipment moves or rotates in the proper direction.

5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.

6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.

8) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.

b. Pumps:

1) Comply with general performance test requirements as specified in this Section.

2) Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.

3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.

4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
5) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
6) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
    a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
    b) Perform efficiency testing with test fluids at maximum rated speed.
    c) Perform priming time testing with test fluids at maximum rated speed.

2. Level 4 Vibration Test: Same as Level 3 vibration test.
3. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

END OF SECTION

SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Contract Drawings:
   1. Schematic diagrams:
      a. Controls are shown as de-energized.
      b. Add relays, where required, to provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      c. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted.
   2. Plan drawings:
      a. Electrical drawings show desired locations, arrangements, and components of the electrical work in a diagrammatic manner.
      b. Locations and sizes of equipment are approximate only.
   3. Installation details:
      a. Contract Drawings include typical installation details the Contractor is to use to complete the electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      b. Not all typical installation details are referenced within the drawing set. Apply and use typical details where appropriate.

B. Section includes:
   1. Requirements for electrical:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation.

1.02 REFERENCES

A. Abbreviations:
   1. FAT: Factory acceptance test that is also referred to as source test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. PCIS: Process control and instrumentation system.

B. Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   2. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   3. Underwriters' Laboratories, Inc. (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. LCP: Local control panel: Operator interface panel that may contain pilot type control devices, operator interface devices, control relays, etc., and does not contain a PLC or RIO.
   2. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
   3. Space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide standoffs, bus, and hardware, as part of the space.
   4. Spare: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
   5. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.
   6. Vendor control panel (VCP): Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

1.04 DELEGATED DESIGN

A. Requirements for Delegated Design are specified in the Technical Sections.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Loop drawings:
      a. Provide electrical information required in the preparation of loop drawings including, but not limited to:
         1) Conduit numbers and associated signal(s) contained within each conduit.
         2) Wire numbers.
         3) Equipment terminal numbers.
         4) Junction boxes and signal(s) contained within each junction box.
         5) Equipment power sources, and associated circuit numbers.
         6) As-built drawings detailing wiring.

B. Meetings:
   1. As specified in Section 01312 - Project Meetings.

C. Sequencing and scheduling:
   1. Equipment anchoring: Project construction schedule must include an event for obtaining the anchor layout drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Provide field wiring and terminations.

B. Equipment mounting and anchoring:
   1. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01850 - Design Criteria, and other loads as required for proper operation of equipment.
      a. For equipment with an operating weight of 400 pounds or greater and equipment that is supported higher than 4 feet above the floor, provide calculations for:
         1) Operating weight and location of the centroid of mass for the equipment.
         2) Forces and overturning moments.
         3) Shear and tension forces in equipment anchorages, supports, and connections.
         4) Design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
   2. Anchorage of equipment to concrete or masonry:
      a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.

b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
1) Adjust bolts to final location and secure the sleeve.

3. Anchorage of equipment to metal supports:
a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.

2.02 MATERIALS

A. Enclosures:
1. Provide enclosures for electrical, instrumentation and control equipment, regardless of Supplier or Subcontractor furnishing the equipment, that meet the requirements of NEMA Standard 250.

PART 3 EXECUTION

3.01 INSTALLATION

A. Demolition:
1. As specified in Technical Sections or as indicated on the Drawings.
2. Disconnect utilities:
a. Disconnect electrical equipment.
b. Disconnect other utilities.
3. Remove and dispose of conduit, wire, electrical equipment, controls, etc., associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
4. Salvage electrical equipment as specified in Section 01738 - Selective Alterations and Demolition.
5. For each piece of equipment to be removed, remove ancillary components (e.g., instruments, solenoid valves, disconnect switches, etc.).
6. Conduit:
a. Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
1) Remove exposed conduit to the point of encasement or burial.
2) Cut conduit flush and plug or cap encased or buried conduit.
b. Where conduits are to remain in place and removal is not indicated on the Drawings**:**
1) Cap conduit open ends.
2) Re-label empty conduits as spare.
7. Remove wire back to the source for conduits to be removed or abandoned in place.

B. Equipment:
1. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.

C. Provide NEC required working space in front of electrical equipment as if it could be worked on energized.

D. Circuits of different service voltage:
   1. Voltage and service levels:
      a. Medium voltage: Greater than 1.0 kV.
      b. Low voltage: 120 V to 480 V.
      c. Instrumentation: Less than 50 VDC.
   2. Install different service voltage circuits in separate raceways, junction boxes, manholes, hand holes, and pullboxes.
   3. In manholes, install cables operating at less than 50 VDC in PVC coated flexible metallic conduit, with corrosion resistant fittings.

E. Conductors shall not pass through equipment they are not terminating in unless indicated on the Drawings or approved by the Engineer.

3.02 COMMISSIONING

A. General:
   1. As specified in Section 01756 - Commissioning, and Technical Sections.
   2. Provide onsite assistance for troubleshooting and correcting electrical issues discovered during commissioning.

B. Functional Testing:
   1. Inspection activities conducted during construction do not satisfy inspection or testing requirements as specified in Section 16950 - Field Electrical Acceptance Tests.

3.03 FIELD QUALITY CONTROL

A. Workmanship:
   1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
      a. Neatly coil and label spare wiring lengths.
      b. Shorten, re-terminate, and re-label excessive used, as well as spare, wire and cable lengths, as directed by the Engineer.

3.04 CLEANING

A. General:
   1. Clean and vacuum enclosures to remove metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:
      a. Use of compressors or air blowers for cleaning is not acceptable.
   2. Clean luminaries in the areas affected by the construction.

END OF SECTION

SECTION 16060

GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Grounding materials and requirements.

1.02 REFERENCES

A. Standards:
   1. ASTM International (ASTM):
      a. B3 - Standard Specification for Soft or Annealed Copper Wire.
      b. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   2. Institute of Electrical and Electronics Engineers (IEEE):
      a. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
   3. National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL):
      a. 467 - Ground and Bonding Equipment.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.

1.04 QUALITY ASSURANCE

A. Grounding components and materials shall be UL listed and labeled.

1.05 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Ground equipment and raceway systems so that the completed installation is in accordance with applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.
   3. Ground connections.

2.02 MANUFACTURERS

A. Compression connectors: One of the following or equal:
   1. Burndy.
   2. Erico.
   3. Harger.
   4. Panduit.
   5. Thomas & Betts.

B. Ground rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Nehring.
   4. Thomas & Betts.

C. Ground cable: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Nehring.
   4. Southwire.

D. Precast ground well boxes: One of the following or equal:
   1. Brooks Products, 3-RT Valve Box.
   2. Christy Concrete Products, G12 Valve Box.

2.03 MATERIALS

A. Ground rod:
   1. Minimum: 3/4-inch diameter, 10-feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. The copper-to-steel bond shall be corrosion resistant.
   3. In accordance with UL 467.
   4. Sectional type joined by threaded copper alloy couplings.
   5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:
   1. Requirements:
      a. Soft drawn (annealed).
      b. Concentric lay, coarse stranded in accordance with ASTM B8.
      c. Bare copper in accordance with ASTM B3.
   2. Size is as indicated on the Drawings, but not less than required by the NEC. Use the following type of wire unless otherwise indicated on the Drawings**:**
      a. Size #6 AWG and smaller; solid conductor.
      b. Size #4 AWG and larger; stranded conductor.

C. Compression connectors:
   1. Manufactured of high copper alloy specifically for the particular grounding application.
   2. Suitable for direct burial in earth and concrete.
   3. Identifying compression die number inscription to be impressed on compression fitting.
   4. Barrels prefilled and sealed with oxide-inhibiting and anti-seizing compound.

D. Grounding electrode conductors:
   1. Minimum size in accordance with the NEC.

E. Main bonding jumpers and bonding jumpers:
   1. Minimum size in accordance with the NEC.

2.04 ACCESSORIES

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

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

B. Provide a separate grounding conductor for each motor and connect at motor terminal box.

C. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
   1. Individually bond these raceways to the ground bus in the equipment.

D. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

E. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

F. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

G. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

H. Grounding at service (600 V or Less):
   1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

I. Ground connections:
   1. Connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer's instructions.
   3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

J. Grounding electrode system:
   1. Ground rods:
      a. Locations as indicated on the Drawings.
      b. Length of rods forming an individual ground array shall be equal in length.
      c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
      d. Install ground rods, coupled, to result in an overall length of 20 feet each.
   2. Metal underground water pipe:
      a. Bond metal underground domestic water pipe to grounding electrode system.
   3. Metal frame of building or structure:
      a. Bond metal frame of building or structure to grounding electrode system.
   4. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
   5. Where grounding conductors are exposed and subject to physical damage, install in Schedule 80 PVC conduit for protection.
   6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

K. Shield grounding:
   1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
   3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
   4. Terminate the signal cable shield on a dedicated grounding terminal block.

L. Antenna ground:
   1. Install individual ground rod or ground system for communication system antenna:
      a. Install a dedicated grounding electrode conductor from the antenna ground to the grounding electrode system.
      b. Do not connect any other grounds to the antenna grounding electrode conductor.
   2. Install ground rod or ground system in accordance with the radio manufacturer's requirements.

M. Where indicated on the Drawings, install ground rods in precast ground wells.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.03 FIELD QUALITY CONTROL

A. The ground system resistance (electrode to ground) of the completed installation, as determined by tests, shall be:
   1. 5 ohms or less for industrial systems.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.04 ADJUSTING

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

END OF SECTION

SECTION 16075

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identification of electrical equipment, devices and components.
   2. Material, manufacturing and installation requirements for identification devices.

1.02 REFERENCES

A. Standards:
   1. National Electrical Code (NEC).
   2. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
   3. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire numbers:
      a. Manufacturer’s catalog data for wire labels and label printer.

C. Record documents:
   1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.04 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.05 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

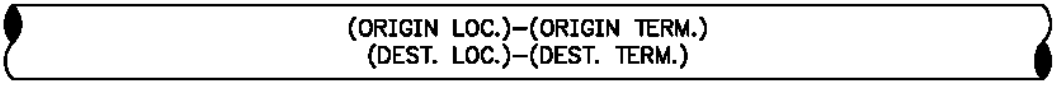
2.01 GENERAL

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

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Nameplates:
   1. Provide a nameplate for each piece of electrical equipment, device, control panel and control panel components.
   2. Provide all nameplates of identical style, color, and material throughout the facility.
   3. Device nameplates information:
      a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.

B. Wire numbers:
   1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
      a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
      c. Internal panel wires on a common terminal shall have the same wire number.
      d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
         1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings.
   2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.



OR

Where:

ORIGIN LOC.= Designation for originating panel or device
ORIGIN TERM. = Terminal designation at originating panel or device
DEST. LOC. = Designation for destination panel or device
DEST. TERM. = Terminal designation at destination panel or device or PLC I/O address at destination panel:

a. Identify equipment and field instruments as the origin.
b. PCMs are always identified as the destination.
c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g., T1, T2, T3, etc.).
f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
    1) Discrete Point: W:X:Y/Z.
    Analog Point: W:X:Y.Z.
    Where:
    W= I for input, O for output.
    X= PLC number (1, 2, 3…)
    Y= Slot number (01, 02, 03…)
    Z= Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)
g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g., C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g., C0010A).

3. **Case 1**: Vendor control panel (VCP) to process control module (PCM):
Field wire number/label: A-B/C-D
A = Vendor control panel number without hyphen (VCP#)
B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)
C = Process control module number without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples: VCP#-10/PCM#-I: 1:01/01
VCP#-10/PCM#-O: 1:10/07
VCP#-10/PCM#-C0100

4. **Case 2**: Field instrument to process control module (PCM):
   Field wire number/label: E-F/C-D
   C = Process control module number without hyphen (PCM#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)
   E = Field mounted instrument tag and loop numbers without hyphen (EDV#)
   F = Manufacturer’s standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

   Examples: TIT#-2,3/PCM#-I: 1:01.1
   TSH#-1/PCM#-I: 2:01/00

5. **Case 3**: Motor control center (MCC) to process control module (PCM):
   Field wire number/label: G-B/C-D
   B =Terminal number within Motor Control Center (manufacturer’s or vendor’s standard terminal number)
   C = Process control module without hyphen (PCM#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a “C” prefix if not connected directly to a PLC I/O point (C0010)
   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Examples:MMS#-10/PCM#-I: 1:01/01
   MMS#-10/PCM#-O: 1:10/07
   MMS#-10/PCM#-C0100

6. **Case 4**: Motor control center (MCC) to vendor control panel (VCP):
   Field wire number/label: G-B/A-B
   A = Vendor control panel number without hyphen (VCP#)
   B = Terminal number within motor control center or vendor control panel (manufacturer’s or vendors standard terminal number)
   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Example: MMS#-X2/VCP#-10

7. **Case 5**: Motor leads to a motor control center (MCC):
   Field wire number/label: H-I/G-B
   B = Terminal number within motor control center (manufacturer’s standard terminal number)
   G = Actual starter designation in the motor control center without hyphen (MMS#)
   H = Equipment tag and loop number without hyphen (PMP#)
   I = Motor manufacturer’s standard motor lead identification (e.g., T1, T2, T3, etc.)

   Example: PMP-#-T3/MMS#-T3

8. **Case 6**: Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):
   Field wire number/label: J-B/C-D
   B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)
   C = Process control module number without hyphen (VCP#)
   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
   J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

   Examples: MMS#-10/PCM#-I: 1:01/01
   MMS#-10/PCM#-O: 2: 10/07
   MMS#-10/PCM#-C0010

9. **Case 7**: Field bus trunk segment:
   Field cable number/label: C/K-L/M; C/K-L/H; C/K-L/J
   C = Process control module without hyphen (PCM#).
   K = Field bus cable type.
   L = Field bus segment number.
   M = Field Bus field network component without hyphen (PTB1) or
   H = Equipment tag and loop number without hyphen (EMV#) or
   J = Starter or variable frequency drive tag and loop number without hyphen (VFD60.0112)

   Examples: PCM#/PA-1A/PTB1PTB1/PA-1B/PTB2
   PCM#/DN-1A/VFD#
   PCM#/DP-2A/ EMV#

10. **Case 8**: Field bus spur (drop):
    Field cable number/label: E/K-L/M
    E = Field mounted instrument tag and loop numbers without hyphen (FIT#)
    K = Field bus cable type.
    L = Field bus segment number
    M = Field bus field network component without hyphen (PTB1), identify ports on the device.

    Examples: FIT#/PA-1C/PTB1-1
    FIT#/PA-1D/PTB1-2

11. Identify all spare conductors as required for other field wires with an "S" prefix:

    Example: S MMS#-10/PCM#-C011

2.03 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

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

C. Conduit and raceway markers:
    1. Brass, one of the following or equal:
        a. Panduit.

2.04 MATERIALS

A. Nameplates:
    1. Colors:
        a. Warning nameplates: White-center, red face.
        b. Other nameplates: Black-center, white face.
    2. Laminated plastic engraving stock:
        a. 3/32-inch-thick material.
        b. 2-ply.
    3. With chamfered edges.
    4. Lettering:
        a. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
        b. Minimum letter height: 1/8-inch.

B. Signs:
    1. Automatic equipment and high voltage signs:
        a. Suitable for exterior use.
        b. In accordance with OSHA regulations.

C. Conductor and cable markers:
    1. Lettering:
        a. Machine printed black characters on white tubing.
        b. Minimum letter height: 10-point type or larger.

D. Conduit and raceway markers:
    1. Solid brass:
        a. Minimum thickness: 0.036 inches.
        b. Letter characters stamped.
        c. Minimum letter height: 3/16 inch.

E. Medium voltage circuit raceway labels:
   1. Vinyl plastic.
   2. Minimum letter height: 1 inch.

PART 3 EXECUTION

3.01 INSTALLATION

A. Nameplates:
   1. Attach nameplates to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. Provide a nameplate for each disconnecting means with the following:
      a. Equipment served, voltage, and fuse size as required.
      b. Identification of the circuit source that supplies the disconnecting means.
   3. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
   4. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
      a. Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the Engineer.

B. Conductor and cable markers:
   1. Apply all conductor and cable markers before termination.
   2. Non heat-shrinkable tubing:
      a. Tubing shall be sized for the wire and insulation on which it is to be placed.
      b. Tubing shall be tight on the wire.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

C. Conduit markers:
   1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Conduit markings shall match the conduit schedule.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. The middle of conduits that are 10 feet or less in length.
      c. Where the conduit penetrates a wall or structure.
      d. Where the conduit emerges from the ground, slab, etc.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Attach brass tags with Type 316 stainless steel wires.
   6. Mark conduits before construction review by Engineer for punch list purposes.
   7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

D. Signs and labeling:
    1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
        a. Fasten warning signs with round head stainless steel screws or bolts.
        b. Locate and mount in a manner to be clearly legible to operations personnel.
    2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc. where the voltage exceeds 600 volts.
    3. Furnish and install warning signs on equipment that has more than one source of power.
        a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
    4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
        a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
    5. Label service entrance equipment, switchgear, switchboards, MCCs, panelboards, and transfer switches with the available short circuit current, equipment label, and date of application in accordance with NEC. Coordinate with Section 16305 - Electrical System Studies for available fault current data.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.03 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 16285

SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. High-energy surge protective devices.

1.02 REFERENCES

A. Definitions:
   1. I_n: Nominal discharge current.
   2. MCOV: Maximum continuous operating voltage.
   3. MOV: Metal oxide varistor.
   4. SAD: Silicon avalanche diode.
   5. SCCR: Short circuit current rating.
   6. SPD: Surge protective device.
   7. VPR: Voltage protection rating.

B. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE):
      a. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
      b. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1,000 V and Less) AC Power Circuits.
      c. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000 V and Less) AC Power Circuits.
      d. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1,000 V and less) AC Power Circuits.
   2. International Electrotechnical Commission (IEC).
   3. National Electric Code (NEC).
   4. National Electrical Manufacturers Association (NEMA).
   5. National Fire Protection Agency (NFPA):
      a. 20 - Standard for the Installation of Stationary Pumps for Fire Protection.
      b. 70 - National Electric Code (NEC).
      c. 75 - Standard for the Fire Protection of Information Technology Equipment.
      d. 780 - Standard for the Installation of Lightning Protection Systems.
   6. Underwriters Laboratory (UL):
      a. 96A - Standard for Installation Requirements for Lightning Protection Systems.
      b. 1283 - Standard for Electromagnetic Interference Filters.
      c. 1449 - Standard for Surge Protective Devices.

1.03 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
   2. Manufacturer's catalog cutsheets indicating:
      a. Manufacturer and model numbers.
      b. Ratings of each SPD including but not limited to:
         1) Short circuit current rating.
         2) Nominal discharge current.
         3) Maximum continuous operating voltage.
         4) Voltage protection rating.
         5) System voltage.
         6) System frequency.
         7) Surge current capacity.
   3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
      a. Overcurrent protection.
      b. UL 1449.

C. Shop drawings:
   1. Provide electrical and mechanical drawings by the manufacturer that detail:
      a. Unit dimensions.
      b. Weights.
      c. Components.
      d. Field connection locations.
      e. Mounting provisions.
      f. Connection details.
      g. Wiring diagram.

D. Commissioning submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Certificates:
         1) Requirements as specified in this Section.
      b. Test Plans:
         1) Test requirements as specified in this Section.
      c. Test Reports.
      d. Owner training.

E. Operation and maintenance manuals:
   1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.04 QUALITY ASSURANCE

A. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
   1. IEEE C62.41.1, C62.41.2, C62.45, C62.62.
   2. Federal Information Processing Standards Publication 94 (FIBS PUB 94).

3. NEMA.
4. NFPA 20, 70, 75 and 780.
5. UL 1449 4th Edition and UL 1283.

B. IEC 801.

C. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B and C3 environments, as tested to IEEE C62.45.

1.05 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.06 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
1. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Extended warranty:
1. Furnish a manufacturer’s full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
2. Warranty shall include:
a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
b. A 24-hour toll-free 800-number for warranty support.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Provide surge protection as indicated on the Drawings.

2.02 MANUFACTURERS

A. One of the following or equal:
1. ABB.
2. Eaton.
3. Southern Tier Technologies.
4. Schneider Electric.

2.03 EQUIPMENT

A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.

B. Electrical requirements:
   1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
   2. MCOV:
      a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
   3. Operating frequency:
      a. 47 to 63 hertz.
   4. SCCR:
      a. 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
      b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
   5. Nominal discharge current I_n:
      a. 20 kA.
   6. Maximum VPR:

Modes	240/120 3W	208Y/120	480Y/277	480V
L-N, L-G, N-G	700	700	1,200	1,800
L-L	1,200	1,200	1,800	1,800

   7. Peak surge current:
      a. Service entrance locations:
         1) 240 kA per phase minimum.
         2) 120 kA per mode minimum.
      b. Branch locations:
         1) 120 kA per phase, minimum.
         2) 60 kA per mode minimum.

C. Protection modes:
   1. Provide SPD protection modes as follows:
      a. Line to Neutral (L-N) where applicable.
      b. Line to Ground (L-G).
      c. Neutral to Ground (N-G), where applicable.

D. Environmental requirements:
   1. Storage temperature:
      a. -40 degrees to 122 degrees Fahrenheit.
   2. Operating temperature:
      a. 32 degrees to 140 Fahrenheit.
   3. Relative humidity:
      a. 5 percent to 95 percent.

4. Audible noise:
    a. Less than 45 dBa at 5 feet (1.5 m).
5. Operating altitude:
    a. Zero to 12,000 feet above sea level.

2.04 COMPONENTS

A. Enclosure:
    1. Located in electrical equipment as indicated on the Drawings.

B. Internal connections:
    1. Provide low impedance copper plates for intra-unit connections:
        a. Attach surge modules using bolted connections to the plates for low impedance connections.
    2. Size all connections, conductors, and terminals for the specified surge current capacity.

C. Surge diversion modules:
    1. MOV:
        a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.

D. Overcurrent protection:
    1. Individually fuse all components, including suppression, filtering, and monitoring components:
        a. Rated to allow maximum specified nominal discharge current capacity.
        b. Overcurrent protection that limits specified surge currents is not acceptable.

E. Connections:
    1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.05 ACCESSORIES

A. Unit status indicators:
    1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
        a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
        b. Indicates the status of protection on each mode or phase.

B. Dry contacts for remote monitoring:
    1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.

C. Provide an audible alarm which activates under any fault condition:
    1. Provide an alarm On/Off switch to silence the alarm.
    2. A visible LED will confirm whether alarm is On or Disabled.
    3. Locate both switches and the audible alarm on the unit’s front cover.

2.06 SOURCE QUALITY CONTROL

A. Permanently affix surge rating to the SPD.

PART 3 EXECUTION

3.01 INSTALLATION

A. Follow the manufacturer's recommended installation practices and comply with all applicable codes.

B. Special techniques:
   1. Install SPDs internal to equipment with as short and straight conductors including ground conductor as practically possible:
      a. Twist the input conductors together to reduce input conductor inductance.
   2. Do not subject SPD to insulation resistance testing.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing:
   1. Perform manufacturer’s standard factory test:
      a. Perform testing in accordance with UL 1449.
   2. Furnish test reports and Manufacturer’s Certificate of Source Testing.

C. Functional Testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 16305

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Short-circuit fault analysis study.
   2. Protective device coordination study.
   3. Arc-flash hazard study.

1.02 REFERENCES

A. Definitions:
   1. Modified: Equipment with load additions or with loads being removed that affect fault current, include new overcurrent protective devices that require settings and device coordination, or require additional/removal/replacement of arc flash labels.

B. Standards:
   1. American National Standards Institute (ANSI).
   2. Institute of Electrical and Electronics Engineers (IEEE):
      a. 1584 - IEEE Guide for Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculations Study in Accordance with IEEE Std 1584(TM).
   3. National Fire Protection Association (NFPA):
      a. 70E – Standard for Electrical Safety in the Workplace.

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Signed and Sealed electrical system study reports.

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. Initial studies and reports:
   1. Include the following in the initial short-circuit current report:
      a. List of all devices included in the studies.
      b. A description of all operating scenarios.
      c. Form and format of arc-flash labels.

C. Delegated Design final studies and reports:
    1. Format and quantity:
        a. Provide 6 bound copies of all final reports.
        b. Provide 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, and any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.
    2. Include the sections below in the final report:
        a. Copies of correspondence and data obtained from the electric utility company.
        b. Letter certifying the inspection and verification of existing equipment and incorporation of applicable RFI's and change orders.
        c. One-line diagrams:
            1) The following information shall be included at a minimum:
                a) Motor horsepower.
                b) Transformer data:
                    (1) kVA.
                    (2) Configuration.
                c) Cable data:
                    (1) Insulation.
                    (2) Size.
                    (3) Length.
            2) One-line diagrams shall be fully legible at 11-inch by 17-inch size.
        d. Include in the short-circuit fault analysis study:
            1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
            2) Normal system connections and those that result in maximum fault conditions.
            3) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
            4) Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.
        e. Protective device coordination study shall include:
            1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
            2) List all requirements used in the selection and setting criteria for any protective devices.
            3) Manufacturer's time-current curves for circuit breakers, fuses, motor circuit protectors, and other protective devices for all new equipment.
            4) TCCs graphically indicating the coordination proposed for the system on log-log graphs:
                a) All TCCs shall be in color.
            5) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
            6) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.
            7) All protective device settings in a tabulated format.

f. Include in the arc-flash hazard study:
    1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
    2) Normal system connections and those that result in maximum arc-flash conditions.
    3) Arc-flash raw data, calculations, and assumptions.
    4) Arc-flash label data:
        a) Identifying the content of each label.
        b) Identifying the location of each label.

D. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.

E. Submit course outline for Owner's training.

1.05 QUALITY ASSURANCE

A. Qualifications of the entity responsible for electrical system studies:
    1. A minimum of 5 years of experience in power system analysis is required for the individual in responsible charge of the studies.
    2. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
        a. Point-to-point calculations are not acceptable.

B. The study shall be performed by an independent firm.

1.06 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
    1. The individual performing the studies shall visit the site and collect all necessary field data in order to perform and complete comprehensive electrical system studies.
    2. Obtain, for all equipment, the required data for preparation of the study including, but not limited to:
        a. Transformer kilovolt-ampere (kVA), nameplate data, and impedances.
        b. Generator impedances, kilovolt-ampere (kVA), and voltage.
        c. Generator decrement curves.
        d. Bus withstand ratings.
        e. Cable and bus data.
        f. Protective device taps, time dials, instantaneous pickups, and time-delay settings.
        g. As-built lengths for all new wire and cable installations covered by the studies.
        h. Grounding schemes (solidly grounded or resistive grounded).
    3. Obtain the Electric Utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
        a. Utility tolerances and voltage variations.
    4. Obtain equipment layouts and configurations from the manufacturer's final submittal requirements and project layout drawings as required.

5. Bus and conductor data:
    a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
    b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
    c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
    d. Use bus withstand values for all equipment having buses.

B. Use medium-voltage cable reactance based on typical dimensions of shielded cables with 133 percent insulation levels, unless otherwise indicated.

C. Certification:
    1. Submit written certification signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor stating that the data used in the study is correct and captures all RFI's, as-builts, and change orders affecting the study.

D. Meetings:
    1. Electrical system study meetings:
        a. As specified in Section 01312 - Project Meetings.
        b. The individual conducting the electrical system studies leads the meeting.
        c. Meet with the Owner and Engineer 3 times.
        d. The purpose of the 3 meetings is as follows:
            1) Initial meeting:
                a) Timing:
                    (1) After delegated design qualifications have been submitted and approved.
                    (2) Prior to producing any electrical equipment submittals.
                b) Meet with the Owner and Engineer to discuss the scope of the studies.
                    (1) Confirm assumptions to be used in the electrical system study with the Owner including but not limited to:
                        (a) Maximum protective device fault clearing time.
                c) Discuss the Owner's operational requirements for both normal operation and maintenance.
            2) Preliminary results meeting:
                a) Timing:
                    (1) After the studies have been completed, reviewed, and accepted by the Engineer.
                b) The purpose of this meeting is to inform the Owner of the results of the study and impacts on normal operation and maintenance including:
                    (1) Protective device coordination problems and recommended solutions.
                    (2) Explanation of the arc-flash hazard study results and its potential impact on operations.
                    (3) Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.

3) Final meeting:
a) Timing:
(1) Prior to substantial completion.
b) Discuss changes to the studies based on the previous meeting.
c) Discuss with the Owner how changes to the electrical system may change the arc-flash hazard category.

E. Sequencing:
1. Below is an outline of the typical work sequence. Proposed changes to the work sequence may be reviewed and approved by the Engineer.
a. Site visit to gather data on the existing facility systems for all studies:
1) Make multiple trips as required to obtain all data for the short-circuit fault analysis, protection device coordination, and arc flash hazard studies.
2) If all new equipment, available data may be gathered from equipment submittals.
b. Initial electrical system study meeting.
c. Submit the initial short-circuit fault analysis study before submittal of any electrical equipment.
1) Only the initial short-circuit results will be reviewed.
d. Submit the preliminary short-circuit fault analysis, protective device coordination, and arc-flash hazard studies after the approval of all electrical equipment.
e. Second electrical system study meeting for preliminary results.
f. Update the model with all changes to the electrical system made during start-up and commissioning.
g. Final arc-flash meeting and final short-circuit fault analysis, protective device coordination, and arc-flash hazard studies.
h. Submit the final electrical system studies.
i. Label equipment with approved arc-flash labels.
j. Owner’s training.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General study requirements:
1. Scope:
a. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall include all equipment in the power distribution system including, but not limited to:
1) Utility equipment (utility transformer and primary protective device).
2) Available utility fault contribution current.
3) All electrical equipment including:
a) Dry-type transformers.
b) 240- and 208-volt panelboards.
4) Generators.
5) Motors.
6) Vendor control panels.
7) HVAC equipment.

b. Study scenarios:
1) The studies shall include all possible electrical system configurations, for example:
a) Operation on normal (utility) source.
b) Operation on generator source.

2. Motors:
a. Each motor shall be individually modeled:
1) Grouping of motors for fault contribution current is not acceptable.

3. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Short-circuit fault analysis study additional requirements:
1. The short-circuit fault analysis shall be performed and submitted in 2 phases:
a. Initial short-circuit fault analysis:
1) Based on the Contract Documents and Electric Utility information.
2) The initial short-circuit fault analysis study shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
a) Measure conductor lengths from the Drawings. Use of arbitrary short conductor lengths is not allowed.
3) Provide a list of assumptions used in the initial study.
b. Final short-circuit fault analysis:
1) The final short-circuit fault analysis shall modify the initial analysis as follows:
a) Utilize the actual equipment provided on the project.
b) Utilize conductor lengths based on installation.

2. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 to 4 cycle interrupting symmetrical RMS, and 30-cycle steady-state short-circuit current values at each piece of equipment in the distribution system.
3. Evaluate bus bracing, short-circuit ratings, fuse interrupting capacity and circuit-breaker-adjusted interrupting capacities against the fault currents, and calculate X/R values:
a. Identify and document all devices and equipment as either inadequate or acceptable.
4. Calculate line-to-ground and double line-to-ground momentary short-circuit values at all buses having ground-fault devices.
5. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including utility X/R ratios, typical values, recommendations, and areas of concern.

C. Protective device coordination study additional requirements:
1. Furnish protective device settings for all functions indicated on the Drawings including, but not limited to:
a. Current.
b. Voltage:
1) Provide settings for all voltage relays based upon actual utility and generator tolerances and specifications.

c. Frequency:
    1) Provide settings for all frequency relays based upon actual utility and generator tolerances and specifications.
d. Negative sequence.
e. Reverse power.
f. Machine protection functions:
    1) Provide settings for all motor and generator protective relays based on the manufacturer's recommended protection requirements.

2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
    a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
        1) Typical TCCs for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.
    b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
        1) These details can be included on the TCC.
    c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
        1) These details can be included on the TCC.
3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include utility relay and fuse characteristics, medium-voltage equipment protective relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
    a. Include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards, and fused disconnect switches.
    b. Provide ground fault TCCs with all adjustable settings for ground fault protective devices.
    c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.
    d. On the TCCs, show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and transformer damage curves.
    e. Cable damage curves.
    f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.
    g. Coordinate time interval medium-voltage relay characteristics with upstream and downstream devices to avoid nuisance tripping.
4. Site generation: When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:
    a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.
5. Suggest modifications or additions to equipment rating or settings in a tabulated form.

D. Arc-flash hazard study additional requirements:
    1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
        a. Perform study with 15 percent arcing fault variation in accordance with IEEE 1584.
        b. Perform arc-flash calculations at minimum and maximum utility and generator fault contributions.
        c. Perform arc-flash calculations for both the line side and load side of the switchgear, switchboard, motor control center, and panelboard main breakers.
        d. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
    2. Provide executive summary of the study results:
        a. Provide summary based upon worst case results.
    3. Provide a detailed written discussion and explanation of the tabulated outputs:
        a. Include all scenarios.
    4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:
        a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
        b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

2.02 MANUFACTURERS

A. Electrical system study software: One of the following or equal:
    1. EasyPower, Power System Software.
    2. SKM Systems Analysis, Powertools.

2.03 COMPONENTS

A. Arc-flash hazard labels:
    1. Dimensions:
        a. Minimum 5 inches by 3.5 inches.
    2. Materials:
        a. Polyester with polyvinyl polymer over-laminate.
        b. Self-adhesive.
        c. Resistant to:
            1) UV.
            2) Chemicals and common cleaning solvents.
            3) Scuffing.
            4) Wide temperature changes.
    3. Contents:
        a. Short-circuit bus identification.
        b. Calculated incident energy (calories/square centimeter) range:
            1) Based on worst-case study results.
        c. Arc-flash protection boundary.

d. Shock hazard boundary:
    1) The Contractor may provide separate labels for indication of the shock hazard boundary.
e. Fed from:
    1) Identify the tag number of the upstream equipment providing power.

4. Color scheme:
    a. For locations above 40 calories/square centimeter:
        1) White label with red “DANGER” strip across the top.
        2) Black lettering.
    b. For locations below 40 calories/square centimeter:
        1) White label with orange “WARNING” strip across the top.
        2) Black lettering.

PART 3 EXECUTION

3.01 INSTALLATION

A. After review and acceptance of the arc-flash hazard study by the Engineer, install all arc-flash hazard labels:
    1. Install labels at all locations required by NFPA, ANSI, or IEEE standards.
    2. At a minimum, install labels in the following locations:
        a. The front of each main or incoming service compartment.
        b. The front of each low-voltage switchgear section.
        c. The front of each medium-voltage circuit breaker door.
        d. The front of each accessible auxiliary or conductor compartment.
        e. Each accessible rear or side vertical section.
        f. Each motor control center vertical section.
        g. Each panelboard covered by the study.
        h. Each control panel, individual starter or VFD, or other equipment covered by the scope of the study.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
    1. Include, but is not limited to:
        a. Introduction and basics of NFPA 70E: 2 hours 2 sessions.
        b. Detailed review of the electrical system study 2 hours 1 session.

3.03 FIELD QUALITY CONTROL

A. The individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
    1. Remove and replace any improperly applied labels.
    2. Repair the equipment finish damaged by removal of any label.
    3. Install labels level or plumb across the entire dimension of the label.

3.04 ADJUSTING

A. After review and acceptance of the draft arc-flash hazard study and protective device coordination study by the Engineer, adjust protective device settings per final study prior to equipment energization.
   1. Devices that require power for configuration may be set during energization, but before any subfed loads are energized.
      Ensure that settings for upstream equipment are set prior to energizing downstream devices. Provide documentation that protective devices are set per the study recommendation.

END OF SECTION

SECTION 16411

DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Knife blade fusible and non-fusible disconnect switches.
   2. Switch-rated plugs and receptacles.

1.02 REFERENCES

A. National Electric Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. Underwriters Laboratories Inc. (UL):
   1. 98 - Enclosed and Dead-Front Switches.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Safety switches and disconnect switches are to be considered synonymous.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Manufacturer.
   2. Manufacturer's specifications and description.
   3. Ratings:
      a. Voltage.
      b. Current.
      c. Horsepower.
      d. Short circuit rating.
   4. Fused or non-fused.
   5. NEMA enclosure type.
   6. Dimensions:
      a. Height.
      b. Width.
      c. Depth.
   7. Weight.
   8. Cross-referenced to the disconnect schedule indicated on the Drawings.

C. Shop Drawings:
   1. Manufacturer's installation instructions:
      a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
      b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
   2. For each switch, indicate nameplate inscription, including voltage, circuit, fuse size (if applicable), and equipment served.

D. Installation instructions:
   1. Provide manufacturer’s installation instructions.

1.05 QUALITY ASSURANCE

A. Regulatory requirements:
   1. NEMA Type KS 1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
   2. UL 98 - Enclosed and Dead-Front Switches.

B. Disconnect switches shall be UL listed and labeled.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. After successful review of the initial fault current study, submit complete equipment Submittal.

1.08 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Provide knife blade disconnect switches and switch-rated plugs and receptacles as indicated on the Drawings and specified in the Contract Documents.

B. Provide equipment with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

2.02 MANUFACTURERS

A. Knife-blade disconnect switches:
   1. One of the following or equal:
      a. ABB.

b. Appleton.
c. Crouse-Hinds.
d. Eaton.
e. Schneider Electric.
f. Siemens.

B. Switch-rated plugs and receptacles:
1. One of the following or equal:
a. Hazardous location plugs and receptacles:
1) MELTRIC DXN Series or equal.
b. High amp plugs and receptables:
1) MELTRIC PF/PFQ Series or equal.
c. Non-hazardous plugs and receptacles:
1) Meltric.
2) Mennekes.

2.03 EQUIPMENT

A. Knife-blade style switch disconnects:
1. Switch mechanism:
a. Quick-make, quick-break heavy-duty operating mechanisms:
1) Provisions for padlocking the switch in the Off position.
2) A minimum of 90-degree handle travel position between Off and On positions:
a) Provide handle position indicators to identify the handle position.
3) Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
a) With an externally operated override.
2. Switch interior:
a. Switch blades visible when the switch is Off and the cover is open.
b. Lugs:
1) Front accessible.
2) Removable.
3) UL listed for 60/75-degree Celsius copper conductors.
c. Current carrying parts completely plated to resist corrosion.
d. Removable arc suppressors to facilitate easy access to line side lugs.
e. Furnish equipment ground kits for every switch.
3. Fused switches:
a. Furnish with fuses as indicated on the Drawings:
b. UL approved for field conversion from standard Class H fuse spacing to Class J fuse spacing:
1) Ratings 100 amps through 600 amps at 240 volts.
2) Ratings 30 amps through 600 amps at 600 volts.
3) Provide spring reinforced and plated fuse clips.
4. Ratings:
a. UL horsepower rated for AC or DC with the rating not less than the load served.
b. Current:
1) 30 to 1,200 amps.

c. Voltage:
    1) 250 volts AC, DC.
    2) 600 volts (30 A to 200 A, 600 volts DC).
d. Poles:
    1) 2, 3, 4, and 6 poles.
e. UL listed short circuit ratings:
    1) 10,000 RMS symmetrical amps when used with or protected by Class H or K fuses (30 to 600 amps).
    2) 200,000 RMS symmetrical amps when used with or protected by Class R or J fuses (30 to 600 amps employing appropriate fuse rejection).
    3) 200,000 RMS symmetrical amps when used with or protected by Class L fuses (800 to 1,200 amps).

B. Switch-rated plugs and receptacles:
1. General:
    a. Provide each disconnect plug and receptacle combination:
        1) Including the minimum number of power, ground, and/or control contacts necessary for the installation.
        2) Boxes as necessary to mount receptacles.
2. Non-hazardous plugs and receptacles:
    a. UL/CSA rated.
    b. Stainless steel or epoxy coated aluminum housing.
        1) Environmental rating: Type 4X, 12; IP 66 suitable.
    c. Auxiliary pilot contact.
    d. SCCR: 10KAIC without fuse.
    e. MSR series switched and interlocked receptacles incorporate an interlocking receptacle and disconnect switch in 1 nonmetallic NEMA 4X, 12 enclosure. Units are available in both fused and non-fused.
    f. Interlock mechanism to prohibit the disconnect from being energized unless the plug is fully inserted and prohibiting the plug from being removed unless the circuit is interrupted first.

C. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050 - Common Work Results for Electrical for the installed location.

D. Size, fusing and number poles as indicated on the Drawings or as required:
1. Provide solid neutral where indicated on the Drawings.

2.04 ACCESSORIES

A. Disconnect switches to have provisions for a field installable “B” type electrical interlock for position indication as indicated on the Drawings.

B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.

C. NEMA Type 7 and Type 9 enclosures furnished with drain and breather kit when used in outdoor applications.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. General:
   1. Use Myers hubs or bolt-on hubs for conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
   2. Provide mounting brackets, stands, supports and hardware as required:
      a. Match finish and materials for brackets, stands, and hardware with the switch installed.
      b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
   3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
      a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
      b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
   4. Provide a nameplate for each disconnect switch:
      a. As specified in Section 16075 - Identification for Electrical Systems.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

END OF SECTION

SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

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

1.02 REFERENCES

A. National Electrical Code (NEC).

B. Underwriter's Laboratories (UL):
   1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.
   2. Manufacturer's time-current curves for molded case circuit breakers furnished.

C. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Owner Training.

D. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

1.05 QUALITY ASSURANCE

A. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

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

2.02 MANUFACTURERS

A. One of the following or equal:
   1. ABB.
   2. Eaton.
   3. Schneider Electric.

2.03 MANUFACTURED UNITS

A. General:
   1. In accordance with UL 489.
   2. Operating mechanism:
      a. Quick-make, quick-break, non-welding silver alloy contacts.
      b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
      c. Mechanically trip free from the handle.
      d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
      e. Lockable in the “OFF” position.
   3. Arc extinction:
      a. In arc chutes.
   4. Voltage and current ratings:
      a. Minimum ratings as indicated on the Drawings.
      b. Minimum frame size 100A.
   5. Interrupting ratings:
      a. Minimum ratings as indicated on the Drawings.
      b. Modify as required to meet requirements of the short circuit fault analysis as specified in Section 16305 - Electrical System Studies.
      c. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.).

B. Motor circuit protectors:
   1. Instantaneous only circuit breaker as part of a listed combination motor controller.
   2. Each pole continuously adjustable in a linear scale with ‘LO’ and ‘HI’ settings factory calibrated.

2.04 COMPONENTS

A. Terminals:
   1. Line and load terminals suitable for the conductor type, size, and number of conductors indicated on the Drawings and in accordance with UL 489.

B. Case:
   1. Molded polyester glass reinforced.
   2. Ratings clearly marked.

C. Trip units:
   1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
   2. Thermal magnetic:
      a. Instantaneous short circuit protection.
      b. Inverse time delay overload.
      c. Ambient or enclosure compensated by means of a bimetallic element.
   3. Solid state:
      a. With the following settings as indicated on the Drawings:
         1) Adjustable long time current setting.
         2) Adjustable long time delay.
         3) Adjustable short time pickup.
         4) Adjustable short time delay.
         5) Adjustable instantaneous pickup.
         6) Adjustable ground fault pickup as indicated on the Drawings.
         7) Adjustable ground fault delay as indicated on the Drawings.

D. Molded case circuit breakers for use in panelboards:
   1. Bolt-on type:
      a. Plug-in type breakers are not acceptable.
   2. Ground fault trip devices as indicated on the Drawings.

2.05 ACCESSORIES

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

2.06 SOURCE QUALITY CONTROL

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

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install breakers to correspond to the accepted Shop Drawings.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.04 ADJUSTING

A. Adjust trip settings in accordance with Protective Device Coordination Study as accepted by the Engineer and in accordance with manufacturer's recommendations.

B. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

END OF SECTION

SECTION 16422

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Motor starters and contactors.

1.02 REFERENCES

A. Abbreviations:
   1. FVNR: Full voltage non-reversing.
   2. FVR: Full voltage reversing.
   3. PWS: Part winding start.
   4. RVAT: Reduced voltage auto transformer.
   5. RVSS: Reduced voltage solid state.
   6. TS1W: 2 speed 1 winding (consequent pole).
   7. TS2W: 2 speed 2 winding.

B. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE).
   2. International Electrotechnical Commission (IEC):
      a. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.
      b. 947-4 - Low-Voltage Switchgear and Control Gear.
   3. National Electrical Manufacturer's Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
         ICS 2-230 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.
   4. Underwriters Laboratories, Inc. (UL):
      a. 508 - Standard for Industrial Control Equipment.
      b. 508A - Standard for Industrial Control Panels.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Overload relay class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures:
   1. Submit motor starter data with equipment submittal.

B. Product data:
   1. Manufacturer.
   2. Catalog cutsheets.
   3. Technical information.
   4. Complete nameplate schedule.
   5. Complete bill of material.
   6. List of recommended spare parts.
   7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
   8. Electrical ratings:
      a. Phase.
      b. Wire.
      c. Voltage.
      d. Ampacity.
      e. Horsepower.
   9. Furnish circuit breaker submittals as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.

C. Shop Drawings:
   1. Elementary and schematic diagrams:
      a. Provide 1 diagram for every starter and contactor.
      b. Indicate wire numbers for control wires on the diagrams:
         1) Wire numbering as specified in Section 16075 - Identification for Electrical Systems.
      c. Indicate interfaces with other equipment on the Drawings.

D. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria:
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

E. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer’s representative qualifications.
      b. Certificates:
         1) Requirements as specified in this Section.

c. Test Plans:
    1) Test requirements as specified in this Section.
d. Test Reports.
e. Manufacturer's representatives field notes and data.
f. Owner Training.

F. Operation and maintenance manuals:
1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section, including, but not limited to:
    a. Electrical ratings:
        1) Phase.
        2) Wire.
        3) Voltage.
        4) Ampacity.
    b. Complete bill of material.
    c. Manufacturer's operating and maintenance instructions starter and/or contactor component parts, including:
        1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
        2) Pilot devices.
    d. Complete renewal parts list.
    e. As-built drawings:
        1) Furnish as-built drawings for each starter and contactor indicating final:
            a) Wire numbers.
            b) Interfaces with other equipment.
        2) 11-inch by 17-inch format.

1.06 QUALITY ASSURANCE

A. Regulatory requirements:
1. Starters and components shall be UL listed and labeled:
    a. UL 508 - Industrial Control Equipment.
    b. UL 508A - Industrial Control Panels.
2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
3. Combination starters shall be UL listed and labeled.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

1.09 MAINTENANCE

A. Spare parts:
   1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
      a. 1 spare breaker of each size and type per starter.

PART 2 PRODUCTS

2.01 GENERAL

A. Starters for motor control centers, individual enclosed starters, or control panels.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in Section 01850 - Design Criteria and as indicated on the Drawings.

B. Non-conditioned spaces:
   1. For equipment located in non-conditioned spaces, provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

C. Outdoor installations:
   1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer’s specified operating ranges.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. NEMA starters and contactors:
      a. ABB.
      b. Allen-Bradley.
      c. Eaton.
      d. Schneider Electric.

2.04 MANUFACTURED UNITS

A. General:
   1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
   2. NEMA size, design, and rated:
      a. NEMA Size 1 minimum.

3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor.
    a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking contacts.
5. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.

B. Manual motor starters:
    1. General:
        a. Provide with number of poles as indicated on the Drawings or as required by the connected load.
        b. Provide handles that clearly indicate the On and Off (with lockout), positions.
        c. Switch shall have positive, quick-make, quick-break mechanisms.
    2. Thermal overload switches:
        a. Provide thermal overloads in manual motor starters where integral overloads are not furnished with the motor.
        b. Size heater elements for approximately 115 percent of the nameplate full load current, for motors with a 1.15 service factor.
        c. Thermal overload units in all phase legs.
        d. Overload conditions interrupts ungrounded conductors.
    3. Enclosure:
        a. Provide the NEMA enclosure type specified in Section 16050 - Common Work Results for Electrical for the starter location.

2.05 COMPONENTS

A. Molded case circuit breakers:
    1. Circuit breaker type and ratings as indicated on the Drawings.
    2. Provide as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.

B. Contactors:
    1. NEMA size as indicated on the Drawings.
    2. Electrically held:
        a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
    3. Factory adjusted and chatter free.
    4. Auxiliary contacts:
        a. Contact ratings in accordance with NEMA A600 rating:
            1) Auxiliary contacts rated 10 amps at 600 volts.
        b. Provide contacts indicated on the Drawings and any additional contacts required for proper operation.
        c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.

5. Constructed in accordance with the following standards:
    a. UL 508.
    b. IEC 947-4:
        1) Type 1 coordination when protected by a circuit breaker.
        2) Type 2 coordination when protected by a suitable UL listed fuse.
    c. IEC 801-1 parts 2 through 6.

C. Overloads:
1. Solid state electronic:
    a. Selectable Class 10, 20protection.
    b. Ambient insensitive:
        1) Operating temperature: -20 to 70 degrees Celsius.
    c. Thermal memory.
    d. Protective functions:
        1) Motor overcurrent.
    e. Self-powered.
    f. Provide current transformers for metering of motor current.
    g. Visible trip indicator.
    h. Push-to-trip test.
    i. Isolated normally open alarm contact.
    j. Normally closed trip contact.
    k. Manual reset.

D. Control power transformer:
1. Furnish integral control power transformer capacity to power:
    a. Motor controls: Motor and starter accessories indicated on the Drawings or specified.
2. Primary and secondary fusing as indicated on the Drawings:
    a. Fusing sized by the manufacturer for the rating of the transformer furnished.
3. Control power transformer secondary voltage:
    a. As indicated on the Drawings.

2.06 ACCESSORIES

A. Lugs and terminals:
1. For external connections of No. 6 AWG and larger.
2. UL listed for either copper or aluminum conductors.

B. Surge protective devices:
1. Furnish surge protection devices across the coil of each starter, contactor, and relay.

C. Pilot devices:
1. Provide pilot lights, switches, elapsed time meters, and other devices as specified or as indicated on the Drawings.
2. As specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

D. Nameplates and wire markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

E. Conformal coating:
   1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. Starters in control panels:
   1. Install as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

C. Manual motor starters:
   1. Provide complete mounting brackets and hardware as necessary for complete support of manual motor starter at locations indicated on the Drawings.
   2. Mount manual motor starter rigidly to exposed building or equipment structural members.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing:
   1. Witnessed, in-person:
      a. Number of Owner and Engineer representatives in person: 2.
   2. Prove out overload control logic as well as interaction with Owner’s control and maintenance systems at the Supplier's facility:
      a. PCIS Programmer shall attend witnessed testing.
   3. Furnish test reports and Manufacturer’s Certificate of Source Testing.

C. Owner Training:
   1. Not required.

3.04 ADJUSTING

A. Make adjustments as necessary and as recommended by the manufacturer, Engineer, or testing firm.

B. Set overloads and motor circuit protectors based on the nameplate values of the installed motor.

END OF SECTION

SECTION 16950

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Responsibilities for testing the electrical installation.
   2. Adjusting and calibration.
   3. Acceptance tests.

B. Copyright information:
   1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

A. Definitions:
   1. Testing laboratory: The organization performing the acceptance tests.

B. Project references:
   1. Specification sections for the electrical equipment being tested.
   2. Electrical equipment shop drawings.

C. Standards:
   1. American National Standards Institute (ANSI).
   2. ASTM International (ASTM):
      a. D877 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
      b. D923 - Standard Practices for Sampling Electrical Insulating Liquids.
      c. D924 - Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
      d. D971 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
      e. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
      f. D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
      g. D1500 - Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
      h. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
      i. D1533 - Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.

j. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
k. D3612 - Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography.

3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   b. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
   c. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
   d. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
   e. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
   f. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
   g. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
   h. C57.13 - IEEE Standard Requirements for Instrument Transformers.
   i. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
   j. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
   k. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.
4. Insulated Cable Engineer's Association (ICEA).
5. InterNational Electrical Testing Association (NETA).
   a. ATS- Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
6. International Electrotechnical Commission (IEC).
7. National Electrical Manufacturers Association (NEMA):
   a. MG1 - Motors and Generators.
8. National Fire Protection Association (NFPA):
   a. 70 - National Electrical Code (NEC).
   b. 110 - Standard for Emergency and Standby Power Systems.
   c. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

A. General submittal requirements:
   1. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. Copper Ethernet test form:
   1. Cable test reports:
      a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
         1) Test type.
         2) Test location.

3) Test date.
4) Cable number.
5) Cable length.
6) Certification that the cable meets or exceeds the specified standard.

b. Furnish hard copy and electronic copy for all traces.

C. Manufacturers' testing procedures:
1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer prior to beginning testing.

D. Test report:
1. Include the following:
a. Summary of Project.
b. Description of equipment tested.
c. Description of tests performed.
d. Test results.
e. Conclusions and recommendations.
f. Completed test forms.
g. List of test equipment used and calibration dates.
h. LAN cable test reports.

E. Test data records:
1. Include the following:
a. Identification of the testing organization.
b. Equipment identification.
c. Nameplate data.
d. Humidity, temperature and or other conditions that may affect the results of the tests and or calibrations.
e. Dates of inspections, tests, maintenance and or calibrations.
f. Indication of the inspections, tests, maintenance, and or calibrations to be performed and recorded.
g. Expected results when calibrations are to be performed.
h. Indication of as-found and as-left results as applicable.
i. Indication of all test results outside specified tolerances.

F. Testing laboratory qualifications:
1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
1) Corporate history and references.
2) Resume of individual performing test.
3) Equipment list and test calibration data.

G. Division of responsibilities:
1. Submit a list identifying who is responsible for performing each portion of the testing.

1.04 QUALITY ASSURANCE

A. Testing laboratory qualifications:
   1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
   2. NETA certification required.
   3. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.05 PROJECT OR SITE CONDITIONS

A. General site and project conditions:
   1. As specified in Section 01850 - Design Criteria.

1.06 ADMINISTRATIVE REQUIREMENTS

A. General requirements:
   1. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.
   2. Conduct all tests in the presence of the Engineer or the Engineer's representative:
      a. Engineer will witness all visual, mechanical, and electrical tests, and inspections.
   3. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.

B. Responsibilities:
   1. Contractor responsibilities:
      a. Ensure that all resources are made available for testing, and that all testing requirements are met.
   2. Electrical subcontractor responsibilities:
      a. Perform routine tests during installation.
      b. Demonstrate operation of electrical equipment.
      c. Commission the electrical installation.
      d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
         1) Providing electrical power as required.
         2) Operating of electrical equipment in conjunction with testing of other equipment.
         3) Activating and shutting down electrical circuits.
         4) Making and recording electrical measurements.
         5) Replacing blown fuses.
         6) Installing temporary jumpers.
   3. Testing laboratory responsibilities:
      a. Perform all acceptance tests specified in this Section.
      b. Provide all required equipment, materials, labor, and technical support during acceptance tests.

C. Sequencing:
    1. Prior to testing:
        a. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.
    2. Perform testing in the following sequence:
        a. Perform routine tests as the equipment is installed including:
            1) Insulation-resistance tests.
            2) Continuity tests.
            3) Rotational tests.
        b. Adjusting and preliminary calibration.
        c. Acceptance tests.
        d. Demonstration.
        e. Commissioning and pump station start-up.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 EXECUTION

2.01 PREPARATION

A. Test instrument calibration:
    1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
        a. The calibrating standard shall be of better accuracy than that of the equipment tested.
    2. The accuracy shall be traceable to the NIST in an unbroken chain.
    3. Calibrate instruments in accordance with the following frequency schedule:
        a. Field instruments: 6 months maximum.
        b. Laboratory instruments: 12 months maximum.
        c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
    4. Dated calibration labels shall be visible on all test equipment.
    5. Maintain an up-to-date instrument calibration record for each test instrument:
        a. The records shall show the date and results of each calibration or test.
    6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.

B. Requirements prior to testing:
    1. Do not begin testing until the following conditions have been met:
        a. All instruments required are available and in proper operating condition.
        b. All required dispensable materials such as solvents, rags, and brushes are available.
        c. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.

d. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
e. Data sheets to record all test results are available.

2.02 INSTALLATION

A. Test decal:
1. The testing laboratory shall affix a test decal on the exterior of equipment or equipment enclosure of protective devices after performing electrical tests.
2. The test decal shall be color coded to communicate the condition of maintenance of the protective. The color scheme for condition of maintenance of overcurrent protective devices shall be:
a. White: electrically and mechanically acceptable.
b. Yellow; minor deficiency not affecting fault detection and operation, but minor electrical or mechanical condition exists.
3. The decal shall include the following information at a minimum:
a. Testing organization.
b. Project identifier.
c. Test date.
d. Technician identifier.

2.03 COMMISSIONING

A. As specified in Section 01756 – Commissioning.

B. Functional Testing:
1. Also called "Field Acceptance Testing".

C. Panelboards:
1. Cleaning:
a. Visually inspect panelboard for evidence of discoloration, abnormal dust accumulation, metal shards, or any other indication of overheating, wear, or other abnormal conditions prior to cleaning.
b. Clean cabinet with a brush, vacuum cleaner, or clean, dry, lint-free rags to remove any accumulation of dust, dirt, or other foreign matter. Do not use liquids, solvents or detergents when cleaning panelboards or components.
c. Avoid blowing dust into panelboards. Do not use a blower or compressed air.
d. Clean Supports, terminals, and other major insulating surfaces with clean, dry, lint-free rags or soft bristled brushes.
e. Remove dust, soot, grease, moisture, and foreign material from surface of circuit breakers.
2. General:
a. Compare equipment nameplate data with the Contract Documents.
b. Check panelboard circuit schedule for accuracy.
c. Verify appropriate anchorage, required area clearances, and correct alignment.
d. Inspect overall general condition for physical damage. Check for broken studs and loose or damaged wires, connector, terminations, etc. Check all bolts, nuts, washer, and pins for tightness. Tighten or use manufacture’s replacement parts as required.

e. Inspect cabinets for signs of rust, corrosion, or deteriorating paint. Inspect cabinets for evidence of localized heat damage to the paint. Investigate sources of heat. Repair painted surfaces.
f. Check that covers are in place and fastened. Plug any open unused knockouts.
g. Inspect panelboard for moisture. Seal off any cracks or openings which have allowed moisture to enter the cabinet. Inspect all component devices. Replace any components that show evidence of damage from moisture.
h. Inspect panelboards and internal components for evidence of overheating, arc spatter, sooty deposits, and tracking. Investigate and correct sources of arcing or overheating. Consult the panelboard manufacturer for recommendations.
i. Verify that fuse and/or circuit breaker sizes and types correspond to record drawings, if available, as well as to the circuit breaker's address for microprocessor communications packages, if equipped.
j. Set adjustable circuit breakers in accordance with engineering coordination study supplied by Contractor.

3. Terminations, Connections, and Lugs:
   a. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use of low-resistance ohmmeter.
         a) Compare bolted connection resistance values to values of similar connections:
            (1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
         a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
   b. Inspect terminations, connection, and lugs for alignment, physical damage, burns, corrosion, discoloration, flaking, heat damage, arcing, pitting, melting, deterioration, carbonization, cracks, chips, breaks, partial discharge, or moisture. Investigate and eliminate sources of any damage.
   c. Follow manufacturer recommendations for cleaning, repairing, and replacing damaged parts.
   d. Replace overheated connections. Tighten connections to proper torque levels as specified above.
4. Conductors and raceways:
   a. Inspect supply conductors and terminations for overheating, discoloration, and oxidation. Investigate and correct any deficiencies.
   b. Ensure the conductors are protected within their ampacities.
   c. Visually check panelboard, cables, and raceways for proper bonding and grounding. Correct improper bonding and grounding.
   d. Inspect conductors for discoloration, arcing, pitting, melting, flaking of insulation and/or metal parts. Repair or replace damaged components in accordance with manufacturer's recommendations.
   e. Inspect for frayed or broken wires. Replace or repair damaged components in accordance with manufacturer recommendations.

f. Inspect for frayed or broken wires. Replace or repair conductors as necessary.
g. Inspect conduits for moisture. Seal conduits which are a source of moisture and provide means to drain moisture away from the panelboard.

5. Circuit breakers:
   a. Breakers rated less than 100 A:
      1) Operate circuit breakers several times in order to exercise the mechanisms and the contacts, and to ensure smooth operation. Do not oil or grease parts of molded case circuit breakers.
      2) Visually check circuit breakers for evidence of overheating and thermal damage. Investigate and eliminate sources of overheating.
      3) Check circuit breakers for visual defects, chipping, cracks, breaks, burns, and deterioration. Replace damaged circuit breakers.
      4) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.
      5) Inspect interchangeable trip-unit circuit breakers for tightness of trip units.
      6) Check circuit breaker terminals and connections for tightness as specified above.
   b. Breakers rated 100 A and higher:
      1) Perform visual and mechanical inspection as specified in this Section.
      2) Perform electrical tests as specified in this Section.

D. Dry type transformers:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with the Contract Documents.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Verify that resilient mounts are free and that any shipping brackets have been removed.
      e. Inspect equipment for cleanliness.
      f. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
      g. Verify that as-left tap connections are as specified.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
         1) Apply voltage in accordance with manufacturer’s published data.
            a) Refer to NETA ATS tables in the absence of manufacturer’s published data.

c. Calculate dielectric absorption ration or polarization index.
d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.

3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Tap connections are left as found unless otherwise specified.
   d. Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      2) Investigate insulation values less than the allowable minimum.
   e. The dielectric absorption ratio or polarization index shall not be less than 1.0.
   f. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
   g. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.

E. Low voltage cables, 600 volt maximum:
   1. Visual and mechanical inspection:
      a. Compare cable data with the Drawings and Specifications.
      b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.
      c. Inspect bolted electrical connections for high resistance by one of the following methods:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
      d. Inspect compression applied connectors for correct cable match and indentation.
      e. Inspect for correct identification and arrangement.
      f. Inspect cable jacket insulation and condition.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      b. Perform insulation resistance test on each conductor sized #8 AWG or larger with respect to ground and adjacent conductors:
         1) Applied potential shall be 500 volts dc for 300 volt rated cable and 1,000 volts dc for 600 volt rated cable.
         2) Test duration shall be 1 minute.

c. Perform continuity tests on all power and control conductors to insure correct cable connection.
d. Verify uniform resistance of parallel conductors.

3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Insulation-resistance values shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      2) Investigate values of insulation-resistance less than the allowable minimum.
   c. Cable shall exhibit continuity.
   d. Deviations in resistance between parallel conductors shall be investigated.

F. Low voltage molded case and insulated case circuit breakers:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with the Contract Documents.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage and alignment.
      d. Verify the unit is clean.
      e. Operate the circuit breaker to ensure smooth operation.
      f. Inspect bolted electrical connections for high resistance by one of the following methods:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
      g. Perform adjustments for final protective device settings in accordance with the coordination study.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
         1) Apply voltage in accordance with manufacturer's published data.
         2) Refer to NETA ATS tables in the absence of manufacturer's published data.
      c. Perform a contact/pole-resistance test.
      d. Determine long-time pickup and delay by primary current injection.
      e. Determine short-time pickup and delay by primary current injection.
      f. Determine ground-fault pickup and delay by primary current injection.
      g. Determine instantaneous pickup value by primary current injection.
      h. Test functions of the trip unit by means of secondary injection.
      i. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.

j. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
   1) Reset all trip logs and indicators.
k. Verify operation of charging mechanism.

3. Test values:
   a. Compare bolted connection resistance values to values of similar connections:
      1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   b. Bolt-torque levels shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   c. Insulation-resistance values shall be in accordance with manufacturer's published data:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      2) Investigate values of insulation-resistance less than the allowable minimum.
   d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
      1) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
   e. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
      1) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
   f. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
   g. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
   h. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
      1) Refer to NETA ATS tables in the absence of manufacturer's published data.
   i. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
   j. Determine energy reducing maintenance switch pickup value by primary current injection.
   k. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
   l. The charging mechanism shall operate in accordance with manufacturer's published data.

G. Low voltage air power circuit breakers - ANSI class breakers:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate data with the Contract Documents.
      b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, and grounding.
d. Verify that all maintenance devices are available for servicing and operating the breaker.
e. Verify the unit is clean.
f. Verify the arc chutes are intact.
g. Inspect moving and stationary contacts for condition and alignment.
h. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
i. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.
j. Inspect bolted electrical connections for high resistance by one of the following methods:
    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
        a) Refer to manufacturer’s instructions for proper foot-pound levels or NETA ATS tables.
k. Verify cell fit and element alignment.
l. Verify racking mechanism operation.
m. Lubrication requirements:
    1) Verify appropriate lubrication on moving current-carrying parts.
    2) Verify appropriate lubrication on moving and sliding surfaces.
n. Perform adjustments for final protective device settings in accordance with the coordination study.
o. Record as-found and as-left operation counter readings.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the circuit breaker closed, and across each open pole:
        1) Test voltage shall be in accordance with manufacturer’s published data.
        2) Refer to NETA ATS tables in the absence of manufacturer’s published data.
    c. Perform a contact/pole-resistance test.
    d. Determine long-time pickup and delay by primary current injection.
    e. Determine short-time pickup and delay by primary current injection.
    f. Determine ground-fault pickup and delay by primary current injection.
    g. Determine instantaneous pickup value by primary current injection.
    h. Determine energy reducing maintenance switch pickup value by primary current injection.
    i. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer’s published data.
    j. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
        1) Reset all trip logs and indicators.
    k. Verify operation of charging mechanism.

3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Settings shall comply with coordination study requirements.
    d. Operations counter shall advance 1 digit per close-open cycle.
    e. Insulation-resistance values shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
        2) Investigate values of insulation-resistance less than the allowable minimum.
    f. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
        1) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
    g. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
        1) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
    h. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
    i. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
    j. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    k. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
    l. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    m. Auxiliary features shall operate in accordance with manufacturer's published data.
    n. The charging mechanism shall operate in accordance with manufacturer's published data.

H. Metering devices electromechanical and solid state:
    1. Visual and mechanical inspection:
        a. Compare equipment nameplate data with the Contract Documents.
        b. Inspect physical and mechanical condition.

c. Inspect bolted electrical connections for high resistance using one of the following methods:
    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
d. Record model number, serial number, firmware revision, software revision, and rated control voltage.
e. Verify operation of display and indicating devices.
f. Record passwords.
g. Verify unit is grounded in accordance with manufacturer's instructions.
h. Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements.
i. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts as applicable.
j. Verify the unit is clean.
k. Verify freedom of movement, endplay, and alignment of rotating disk(s).

2. Electrical tests:
    a. Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
    b. Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital, and analog.
    c. After initial system energization, confirm measurements and indications are consistent with loads present.
    d. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    e. Verify accuracy of meter at all cardinal points.
    f. Calibrate meters in accordance with manufacturer's published data.
    g. Verify all instrument multipliers.
    h. Verify that current transformer, and voltage transformer secondary circuits are intact.
3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Meter accuracy shall be in accordance with manufacturer's published data.
    d. Calibration results shall be within manufacturer's published tolerances.
    e. Instrument multipliers shall be in accordance with system design specifications.
    f. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

I. Grounding systems:
   1. Visual and mechanical inspection:
      a. Inspect ground system for compliance with the Contract Documents, and the NEC.
      b. Inspect physical and mechanical condition.
      c. Inspect bolted electrical connections for high resistance using one of the following methods:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
      d. Inspect anchorage.
   2. Electrical tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
      b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
      c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
   3. Test values:
      a. Grounding system electrical and mechanical connections shall be free of corrosion.
      b. Compare bolted connection resistance values to values of similar connections:
         1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      c. Bolt-torque levels shall be in accordance with manufacturer's published data:
         1) Refer to NETA ATS tables in the absence of manufacturer's published data.
      d. The resistance between the main grounding electrode and ground shall be as specified in Section 16060 - Grounding and Bonding.
      e. Investigate point-to-point resistance values that exceed 0.5 ohm.

J. Rotating machinery, ac induction motors and generators:
   1. Visual and mechanical inspection:
      a. Compare equipment nameplate information with the Contract Documents.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, and grounding.
      d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging.
      e. Inspect bolted electrical connections for high resistance using one or more of the following methods:
         1) Use of low-resistance ohmmeter.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
            a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

f. Manually rotate the rotor and check for problems with the bearings or shaft.
g. Rotating equipment:
    1) Operate at rated design load conditions.
    2) Confirm that equipment is properly assembled.
    3) Confirm the equipment moves or rotates in the proper direction.
    4) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
    5) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
h. Verify correct application of appropriate lubrication and lubrication systems.
i. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.

2. Electrical tests - AC Induction:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform insulation-resistance test in accordance with IEEE 43:
        1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio for 60/30 second periods.
        2) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
    c. On machines rated at 2,300 volts and greater, perform dielectric withstand voltage tests in accordance with:
        1) IEEE 95 for dc dielectric withstand voltage tests.
        2) NEMA MG1 for ac dielectric withstand voltage tests.
    d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
    e. Perform insulation-resistance test on insulated bearings in accordance with manufacturer’s published data.
    f. Test surge protection devices as specified in this Section.
    g. Test motor starter as specified in this Section.
    h. Perform resistance tests on resistance temperature detector (RTD) circuits.
    i. Verify operation of motor space heater, if applicable.
    j. Perform vibration test while machine is running under load.
3. Test values:
    a. Inspection:
        1) Air baffles shall be clean and installed in accordance with the manufacturer’s published data.
        2) Filter media shall be clean and installed in accordance with the manufacturer’s published data.
        3) Cooling fans shall operate.
        4) Slip ring alignment shall be within manufacturer’s published tolerances.
        5) Brush alignment shall be within manufacturer’s published tolerances.
        6) Brush rigging shall be within manufacturer’s published tolerances.

b. Compare bolted connection resistance values to values of similar connections:
    1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
c. Bolt-torque levels shall be in accordance with manufacturer's published data:
    1) Refer to NETA ATS tables in the absence of manufacturer's published data.
d. Airgap spacing and machine alignment shall be in accordance with manufacturer's published data.
e. The recommended minimum insulation-resistance ($IR_{1\ min}$) test results in megohms shall be in accordance with NETA ATS tables.
    1) The polarization index value shall not be less than 2.0.
    2) The dielectric absorption ratio shall not be less than 1.4.
f. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
g. Investigate phase-to-phase stator resistance values that deviate by more than 5 percent.
h. Power factor or dissipation factor values shall be compared to manufacturer's published data:
    1) In the absence of manufacturer's published data, compare values of similar machines.
i. Tip-up values shall indicate no significant increase in power factor.
j. If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
k. Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
    1) In the absence of manufacturer's published data, compare values of similar machines.
l. Test results of surge protection devices shall be as specified in this Section.
m. Test results of motor starter equipment shall be as specified in this Section.
n. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
o. Heaters shall be operational.
p. Vibration amplitudes of the uncoupled and unloaded machine shall be in accordance with manufacturer's published data:
    1) In the absence of manufacturer's published data, vibration amplitudes shall not exceed values in NETA ATS tables.
    2) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.

K. Motor starters, low voltage:
    1. Visual and mechanical inspection:
        a. Compare equipment nameplate information with the Contract Documents.
        b. Inspect physical and mechanical condition.
        c. Inspect anchorage, alignment, and grounding.

d. Verify the unit is clean.
e. Inspect contactors:
    1) Verify mechanical operation.
    2) Verify contact gap, wipe, alignment, and pressure is in accordance with manufacturer's published data.
f. Motor-running protection:
    1) Verify overload element rating/motor protection settings are correct for its application.
    2) If motor running protection is provided by fuses, verify correct fuse rating.
g. Inspect bolted electrical connections for high resistance using one of the following methods:
    1) Use of low-resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
h. Lubrication requirements:
    1) Verify appropriate lubrication on moving current-carrying parts.
    2) Verify appropriate lubrication on moving and sliding surfaces.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
        1) Test voltage shall be in accordance with manufacturer's published data.
        2) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Test motor protection devices in accordance with manufacturer's published data.
    d. Test circuit breakers as specified in this Section.
    e. Perform operational tests by initiating control devices.
3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
    c. Insulation-resistance values shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
        2) Investigate values of insulation-resistance less than the allowable minimum.
    d. Motor protection parameters shall be in accordance with manufacturer's published data.

e. Circuit breaker test results shall as be specified in this Section.
f. Control devices shall perform in accordance with system design requirements.

L. Surge arresters, low-voltage:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with the Contract Documents.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.
e. Inspect bolted electrical connections for high resistance using one of the following methods:
1) Use of low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
h. Record stroke counter reading.
2. Electrical tests:
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
b. Perform an insulation-resistance test on each arrester, phase terminal- to- ground:
1) Apply voltage in accordance with manufacturers published data.
2) Refer to NETA ATS tables in the absence of manufacturer's published data.
c. Test grounding connection as specified in this Section.
3. Test values:
a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
c. Insulation-resistance values shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
2) Investigate insulation values less than the allowable minimum.
d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

M. Switches, air, low-voltage:
    1. Visual and mechanical inspection:
        a. Compare equipment nameplate data with the Contract Document.
        b. Inspect physical and mechanical condition.
        c. Inspect anchorage, alignment, grounding, and required clearances.
        d. Verify the unit is clean.
        e. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
        f. Verify breakersizes and types as indicated on the Drawings, short-circuit studies, and coordination study.
        g. Verify that each fuse has adequate mechanical support and contact integrity.
        h. Inspect bolted electrical connections for high resistance using one of the following methods:
            1) Use of a low resistance ohmmeter.
            2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
                a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
        i. Verify operation and sequencing of interlocking systems.
        j. Verify correct phase barrier installation.
        k. Verify correct operation of all indicating and control devices.
        l. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
    2. Electrical tests:
        a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
        b. Measure contact resistance across each switchblade.
        c. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data:
            1) In the absence of manufacturer's published data, use NETA ATS requirements.
        d. Measure fuse resistance.
        e. Verify cubicle space heater operation.
        f. Perform ground fault test as specified in this Section, if applicable.
        g. Perform tests on other protective devices as specified in this Section, if applicable.
    3. Test values:
        a. Compare bolted connection resistance values to values of similar connections:
            1) Investigate values which deviate from those of similar bolted connection by more than 50 percent of the lowest value.
        b. Bolt-torque levels shall be in accordance with manufacturer's published data:
            1) Refer to NETA ATS tables in the absence of manufacturer's published data.

4. Test values - electrical:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
        1) If manufacturer's published data is not available, investigate values which deviate from those of similar bus connections and sections by more than 50 percent of the lowest value.
    c. Insulation-resistance values shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
        2) Investigate insulation values less than the allowable minimum.
    d. Heaters shall be operational.
    e. Ground fault tests shall be as specified in this Section.
    f. Results of protective device tests shall be as specified in this Section.

N. Copper Ethernet cable installation testing:
    1. Pre-installation:
        a. Immediately prior to installation, verify that cable to be installed matches that which was submitted.
        b. Verify that no damage has been done to the cable during shipping or handling.
        c. Inspect cable for physical and mechanical damage.
        d. Engineer shall be notified if a cable fails to meet inspection and the cable shall not be installed unless otherwise directed by the Engineer.
    2. Post-installation:
        a. Prior to copper Ethernet cable termination, perform cable end-to-end continuity validation testing on all installed cables, conductor pairs and cable shields using toner and probe kit. Any cable that fails testing shall be removed and replaced.
        b. Inspect equipment outlet connectors for damage and ensure connectors hold tightly in field device ports.
    3. Test equipment:
        a. Certification equipment used for the testing shall be capable of verifying twisted pair cable installation with end-to-end continuity testing.
        b. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
        c. Manufacturers: The following or equal:
            1) Fluke Networks, IntelliTone Pro 200 Toner and Probe Kit, MT-8200-60-KIT.
        d. Refer to Section 17950 - Commissioning for Instrumentation and Controls for Permanent Link testing requirements.

O. Direct-current systems, batteries, valve-regulated lead-acid:
    1. Visual and mechanical inspection:
        a. Verify that batteries are adequately located.
        b. Verify that battery area ventilation system is operable.
        c. Verify existence of suitable eyewash equipment.

d. Compare equipment nameplate data with the Contract Documents.
e. Verify adequacy of battery support racks or cabinets, mounting, anchorage, alignment, grounding, and clearances.
f. Verify the units are clean.
g. Verify the application of an oxide inhibitor on battery terminal connections.
h. Inspect bolted electrical connections for high resistance using one of the following methods:
    1) Use of low resistance ohmmeter.
    2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
        a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.

2. Electrical tests:
    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
    b. Measure negative post temperature.
    c. Measure charger float and equalizing voltage levels.
    d. Verify all charger functions and alarms.
    e. Measure each monoblock/cell voltage and total battery voltage with charger energized and in float mode of operation.
    f. Measure intercell connection resistances.
    g. Perform internal ohmic measurement tests.
    h. Perform a load test in accordance with manufacturer's published data or IEEE 1188.
    i. Measure the battery system voltage from positive to ground and negative to ground.
3. Test values:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Bolt-torque levels shall be in accordance with manufacturer's published data:
        1) Refer to NETA ATS tables in the absence of manufacturer's published data.
4. Test values - electrical:
    a. Compare bolted connection resistance values to values of similar connections:
        1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Negative post temperature shall be within manufacturer's published data or IEEE 1188.
    c. Charger float and equalize voltage levels shall be in accordance with the battery manufacturer's published data.
    d. Results of charger functions and alarms shall be in accordance with manufacturer's published data.
    e. Monoblock/cell voltages shall be in accordance with manufacturer's published data.
    f. Monoblock/cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical monoblocks/cells in a fully charged state.

g. Results of load tests shall be in accordance with manufacturer's published data or IEEE 1188.
h. Voltage measured from positive to ground shall be similar in magnitude to the voltage measured from negative to ground.

P. Direct-current systems, chargers:
1. Visual and mechanical inspection:
a. Compare equipment nameplate data with the Contract Documents.
b. Inspect for physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Inspect all bolted electrical connections for high resistance using one of the following methods:
1) Use of low resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
2. Electrical tests:
a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
b. Verify float voltage, equalize voltage, and high voltage shutdown settings.
c. Verify current limit.
d. Verify correct load sharing (parallel chargers).
e. Verify calibration of meters as specified in this Section.
f. Verify operation of alarms.
g. Measure and record input and output voltage and current.
h. Measure and record ac ripple current and voltage imposed on the battery.
i. Perform full-load testing of charger.
3. Test values:
a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Bolt-torque levels shall be in accordance with manufacturer's published data:
1) Refer to NETA ATS tables in the absence of manufacturer's published data.
4. Test values - electrical:
a. Compare bolted connection resistance values to values of similar connections:
1) Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Float and equalize voltage settings shall be in accordance with the battery manufacturer's published data.
c. Current limit shall be within manufacturer's recommended maximum.
d. Results of load sharing between parallel chargers shall be in accordance with system design specifications.
e. Results of meter calibration shall be as specified in this Section.
f. Results of alarm operation shall be in accordance with manufacturer's published data and system design.

g. Input and output voltage shall be in accordance with manufacturer's published data.
h. AC ripple current and voltage imposed on the battery shall be in accordance with manufacturer's published data.
i. Charger shall be capable of manufacturer's specified full load.

2.04 CLEANING

A. Dispose of all testing expendables.

B. Vacuum all cabinets.

C. Sweep clean all surrounding areas.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 17050

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Process control and instrumentation systems requirements for common components including installation.
   2. Loop drawings:
      a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and pre-purchased equipment.
      b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
      c. Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.
   3. Requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in Technical Sections, including packaged mechanical systems, LCPs, VCPs, etc.
   4. System to include a backup system as indicated on the Drawings.

B. Contract Drawings:
   1. Schematic diagrams:
      a. Use schematic diagrams in conjunction with the descriptive operating sequence in the Technical Sections to furnish a coordinated and fully functional control system.
      b. Schematic diagrams show control function only.
         1) Incorporate other necessary functions for proper operation and protection of the system.
      c. Controls are indicated on the Drawings as de-energized.
      d. Add relays, where required, to provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      e. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated on the Drawings.

1.02 REFERENCES

A. Abbreviations:
   1. ACB: Automatic current balance.
   2. ATS: Automatic Transfer Switch.

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

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

B. Standards:
   1. American Petroleum Institute (API):
      a. RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
      b. RP 551 - Process Measurement Instrumentation.
   2. International Organization for Standardization (ISO):
      a. 9001 - Quality Management Systems - Requirements.
   3. International Society of Automation (ISA):
      a. 5.1 - Instrumentation Symbols and Identification.
      b. 5.4 - Instrument Loop Diagrams.
      c. 20 Instrument Forms Plus Pro-Combo-Enterprise Version (Microsoft SQL Server Express Database Software based).
   4. National Electrical Manufacturers Association (NEMA).

5. National Fire Protection Association (NFPA):
    a. 70 - National Electrical Code (NEC).
6. National Institute of Standards and Technology (NIST).
7. Underwriters Laboratories, Inc. (UL):
    a. 508 - Standard of Safety for Industrial Control Equipment.
    b. 508A - Standard of Safety for Industrial Control Panels.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
    1. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24 VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
        a. Fieldbus communications signal or both.
    2. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
    3. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
    4. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.
    5. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
    6. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
    7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24 VDC signal, a digital bus communications signal, or both.
    8. RS-485: RS-485 is also known as TIA-485 or EIA-485, is a standard defining the electrical characteristics of drivers and receivers for use in serial communications system. Electrical signaling is balanced, and multipoint systems are supported, can be used with data rates up to 10 Mbit/s or at lower speeds distances up to 1,000 meters (4,000 feet).
    9. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.

1.04 DELEGATED DESIGN

A. The requirements for Delegated Design are specified in the Technical Sections.

1.05 SUBMITTALS

A. General:
   1. Adhere to the wiring numbering scheme as specified in Section 16075 - Identification for Electrical Systems throughout the Project:
      a. Uniquely number each wire.
      b. Wire numbers must appear on Equipment Drawings.
   2. Some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
      a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout Shop Drawings, datasheets, and similar Submittals.
      b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

B. Specific Submittal requirements:
   1. Control Panel Drawings:
      a. General Requirements:
         1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
         2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
         3) Nameplates and Wire Labeling:
            a) Nameplate legend including text, letter size, materials, and colors.
            b) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
         4) Structural Requirements:
            a) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
            b) Weight.
         5) Clearly show modifications to existing circuits:
            a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
      b. Required for materials and equipment listed in this and other Technical Sections.
      c. Front, side, rear, internal, external elevations, and top and bottom views, showing all dimensions and all to scale.
         1) Locations of conduit entrances and access plates.
         2) Component layout and identification.
         3) Complete and detailed bills of materials:
            a) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
            b) Include all items within an enclosure.
         4) Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium-voltage power cables.

5) Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
6) NEMA rating.
7) Material and finish.

2. Schematics and Wiring Diagrams:
   a. General Requirements:
      1) Submit panel wiring diagrams for every panel that contains wiring.
      2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
      3) Nameplates and Wire Labeling:
         a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
      4) Clearly show modifications to existing circuits:
         a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
   b. Include the following information:
      1) Name of panel.
      2) Wiring sizes and types.
      3) Terminal strip numbers.
      4) Terminal identification for device and field connections.
      5) Wire tags and labels.
      6) Functional name and manufacturer's designation for items to which wiring are connected.
      7) Set points for relays and control or alarm contact settings.
   c. Incorporate equipment manufacturer’s Shop Drawing information into the schematic diagrams in order to document the entire control system.
3. Loop drawings:
   a. General Requirements:
      1) Submit loop drawings for every analog, discrete, fieldbus signal, vendor supplied equipment packages, and control panels.
         a) Includes monitoring, alarming, interlocks, and control devices.
      2) Use equipment and instrument tags as depicted on the P&IDs for all Submittals.
      3) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
      4) Provide Drawings for every instrumentation loop system:
         a) Furnish a separate Drawing sheet for each system or loop diagram.
      5) Nameplates and Wire Labeling:
         a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
      6) Clearly show modifications to existing circuits:
         a) Show existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
      7) Provide loop drawings in the format indicated in the Contract Drawings.
   b. Provide a complete index in the front of each bound volume:
      1) Index the loop drawings by systems or process areas.

c. In addition to the ISA-5.4 requirements, show the following details:
    1) Functional name of each loop.
    2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
    3) Show all terminal numbers, regardless of the entity providing the equipment.
    4) Panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.
    5) Terminal assignments associated with every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
    6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
    7) Cables required for communication requirements.

4. PLC I/O List:
    a. A complete listing of the PCS system point I/O database:
        1) Include for each data point relevant parameters such as range, contact orientation, limits, incremental limits, I/O hardware address, and PLC assignment.
        2) Organize on a site-by-site basis and separate by point type.
        3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
        4) Upon completion of the Work, update I/O lists to indicate the final as-built configuration of the systems:
            a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.
5. Instrument Datasheets:
    a. The datasheets provided with the instrument specifications are preliminary and are not complete but are provided to assist with the completion of final instrument datasheets. Additional datasheets may be required.
    b. Furnish fully completed datasheets for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
    c. Format: Provide datasheets in Microsoft Word or Microsoft Excel.
        1) Features and options that are furnished.
    d. Provide completed datasheet as specified in the Technical Sections and for each control system component.
6. Instrument Installation Drawings:
    a. Provide instrument installation, mounting, and anchoring details for components and assemblies, including access requirements and conduit connection or entry details.
    b. Each installation shall be identified by the equipment or instrument by tag number.
    c. Provide certification by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.

d. Provide, at a minimum, the following contents for each detail:
    1) Necessary sections and elevation views required to define instrument location by referencing tank, building, or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
    2) Ambient temperature and humidity where the instrument is to be installed.
    3) Corrosive qualities of the environment where the instrument is to be installed.
    4) Hazardous rating of the environment where the instrument is to be installed.
    5) Process line pipe or tank size, service, and material.
    6) Process tap elevation and location.
    7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
    8) Routing of tubing and identification of supports.
    9) Mounting brackets, stands, anchoring devices, and sunshades.
    10) Conduit entry size, number, location, and delineation between power and signal.
    11) NEMA ratings of enclosures and components.
    12) Clearances required for instrument servicing.
    13) List itemizing manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

7. Product data:
    a. Provide a technical brochure or bulletin (“cutsheet”) for each instrument or equipment on the project labeled with equipment and instrument tags as depicted on the P&IDs.
        1) Submit with the corresponding datasheets.
        2) Organization: Index product data in the Submittal by systems or loops.
    b. Engineering data:
        1) Test data and performance curves, when applicable.
    c. Manufacturer's technical reference manuals.
8. Commissioning Submittals:
    a. As specified in Section 01756 - Commissioning.
    b. Manufacturer representative qualifications.
    c. Manufacturer certificates.
    d. Test plans.
    e. Test reports.
    f. Owner Training Submittals.
    g. Operation and maintenance manuals.
        1) Organize the operation and maintenance manuals for each process in the following manner:
            a) Section A - Process and Instrumentation Diagrams.
            b) Section B - Control Panel Drawings.
            c) Section D - Schematics and Wiring Diagrams.
            d) Section E - Loop Drawings.
            e) Section F - Network Diagrams.
            f) Section G - PLC I/O List.
            g) Section H - Control Descriptions.
            h) Section I - Instrument Datasheets.

i) Section J - Instrument Installation Drawings.
j) Section K - Product Data.
k) Section L - Sizing Calculations.
l) Section M - Test Results.
m) Section N - Operational Manual.
n) Section O - Spare Parts List.

1.06 QUALITY ASSURANCE

A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.

B. Provide equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

C. The ICSC must have their own operating UL listed panel fabrication facility.
   1. Panels must be fabricated at this facility and meet UL 508/508A requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Upon receipt of instruments in the field:
   1. Outside of the package: Prominently display tag number identification.
   2. On each instrument: Provide a nameplate as specified in this Section.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

B. Area classifications:
   1. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Project PCIS overview conference:
   1. Contractor leads the meeting.
   2. Timing:
      a. Prior to start of ICSC and Programmer Work.
   3. Attendees:
      a. Engineer, Owner, and ICSC, ICSC.
      b. Contractor.
      c. Electrical subcontractor.
      d. Manufacturers furnishing major pieces of equipment must attend, including, but not limited to:
         1) Vendor control panels.
         2) Lighting.
         3) Engine generators.
   4. Agenda:
      a. Meeting purpose:
         1) Review the entire project, equipment, control philosophy, schedules, and Submittal requirements.
      b. Review entire project.

c. Review equipment lists.
d. Review control philosophy.
e. Review schedules.
f. Review Submittal requirements.
g. Safety and security.
h. Action items.
i. Next meeting.

B. System configuration meetings: Meet on at least the following occasions:
1. Preliminary meeting:
a. Contractor leads the meeting.
b. Timing:
1) Before configuration work is begun.
c. Attendees:
1) Engineer, Owner, and ICSC.
d. Agenda:
1) Meeting purpose:
a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
2) Review the ICSC provided examples of displays, display symbols, reports, etc., to show the capabilities of the system software.
3) Safety and security.
4) Action items.
5) Next meeting.
2. Development review meeting:
a. Contractor leads the meeting.
b. Timing:
1) After the initial database is entered and typical screens and reports have been entered.
c. Attendees:
1) Engineer, Owner, and ICSC.
d. Agenda:
1) Meeting purpose:
a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
2) Review the system configuration.
3) Review the HMI system database.
4) Review the control schemes.
5) Review the displays.
6) Review the report formats.
7) Safety and security.
8) Action items.
9) Next meeting.
3. Pre-submittal review meeting:
a. Contractor leads the meeting.
b. Timing:
1) Before producing any Submittals.
c. Attendees:
1) Engineer, Owner, and ICSC.

d. Agenda:
    1) Meeting purpose:
        a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
        b) Review an informal hardcopy of developed HMI screens for review by the Engineer.
    2) Review the system configuration.
    3) Review the HMI system database.
    4) Review the control schemes.
    5) Review the displays.
    6) Review the report formats.
    7) Review an informal hardcopy of developed HMI screens.
    8) Review the Submittal schedule.
    9) Safety and security.
    10) Action items.
    11) Next meeting.

4. Final review meeting:
    a. Contractor leads the meeting.
    b. Timing:
        1) After initial completion of configuration work.
        2) Prior to the Source Test.
    c. Attendees:
        1) Engineer, Owner, and ICSC.
    d. Agenda:
        1) Meeting purpose:
            a) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.
        2) Review the system configuration.
        3) Review the HMI system database.
        4) Review the control schemes.
        5) Review the displays.
        6) Review the report formats.
        7) Safety and security.
        8) Action items.
        9) Next meeting.
    e. Make final format revisions after this review.

C. Control logic meetings: Meet on at least the following occasions:
    1. Preliminary meeting:
        a. Contractor leads the meeting.
        b. Timing:
            1) Before configuration work is begun on any PLCs programmed or configured by the Contractor (including those provided through subcontractors and suppliers).
        c. Attendees:
            1) Owner, Engineer, and ICSC.
            2) Individuals responsible for programming PLCs and other programmable devices supplied by Contractor may attend by telephone conference call.

d. Agenda:
    1) Meeting purpose:
        a) Discuss overall control logic.
    2) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
    3) Review contact information for each individual responsible for programming each said PLC and other programmable device.
    4) Review schedule of Submittals that will contain HMI/LOI interface information.
    5) Safety and security.
    6) Action items.
    7) Next meeting.

2. Development review meeting:
    a. Contractor leads the meeting.
    b. Timing:
        1) After approximately one-half of the HMI/LOI interface Submittals have been submitted.
    c. Attendees:
        1) Owner, Engineer, and ICSC.
        2) Individuals responsible for programming PLCs and other programmable devices supplied by Contractor may attend by telephone conference call.
    d. Agenda:
        1) Meeting purpose:
            a) Discuss progress on control logic.
        2) Discuss HMI/LOI interface Submittals to date.
        3) Discuss HMI/LOI interface future Submittals and their requirements.
        4) Discuss half of the screens “drafted” but not submitted.
        5) Review list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface.
        6) Review contact information for each individual responsible for programming each said PLC and other programmable device.
        7) Review schedule of Submittals that will contain HMI/LOI interface information.
        8) Safety and security.
        9) Action items:
            a) Document Vendor Control Panel programming requirements.
        10) Next meeting.

3. Pre-submittal review meeting:
    a. Contractor leads the meeting.
    b. Timing:
        1) Before producing any Submittals.
    c. Attendees:
        1) Engineer, Owner, and ICSC.
    d. Agenda:
        1) Meeting purpose:
            a) Coordinate Submittals.
        2) Review the system configuration, the HMI system database, control schemes, displays, report formats, etc.

3) Review an informal hardcopy of developed HMI screens for review by the Engineer to determine that requirements are being sufficiently met.
4) Review the Submittal schedule.
5) Safety and security.
6) Action items.
7) Next meeting.

4. Vendor control panel programming meetings:
   a. Contractor leads the meeting.
   b. Timing:
      1) Prior to start of vendor control panel programming or set up Work.
   c. Attendees:
      1) Owner, Engineer, and ICSC.
      2) Individuals responsible for programming or setting up PLCs and other programmable devices supplied by Contractor may attend by telephone conference call.
      3) Each equipment supplier who is providing equipment with a PLC and/or LOI.
   d. Agenda:
      1) Meeting purpose:
         a) Coordinate control logic requirements for specific equipment.
      2) Review minimum Vendor Control Panel programming or set up requirements:
      3) Review advanced Vendor Control Panel programming requirements, as applicable:
         a) Alarms: Clearing, formats, colors, and status.
         b)
      4) Safety and security.
      5) Action items.
      6) Next meeting.
5. Final review meeting:
   a. Contractor leads the meeting.
   b. Timing:
      1) After HMI/LOI interface Submittals have been submitted.
   c. Attendees:
      1) Owner, Engineer, and ICSC.
      2) Individuals responsible for programming or set up PLCs and other programmable devices supplied by Contractor may attend by telephone conference call.
   d. Agenda:
      1) Meeting purpose:
         a) Discuss HMI/LOI interface Submittals and requirements.
      2) Review minimum programming or set up requirements:
      3) Review advanced requirements, as applicable:
         a) Alarms: Clearing, formats, colors, and status.
      4) Action items.
      5) Next meeting.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of Submittal of the Shop Drawings unless otherwise specified to match existing equipment.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Non-conditioned spaces:
   1. Provide additional temperature conditioning equipment to maintain equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines.

B. Outdoor installations:
   1. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
   2. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in the Sections for the equipment.

C. This facility includes classified areas:
   1. As specified in Section 16050 - Common Work Results for Electrical.
   2. Provide enclosures suitable for the area classification.
   3. Where suitable enclosures are not available, utilize other methods such as intrinsic safety barriers.

D. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.

E. Furnish current version of software unless specifically noted in the Contract Documents.
   1. Use of an older version to maintain functionality of an existing system is acceptable with written permission from the Engineer.
   2. Equipment or software with limited support or end of life with the vendor is not acceptable.

F. Discrete circuit configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

G. Grounding:
   1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable.
   3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
   4. Terminate the signal cable shield on a dedicated grounding terminal block.
   5. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

H. Terminal blocks:
   1. Schematics do not reflect the actual conductor routing. Add intermediate terminal in enclosures and equipment as needed based on the actual conductor routing.

I. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4 to 20 mA 24 VDC, except as indicated.
      c. Electrically or optically isolate analog signals from other signals.
      d. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
      e. Maintain the total 4 to 20 mA loop impedance to 10 percent below the published value at the loop operating voltage.
      f. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
   2. Discrete input signals:
      a. As indicated in the controller hardware specification.
   3. Discrete output signals:
      a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
      b. Provide external terminal block mounted fuse with blown fuse indication for discrete outputs.
      c. Provide interposing relays for discrete outputs for voltage and/or current compatibilities.
      d. Provide interposing relays as required for functionality of the control circuit.
   4. Signal performance and design criteria:
      a. Stability:
         1) After controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
      b. Response:
         1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.

c. Agreement:
    1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
d. Repeatability:
    1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
e. Sensitivity:
    1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
f. Performance:
    1) Instruments and control devices shall perform in accordance with the manufacturers' specifications.

2.03 ACCESSORIES

A. Provide flow conditioning devices or other required accessories as needed to meet the accuracy requirements in the Contract Documents.

PART 3 EXECUTION

3.01 INSTALLATION

A. PCIS configurations are diagrammatic:
    1. Locations of equipment are approximate unless dimensioned.
    2. Where Project conditions require, make reasonable changes in locations and arrangements.

B. Field instruments installation:
    1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
    2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
        a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
        b. Provide sun shields for field electronic instruments, panels, and enclosures located outdoors. Sun shields shall include standoffs to allow air gap between shield and equipment.
        c. Orient LED, LCD, or other readout screens north to minimize sun glare and reduce potential of sun damage.
    3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
        a. Type of flexible conduit required for the area classification:
            1) Area classification as specified in Section 16050 - Common Work Results for Electrical.
        b. Maximum length of 18 inches.

4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
    a. Special cable applications shall be in accordance with the NEC.
5. Verify the correctness of each installation:
    a. Polarity of electric power and signal connections.
6. Ensure process connections are free of leaks.

C. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
4. Bends:
    a. Make bends for parallel lines symmetrical.
    b. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
    a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

D. Cable and conductor termination:
1. Terminate cables and conductors on terminal blocks.
2. Terminal block enclosures:
    a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.

E. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
2. Individually fuse each 4 to 20 mA DC loop with a 1/2-amp fuse between power supplies and receiver surge protectors.
3. Provide voltage surge protection for 4 wire transmitters and analyzers:
    a. Protect both power source and signal loop.

3.02 RE-INSTALLATION

A. Existing instrumentation:
1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
2. Provide certification of this Work before reinstallation of each instrument.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and Technical Sections.

B. Functional Testing:
   1. Assist with troubleshooting and correcting instrumentation and control issues.

3.04 ADJUSTING

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

B. Make revisions necessary to the control system software settings, as directed by the Engineer.
   1. It is understood that the Contractor knows and agrees that changes will be required in the control system software settings during commissioning.

3.05 CLEANING

A. Vacuum clean control panels and enclosures before process start-up and again after final completion of the project.

B. Clean panel surfaces.

C. Return to new condition any scratches and/or defects.

D. Wipe instrument faces and enclosures clean.

E. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
   1. Neatly coil and label spare wiring lengths.
   2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

END OF SECTION

SECTION 17055

PACKAGED CONTROL SYSTEM

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General requirements for a Pump Control Panel (PCP) designed to monitor and control the pumps and field instruments required for a complete package control system.

1.02 REFERENCES

A. Abbreviations:
   1. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
   2. DPDT: Double-pole, double-throw.
   3. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
   4. FAT: Factory acceptance test also known as Source Test.
   5. HART: Highway addressable remote transducer.
   6. HOA: Hand-Off-Auto control function that is totally PLC based.
      a. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software.
      b. In the Auto mode, equipment is started or stopped, and valves are opened or closed through a control algorithm within the PLC software.
      c. In the Off mode, the equipment is prohibited from responding from the PLC control.
   7. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically, information is displayed in a graphical format.
   8. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
   9. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
   10. I/O: Input/Output.
   11. IP: Internet protocol or ingress protection.
   12. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
   13. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc., and does not contain a PLC or RIO.

14. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
15. LOR: Local-Off-Remote control function.
    a. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA.
    b. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions.
    c. In the Off mode, the equipment is prohibited from responding to any control commands.
16. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
17. P&ID: Process and instrumentation diagram.
18. PC: Personal computer.
19. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
20. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
21. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
22. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
23. PLC: Programmable logic controller.
24. PS: Power supply.
25. RIO: Remote I/O device for the PLC consisting of remote I/O racks or remote I/O blocks.
26. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. Remote communications devices typically are radios, modems, etc.
27. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
28. SPD: Surge protection device.
29. SPDT: Single-pole, double-throw.
30. SPST: Single-pole, single-throw.
31. UPS: Uninterruptible power supply.

32. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
33. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

B. Code compliance:
   1. The following codes and standards are hereby incorporated into these Specifications:
      a. Institute of Electrical and Electronics Engineers (IEEE):
         1) C62.41.1 - IEEE Guide on the Surge Environment in Low-Voltage (1,000V and less) AC Power Circuits.
      b. International Society of Automation (ISA):
         1) 5.4 - Instrument Loop Diagrams.
         2) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
      c. National Electrical Manufacturer's Association (NEMA):
         1) 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
      d. National Fire Protection Association (NFPA).
      e. Underwriters Laboratories Inc. (UL):
         1) 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
         2) 508 - Standard for Industrial Control Equipment.
         3) 508A - Standard for Industrial Control Panel.
         4) 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
         5) 1283 - Standard for Electromagnetic Interference Filters.
         6) 1449 - Transient Voltage Surge Suppressors.
         7) 61800-5-1 - Standard for Adjustable Speed Electrical Power Drive Systems.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Definitions of terms and other electrical and instrumentation considerations as set forth in the:
      a. Factory Mutual or FM Global (FM).
      b. Institute of Electrical and Electronic Engineers (IEEE).
      c. International Electrical Testing Association (NETA).
      d. International Electrotechnical Commission (IEC).
      e. International Organization for Standardization (ISO).
      f. International Society of Automation (ISA).
      g. National Electrical Code (NEC).
      h. National Fire Protection Association (NFPA).
      i. National Institute of Standards and Technology (NIST).
      j. Underwriter Laboratories (UL).

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

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. General:
    1. Furnish Submittals as specified in Section 01330 - Submittal Procedures and this Section.
    2. Furnish Submittals that are fully indexed with a tabbed divider for every component.

3. Sequentially number pages within the tabbed sections. Submittals and Operations and Maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
4. Edit Submittals and operation and maintenance manuals so that the Submittal specifically applies to only the equipment furnished. Neatly cross out extraneous text, options, models, etc., that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
5. Use equipment and instrument tags, as indicated on the Drawings, for all Submittals.

B. Pre-bid information:
1. Electrical and Instrumentation Drawings have been prepared based on information provided by potential equipment suppliers and existing installations of similar equipment. Suppliers of packaged systems shall provide sufficient information to the Contractor to allow an adequate estimate of the Electrical and Instrumentation Work associated with the installation of the packaged system.
2. To the extent practical, packaged systems shall be factory assembled and wired. Information on packing splits and other anticipated field wiring requirements shall be provided to the Contractor prior to the bid.
3. Contractor shall be responsible to obtain the necessary information to accurately estimate the electrical connections to the packaged system equipment.

C. Product data:
1. General:
   a. Submitted for non-custom manufactured material specified in this and other sections and indicated on Shop Drawings.
   b. Include:
      1) Catalog cuts.
      2) Bulletins.
      3) Brochures.
      4) Quality photocopies of applicable pages from these documents.
      5) Identify on the datasheets the project name, applicable specification section, and paragraph.
      6) Identify model number and options for the actual equipment being furnished.
   c. Neatly cross out options that do not apply or equipment not intended to be supplied.
2. Material and equipment schedules:
   a. Furnish a complete schedule and/or matrix of materials, equipment, apparatus, and instruments that are proposed:
      1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
3. Instrument datasheets:
   a. Furnish fully completed datasheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA 20. Include the following information on the datasheet:
      1) Component functional description specified in this Section and indicated on the Drawings.
      2) Manufacturers model number or other product designation.

3) Tag number specified in this Section and indicated on the Drawings.
4) System or loop of which the component is a part.
5) Location or assembly at which the component is to be installed.
6) Input and output characteristics, including digital bus communication.
7) Scale range with units and multiplier.
8) Requirements for electric supply.
9) Requirements for air supply.
10) Power consumption.
11) Response timing.
12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
13) Special requirements or features, such as specifications for ambient operating conditions.
14) Features and options that are furnished.

D. Shop Drawings:
1. General:
a. Show interfaces between any of the following: Instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flowmeters, chemical feeders, digital bus network equipment, and other equipment related to the control work provided.
2. Shop Drawing requirements:
a. Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
b. Locations of conduit entrances and access plates.
c. Component layout and identification.
d. Schematic and wiring diagrams with wire numbers and terminal identification.
e. Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
f. Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
g. Weight.
h. Finish.
i. Nameplates with legends:
1) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
j. Temperature limitations, as applicable.
3. Loop drawings when applicable:
a. Submit loop drawings for every analog, discrete, fieldbus signal and control circuit:
1) Provide a loop drawing Submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop for supplier provided equipment.
b. Show every instrument and I/O point on at least 1 loop diagram.
c. Provide a complete index in the front of each bound volume:
1) Index the loop drawings by systems or process areas.

d. Provide drawings showing definitive diagrams for every instrumentation loop system:
    1) Show and identify each component of each loop or system using requirements and symbols from ISA S5.4.
    2) Furnish a separate drawing sheet for each system or loop diagram.
e. In addition to the ISA S5.4 requirements, show the following details:
    1) Functional name of each loop.
    2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
    3) Show all terminal numbers, regardless of the entity providing the equipment.
    4) PCP panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.
    5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
    6) If a circuit is continued on another drawing show the name and number of the continuation drawing on the loop drawing. Provide complete references to continuation Drawings.
f. [Contractor shall be responsible for reviewing existing plant as-built information for the generation of Drawings that include existing plant control equipment. Whereas-built information is not available, accurate information shall be collected through site surveys.

4. Control panel drawings:
    a. Layout drawings:
        1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for items provided.
        2) As a minimum, include the following information:
            a) To scale front, side, and plan views.
            b) Dimensions.
            c) Interior and exterior arrangements.
            d) Mounting information, including conduit entrance location.
            e) Finish data.
            f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
            g) Nameplate legend including text, letter size, materials, and colors.
    b. Wiring and piping diagrams:
        1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
        2) Include the following information:
            a) Name of panel.
            b) Wiring and piping sizes and types.
            c) Terminal strip numbers.
            d) Wire tags and labels.
            e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
            f) Electrical control schematics in accordance with ANSI standards.

c. Calculations:
    1) Provide installation details based on calculated shear and tension forces:
        a) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
    2) For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
        a) Weight including panel internal components.
        b) Seismic forces and overturning moments.
        c) Shear and tension forces in connections.
    3) Cooling calculations, to include, but not limited to:
        a) Highest expected ambient temperature for the enclosure's location.
        b) Internal heat load.
        c) Exposure to direct sunlight.
        d) Dimensions of the enclosure in inches.
        e) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

5. Schematic diagrams:
    a. Submit schematic diagrams for electrical equipment in ladder diagram format.
    b. Include device and field connection terminal numbers on schematic diagrams.

E. Process control and LOI software set up Submittal:
1. A complete listing of the PLC system point I/O database:
    a. Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
    b. Organize on a site-by-site basis, separate by point type.
    c. In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
    d. Upon completion of the Work, update I/O lists to indicate the final as-built configuration of the systems:
        1) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.
2. Preliminary LOI screens, including pop-ups, trends, and alarm screens. Provide electronic and hard copy.
3. Final LOI screens . Provide electronic and hard copy.

F. Testing:
1. For each test specified in this Section, prepare and submit complete test plans, test procedures, test forms, test binders, and test reports, and other Submittals, as specified below.
2. Submit manufacturer's certifications and manufacturer's field reports where required.

3. Submit test plans, procedures, forms, and binders for approval by the Engineer before scheduling or performing tests.
4. Additional test form and test procedure requirements are specified with individual test requirements.

G. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 – Design Criteria.
a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
b. For equipment installed outdoors.
c. For wall mounted equipment weighing 125 pounds or more.

H. Furnish commissioning Submittals listed below, as specified in this Section, and in Section 01756 – Commissioning:
1. Manufacturer's representative qualifications.
2. Owner training.

1.06 QUALITY ASSURANCE

A. Assemble panels, enclosures, and rack systems along with internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels.

1.07 DELIVERY, STORAGE, AND HANDLING

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

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

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 – Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Coordination.

B. Meetings:
   1. Supplier shall schedule a coordination meeting with the Owner and Engineer.
      a. Meeting shall take place before installation of control systems equipment.
      b. Supplier shall bring sample LOI graphic screens, including pop-up, trends, and alarm screens.
      c. Sample LOI graphic screens shall be reviewed and discussed.
      d. Additional items for discussion:
         1) Tag Naming Conventions.
         2) Interlock and Permissive definitions.
         3) Standard code blocks for common control functionality.
         4) Alarms: Clearing, formats, colors, and status.

C. Sequencing:
   1. After successful completion of the pre-commissioning test as accepted by the Engineer and Owner, the performance test can proceed.
   2. Performance test may be performed concurrently with the 7-day operational test specified in Section 01756 – Commissioning.

D. Scheduling.

1.10 WARRANTY

A. As specified in Section 01783 – Warranties and Bonds.

1.11 MAINTENANCE

A. Supplier shall provide the following spare PLC hardware for the PLC equipment in the PCP.
   1. 1 spare CPU for every type of CPU in the system.
   2. 1 spare network communication cable for every type used in the system.

B. Provide 5 spare fuses of each type and rating furnished.

PART 2 PRODUCTS

2.01 GENERAL

A. PCP:
   1. PLC processor, power supply, I/O backplanes, I/O modules, communications modules, and communication cables sized for connected I/O and required spares.
   2. LOI on the face of the PCP enclosure for monitoring and control of the package control system.
   3. Uninterruptable power supply.

4. PCP shall exercise control over all aspects of the package control system.
5. All PLC and LOI programming or set up required for fully functional package control system.

B. Field instruments for process and equipment monitoring.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

B. Signal transmission:
   1. Analog signals:
      a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
      b. Furnish electrical analog signals outside control panels that are 4 to 20 mA 24 VDC, except as indicated.
      c. Analog signals within enclosures may be 1 to 5 VDC.
      d. Electrically or optically isolate analog signals from other signals.
      e. Discrete output signals:
         1) Output type according to the Supplier's discretion.
         2) Provide external terminal block mounted fuse with blown fuse indication for discrete outputs.
         3) Interposing relays:
            a) Provide interposing relays as required.
      f. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
      g. Maintain the total 4 to 20 mA loop impedance to 10 percent below the published value at the loop operating voltage.
      h. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.

C. Discrete circuit configuration:
   1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
   2. Alarm contacts: Fail to the alarm condition.
   3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

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

2.03 CONTROL PANEL

A. General:
   1. PLC processor, power supply, I/O backplanes, and modules sized for connected I/O and required spares.
   2. An LOI shall be provided on the face of the PCP enclosure for monitoring and control of the system.
   3. PCP shall exercise control over all aspects of the system. Each unit shall be equipped with a control panel containing I/O modules and necessary interface with the PCP.
   4. PCP shall continuously monitor all operating parameters and shall respond to alarms and emergency conditions by shutting down or activating system components. PCP shall indicate alarm conditions locally at the LOI**.**
   5. Uninterruptible power supply.
   6. PLC and LOI programming or set up required for fully functional package control system.

2.04 PROGRAMMABLE LOGIC CONTROLLERS (PLC) HARDWARE

A. PLC hardware shall be:
   1. Flygt Multismart 3PC2.

B. Installed spare requirements:
   1. I/O points:
      a. Provide total of 25 percent spare capacity for each type of I/O signal at the PCP.
      b. Provide 25 percent spare capacity for each type of I/O signal at the local control panels.
      c. Wire spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
      d. Space shall be available in the PCP to support the future addition of 50 percent additional spare I/O.
   2. PLC backplane capacity:
      a. Provide 25 percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
   3. PLC memory:
      a. 50 percent spare memory.
   4. PLC shall be capable of supporting the future addition of 100 percent additional spare memory.

2.05 BATTERY

A. General:
   1. Provide Battery at PCP.
   2. Battery shall be sized to provide minimum 30 minutes runtime at full load.

2.06 HUMAN MACHINE INTERFACE (LOI) HARDWARE

A. General:
   1. NEMA Type 12 rated.
   2. LOI shall communicate directly with PLC processor via dedicated communication cable.
   3. Provide color touch-screen type display.
   4. Screen size: Packaged Control System Supplier's preference.

B. LOI: One of the following or equal:
   1. Flygt Multismart.

2.07 PLC AND LOI PROGRAMMING

A. General:
   1. PLC programming software system shall be manufactured by the PLC hardware manufacturer.
   2. Provide 1 licensed copy of PLC programming software to the Owner.
   3. LOI programming software system shall be manufactured by LOI hardware manufacturer.
   4. Provide 1 licensed copy of LOI programming software to the Owner.

B. PLC programming software: One of the following or equal:
   1. Flygt programming software.

C. LOI programming software: One of the following or equal:
   Flygt programming software.

D. General programming requirements:
   1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
      a. Unless otherwise noted, utilize floating-point format for PLC algorithms and calculations.
      b. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
   2. Store adjustable parameters in the PLC and configure so that an operator with sufficient security access can change the parameters from the LOI or HMI. Update and display the current value at all locations, regardless of where the last change was made.
   3. Reusable PLC code blocks:
      a. Develop and use new standard user defined function blocks (UDFBs) and user defined types (UDTs) where appropriate. One instance of each standard code block shall reside in each PLC and shall be referenced in main routines and subroutines.
   4. Documentation:
      a. Control logic shall be completely annotated including all rungs, instructions, and tags.
      b. Each routine shall have a title and a detailed description of the control strategy represented by the control logic. Where parameters are passed to the routine, all parameters shall be defined in the routine description.

c. Analog tag descriptions representing process variables shall include the engineering unit range of the analog variable.
d. Digital tag descriptions shall include the On and Off state labels.
e. Complete, grammatically correct sentences and terminology, consistent with water treatment processes, shall be utilized in the development of rung and routine descriptions.
f. Equations developed in the process logic shall be fully documented in the rung or routine description. A description of each constant and variable utilized in the equation shall be defined including engineering units.

5. Saved setpoints:
   a. Provide an operator selection to save setpoint values.
   b. Provide an operator selection to restore setpoints to the last saved value.
6. Calculated values:
   a. Program calculations such that division by zero errors cannot occur.
   b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
   c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts and to rollover to zero at an even decimal interval (1 followed by 4 or more zeros).
7. Timers:
   a. Provide programmable settling and proving timers in control sequences as required for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
      1) Settling timers may be overridden by setting the timer to 0 seconds.
8. PLC status:
   a. Furnish information that depicts the status of all enclosures containing PLC or I/O in the control system, including, but not limited to, the following:
      1) PLC cabinet over-temperatures from high temperature switch.
      2) Intrusion status on enclosures equipped with intrusion switches.
      3) AC power failure.
         a) Monitor ahead of UPS.
      4) DC power supply failure.
         a) For redundant power supplies, alarm when either power supply or the diode bridge fails.
      5) UPS failure signal.
      6) UPS Low Battery signal.
      7) Digital bus network Coupler and or Gateway failure signal.
      8) Ethernet Switch failure signal.
9. PLC system communication status:
   a. Furnish a minimum of 1 screen to display all communication errors and status within the control system network:
      1) PLC to RIO.
      2) Digital bus network status.
      3) Display status of each node, and summary of failures over the past 60 minutes.
   b. Generate a communications alarm if any communication fault is detected.
   c. In the event of communications loss:
      1) Continue normal operation at each PLC with last known shared values.

E. Common control functions:
   1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
   2. Alarms:
      a. Generate alarms within the PLC logic.
      b. Indicate alarms at the LOI. Enable acknowledgement from the LOI.
      c. Generate high, high-high, low, and low-low level alarms where indicated:
         1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
         2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or has not been running long enough to establish flow.
      d. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
         1) Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
   3. Where run time accumulation is required, integrate accumulated run time to the nearest 0.1 hours whenever the running status input indicates that the equipment is running:
      a. Display total run time in hours.
   4. For monitored analog values:
      a. Convert values to engineering units in floating-point format within the PLC.
      b. Totalize flows in the PLC logic:
         1) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
         2) Where no totalizer input is shown, integrate the analog input over time.
         3) Display totals on the HMI and LOI.
   5. Analog data processing:
      a. Engineering units conversion:
         1) Use engineering units for analog point values. Convert analog inputs to engineering units.
      b. Analog magnitude checking:
         1) Provide clamps to prevent operator-entered values (setpoints, etc.) that fall outside acceptable limits.
   6. Tank and vessel levels:
      a. Display tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
         1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during the Submittal phase.
      b. Monitor rate of change of volume on all tanks and vessel:
         1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.

7. I/O filtering and processing:
    a. Analog input filtering:
        1) Provide PLC programming or set up for each analog input to implement an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, shall configure analog inputs with no filtering affect.
        2) Monitor analog input signal quality:
            a) Over range: Input value is above the normal range (typically over 21 mA).
            b) Under range: Input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
            c) Generate alarms for over or under range inputs.
            d) Do not use over- or under-range values for control or calculation purposes:
                (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
                (2) Otherwise, hold outputs affected by the signal at their last values before the signal went out of range.
        3) Digital input filtering (proving timer):
            a) Provide an adjustable time delay function (0 to 10 seconds) on discrete input for the purpose of de-bouncing.
            b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
8. LOI/HMI HAND-OFF-AUTO:
    a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections accessed from an LOI or HMI for operators with sufficient security, to provide the following operating modes:
        1) AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
        2) HAND: Enables Manual control where control decisions are made by an operator through the START-STOP, OPEN/CLOSE, or other selections as indicated.
        3) OFF: Automated control is disabled, and PLC calls for associated equipment to stop and valves to close or go to their identified safe state.
9. Display the current status of all operator selections (HAND/AUTO, START/STOP, etc.) on the LOI and HMI.
10. Motor control:
    a. Display current REMOTE status on the screens.
    b. Monitor the device’s running status:
        1) Display the current status (running or stopped) on the screens.
11. Interlocks:
    a. Implement software interlocks where indicated to place equipment in a safe condition in response to impending hazardous process conditions.
    b. Apply software interlocks when equipment is operating in PCS AUTO or PCS HAND.

12. Permissives:
    a. Implement software permissives where indicated to prevent equipment from starting in an unsafe condition.
    b. Apply software permissives when equipment is operating in PCS AUTO or PCS HAND.

2.08 PANELS, ENCLOSURES, AND PANEL COMPONENTS

A. General:
1. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.
2. It shall be the responsibility of the Supplier to design and size all panels.
3. Design panels to fit in the space as indicated on the Drawings.

B. Requirements:
1. Each panel will be fed by **a** 240-volt 3-phase AC power circuit or as otherwise indicated on the Drawings. Panel designs shall include control power transformers, power supplies and distribution components required to derive necessary control voltages.
2. Panel enclosure ratings shall conform to the area classifications as specified in Section 16050 – Common Work Results for Electrical.
3. Unless otherwise indicated on the Drawings**,** instruments provided as part of the packaged system shall be powered from Supplier-provided control cabinets.

C. Panels/enclosures:
1. Manufacturers: One of the following or equal:
    a. Rittal.
    b. nVent (formerly Hoffman Engineering).
    c. Saginaw Control & Engineering.
2. Panel assembly:
    a. General guidelines for panel fabrication include:
        1) Continuous welds ground smooth.
        2) Exposed surfaces free of burrs and sharp edges.
        3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
    b. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
3. In addition to the requirements specified above, the following requirements for NEMA Type 4X stainless steel enclosures apply:
    a. Minimum 14-gauge, Type 304 stainless steel.
    b. Captive stainless steel cover screws threaded into sealed wells.
    c. Finish: Unpainted, brushed finish.
    d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.

4. General wiring requirements:
    a. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for general purpose (no open wiring) unless otherwise specified.
    b. Install components in accordance with the manufacturer's instructions included in the listing and labeling.
    c. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a control power transformer and flange mounted disconnect.
        1) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected. Reactivate power once all doors are closed.
        2) Disconnect shall remove power from all power and control circuits, except for externally wetted signal and control signals. Externally powered circuits shall be grouped together, labeled, and provided with finger safe barriers.
    d. Control panels supplied with 120 VAC:
        1) Provide an internal breaker with the line side terminals covered by a barrier.
        2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
    e. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
    f. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
    g. Provide surge protection device on input supply power.
    h. Provide nonmetallic ducts for routing and organization of conductors and cables:
        1) Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring.
            a) 120 VAC: Grey colored ducts.
            b) 24 VDC: White colored ducts.
    i. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
        1) Screw-on cable tie mounts.
        2) Hammer-on cable-tie mounting clips.
        3) Fingers of the nonmetallic duct.
    j. Wire ties:
        1) No wire ties inside wire duct.
        2) Use Panduit Cable tie installation tool, with tension control/cutoff.
        3) Verify cut ends are cut flush filed smooth after installed.
    k. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
    l. Support panel conductors where necessary to keep them in place.
    m. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.

n. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
    1) Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
o. Control panel shall be the source of power for 120 VAC devices interconnected with the control panel, including, but not limited to:
    1) Solenoid valves.
    2) Instruments mounted both in the control panel and remotely connected to the control panel.

D. Thermal management:
1. Provide heating, cooling, and dehumidifying devices in order to maintain instrumentation and control devices to within an acceptable range.
2. Provide enclosure temperature sensor:
    a. Manufacturers: One of the following or equal:
        1) Omega, EWS Series.
        2) TCS Basys Controls, TS Series.

E. Panel meters:
1. Digital:
    a. Self-contained instruments that display process signals directly in engineering units.
    b. Manufacturers: The following or equal:
        1) Action Instruments Visipak.
        2) Red Lion.

F. Pilot devices:
1. General:
    a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
    b. Size:
        1) 30.5 millimeters.
    c. Heavy duty.
    d. Pushbuttons:
        1) Contacts rated:
            a) NEMA Type A600.
        2) Furnish 1 spare normally open and normally closed contact with each switch.
    e. Selector switches:
        1) Contacts rated:
            a) NEMA Type A600.
            b) Knob type.
        2) Furnish 1 spare normally open contact and normally closed contact with each switch.
        3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
    f. Pilot lights:
        1) Type:
            a) LED for interior installations.
        2) Push to test.

3) Lamp color:
a) On/Running/Start: Red.
b) Off/Stop: Green.
c) Power: White.
d) Alarm: Amber.
e) Status or normal condition: White.
f) Opened: Red.
g) Closed: Green.
h) Failure: Red.

2. Indoor and outdoor areas:
a. NEMA Type 4/13.
b. Manufacturers: One of the following or equal:
1) Allen-Bradley, Type 800T.
2) Square D, Class 9001 Type K.
3) General Electric, Type CR104P.
4) IDEC TWTD Series.

3. Corrosive areas:
a. NEMA Type 4X.
b. Corrosion resistant.
c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
d. Manufacturers: One of the following or equal:
1) Cutler Hammer, Type E34.
2) Square D, Class 9001 Type SK.
3) Allen-Bradley, Type 800H.
4) IDEC TWTD Series.

4. Hazardous (Classified) Areas/Class I Division 2:
a. NEMA Type 4X.
b. Corrosion resistant.
c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy-coated zinc:
1) Contacts contained within a hermetically sealed chamber:
a) Pushbuttons.
b) Selector switches.
c) Push-to-test contacts on pilot lights.
2) UL listed and labeled for Class I Division 2 areas.
d. Manufacturers: One of the following or equal:
1) Cutler Hammer, Type E34.
2) Allen-Bradley, Type 800H.

G. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
a. Minimum isolation level: 1.5 kV AC/50 Hz for at least 1 minute.
b. Adjustable span and zero.
c. Accuracy: Within 1.0 percent of span.
d. Ambient temperature range: -20 degrees Celsius to +65 degrees Celsius.
2. Manufacturers: One of the following or equal:
a. Phoenix Contact, Mini Analog Pro.
b. Acromag, 1500, 600T, 800T, Flat Pack or ACR Series.

c. Action Instruments, Q500 Series or Ultra SlimPakII.
d. AGM Electronics, Model TA-4000.
e. Moore Industries, MIT 4-Channel.

H. Relays:
1. General:
a. For all types of 120 VAC relays, provide transient surge protection across the coil of each relay.
b. For all types of 24 VDC relays, provide a free-wheeling diode across the coil of each relay.
c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
2. General purpose:
a. Magnetic control relays.
b. NEMA ratings:
1) 300 volts.
2) 10 Amps thermal continuous test current.
3) 60 Amps make.
4) 6 Amps break.
c. Plug-in type.
d. LED indication for relay energized.
e. Coil voltages: As required for the application.
f. Minimum poles: DPDT.
g. Touch safe design: Connection terminals to be protected against accidental touch.
h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
j. Relays with screw-type socket terminals.
k. Provide additional (interposing) relays when the following occurs:
1) Number or type of contacts shown exceeds the contact capacity of the specified relays.
2) Higher contact rating is required in order to interface with starter circuits or other equipment.
l. DIN rail mounting on 35-mm rail.
m. Ice Cube type relays shall be provided with retainer clips to secure relay in socket.
n. Manufacturers: One of the following or equal:
1) Potter and Brumfield, Type KRP or KUP.
2) IDEC, R* series. (* = H, J, R, S, U).
3) Allen-Bradley, Type 700 HC Series.
4) Schneider Electric, Type K, RXM.
3. Time delay:
a. Provide time-delay relays to control contact transition time.
b. Contact rating:
1) 240 volts.
2) 10 amps continuous.
3) 3,600 volt-amps make.
4) 360 volt-amps break.
c. Coil voltage: As required for the application.

d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
    1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
e. Minimum poles: 2 PDT.
f. Units include adjustable dial with graduated scale covering the time range in each case.
g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
h. Manufacturers: One of the following or equal:
    1) Finder.
    2) IDEC, RTE Series.
    3) Tyco Electronics (formerly Agastat), Series 7000 (pneumatic).
    4) Allen-Bradley, Type 700-HR.

I. Terminal blocks:
1. Din rail mounting on 35-mm rail.
2. Suitable for specified AWG wire.
3. Rated for 30 amps at 600 volts.
4. Screw terminal type.
5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
6. Finger safe protection for all terminals for conductors.
7. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees Celsius to 105 degrees Celsius.
8. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine printed terminal identification.
9. Identify terminals suitable for use with more than 1 conductor.
10. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
11. Provide minimum 10 percent spare terminals.
12. Manufacturers: One of the following or equal:
    a. Phoenix Contact, UT4 Series.
    b. Allen-Bradley Series 1492.

J. Surge protection devices (SPD):
1. 120 VAC control panel power SPD:
    a. Provide SPD for panel 120 VAC power entrances:
        1) Non-faulting and non-interrupting design.
        2) Provide line to neutral and neutral to ground surge protection.
    b. Provide surge protection at secondary of main circuit breaker:
        1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
        2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
    c. DIN rail mounting.

d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
    1) Gastight connections.
    2) Visual status indication of MOV status on the input and output circuits.
    3) Dry contact rated for remote status indication.
e. Approvals:
    1) Tested in accordance with IEC 61643-11.
    2) Tested in accordance with UL 1283.
    3) Tested in accordance with UL 1449.
    4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
f. Manufacturers: One of the following or equal:
    1) Phoenix Contact, Type SFP Filter.
    2) ASCO, Model 277.

2. 24 VDC control panel power SPD:
    a. Provide SPD for 24 VDC power circuits.
    b. Provide surge protection at DC power supply output.
    c. DIN rail mounting.
    d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
        1) Optical status indicator.
        2) Dry contact rated for remote status indication.
    e. Approvals:
        1) Tested in accordance with IEC 61643-11.
    f. Manufacturers: One of the following or equal:
        1) Phoenix Contact, Plugtrab PLT-SEC-T3-24-FM-UT.
3. Panel mounted control, signal, and data line SPD:
    a. General:
        1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
        2) Approvals:
            a) Tested in accordance with IEC 61643-21.
            b) Tested in accordance with UL 497B.
        3) SPD shall consist of 2 parts:
            a) Base module:
                (1) DIN rail mounting.
                    (a) Grounded to DIN rail via mounting rail foot.
            b) Plug protection module:
                (1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
        4) Provide indirect shield ground style SPD unless otherwise noted.
        5) Provide ability to locally identify and indicate SPD health.
        6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
        7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
        8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.

b. Manufacturers: One of the following or equal:
    1) Phoenix Contact, Plugtrab PT-IQ Series.
    2) Dehn, Blitzductor XTU Series.

4. Copper Ethernet SPD:
    a. Protects network equipment from lightning or other surge events.
    b. Suitable for Gigabit networks.
    c. Compatible with shielded Cat 6 cabling with shielded RJ-45 ports.
    d. Compliant with PoE standards IEEE 802.3af and 802.3at.
    e. Nominal discharge surge current: 10 kA.
    f. Approvals:
        1) Tested in accordance with IEC 61643-21.
        2) Tested in accordance with UL 497B.
    g. Manufacturers: One of the following or equal:
        1) Phoenix Contact, DT-LAN-CAT6+.
        2) Weidmuller, VDATA CAT6.
        3) Eaton/MTL, ZoneBarrier.
5. Field device mounted SPD:
    a. Conduit entry mounting.
        1) Provide parallel or through wiring configurations as required by the application.
            a) Use parallel wiring configuration if there is an available cable gland at the device.
            b) Use through wiring configuration if there is no available cable gland at the device.
        2) Provide Screw connections compatible with field device.
    b. NEMA 4X stainless steel material housing.
    c. Approvals:
        1) Tested in accordance with IEC 61643-21.
    d. 4-wire field device:
        1) Module shall provide simultaneous protection of signal cable, communication bus, or data line, and power supply line.
            a) Maximum continuous voltage:
                (1) DC:
                    (a) Signal: 32 VDC.
                    (b) Power supply: 255 VDC.
                (2) AC:
                    (a) Signal: 22.6 VAC.
                    (b) Power supply: 255 VAC.
        2) Manufacturers: The following, Engineer knows of no equal:
            a) Endress+Hauser, HAW569-CB2C.
    e. 2-wire or 3-wire field device:
        1) Module shall provide protection for the signal cable, communication bus or data line.
        2) Manufacturers: One of the following or equal:
            a) Endress+Hauser, HAW569 Series.
            b) Phoenix Contact, Surgetrab S-PT Series.
            c) Eaton/MTL, TP Series.

K. Power supplies:
   1. Design power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
   2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
   3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
   4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
      a. Provide automatic switchover upon module failure.
      b. Alarm contacts monitored by the PLC.
   5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
   6. Sized to provide 40-percent excess rated capacity.
   7. UL 61800-5-1 listed to allow full-rated output without de-rating.
   8. Provide fuse or short-circuit protection.
   9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
   10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
   11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
   12. Touch-safe design: Connection terminals to be protected against accidental touch.
   13. DIN rail mounting on 35-millimeter rail:
      a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
   14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
   15. Manufacturers: One of the following or equal:
      a. Fully redundant:
         1) Phoenix Contact, Quint Power Supply with SFB technology.
            a) Phoenix Contact, Quint.
         2) IDEC, PS5R Series:
         3) Sola.
         4) PULS.
      b. Redundancy module:
         1) Phoenix contact, O-ring redundancy module.

L. Intrinsic safety barriers:
   1. Transformer isolated barrier:
      a. Containing a transformer to provide complete:
         1) Isolation between the safe and hazardous areas for loop powered devices.
         2) 3-way isolation between the safe area, hazardous area and power supply powered devices.
      b. Resistor for current limitation.

c. Fuses for short circuit protection.
d. Provide barriers with pluggable connectors that are coded for easy replacement.
e. Transmission error shall be less than or equal to 0.1 percent of full scale.
f. DIN rail mounted on 35-mm DIN rail.
g. Approvals:
1) FM.
2) UL 913.

2. Manufacturers: One of the following or equal:
a. Phoenix Contact, MACX Series.
b. Pepperl + Fuchs.

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

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

O. Conductors and cables:
1. Power and control wiring:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 volts Type MTW.
c. Minimum sizes:
1) Primary power distribution: 12 AWG.
2) Secondary power distribution: 14 AWG.
3) Control: 16 AWG.
d. Color:
1) AC power (line and load): BLACK.
2) AC power (neutral): WHITE.
3) AC control: RED.
4) AC control: ORANGE for foreign voltages.
5) DC power and control (ungrounded): BLUE.
6) DC power and control (grounded): WHITE with BLUE stripe.
7) Ground: GREEN.

2. Signal cables:
    a. Materials: Stranded, soft annealed copper.
    b. Insulation: 600 V, PVC outer jacket, 16 AWG paired triad overall aluminum shield (tape), with copper drain wire.
    c. Color:
        1) 2 conductor:
            a) Positive (+): BLACK.
            b) Negative (-): WHITE and RED.
        2) 3 Conductor:
            a) Positive (+): BLACK.
            b) Negative (-): RED.
            c) Signal: WHITE.
    d. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

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

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

2.09 FIELD INSTRUMENTS

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

B. Pressure transmitters shall be one of the following:
   1. Emerson, Rosemount 3051 Series.
   2. Emerson, Rosemount 2051 Series with High performance option.
   3. Yokogawa, EJA Series.
   4. ABB, 266 Series.
   5. Endress & Hauser, Cerabar S Series.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Field instruments installation:
   1. Install field instruments as specified in the Contract Documents and in accordance with API 550 and 551 and the manufacturer's instructions.
   2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
      a. Mount field instruments on a pipe stand or local panel if they are not directly mounted.
      b. Provide sun shields for field electronic instruments exposed to direct sunlight.
   3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
      a. Type of flexible conduit required for the area classification.
      b. Maximum length of 18 inches.

4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
    a. Special cable applications shall be in accordance with the NEC.
5. Verify the correctness of each installation:
    a. Polarity of electric power and signal connections.
    b. Ensure process connections are free of leaks.

B. Process sensing lines and air tubing:
1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
2. Provide supports for rigid tubing at intervals of not more than 3 feet.
3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
4. Bends:
    a. Use proper tool.
    b. Make bends for parallel lines symmetrical.
    c. Make bends without deforming or thinning the walls of the tubing.
5. Square-cut and clean ends of tubing before being inserted in the fittings.
6. Provide bulkhead fittings at panels requiring pipe and/or tubing entries.
7. Use stainless steel tubing for piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
    a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.

C. Equipment tie-downs:
1. Anchor instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the site.
2. Control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.

D. Instrument tagging:
1. Provide all field-mounted instruments with nameplates:
    a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
        1) Affix tags with stainless steel wire fasteners.
2. Provide back of panel instruments with nameplates:
    a. Engraved with the instrument's full tag number.
3. Provide front of panel instruments with a nameplate:
    a. Engraving to include the following:
        1) Instrument's full tag number.
        2) Service description.
    b. Nameplates:
        1) Secure nameplates to the panel with stainless steel screws.
        2) Use an approved adhesive if screws would violate the NEMA or other ratings of the enclosure.

E. Cable and conductor termination:
   1. Terminate cables and conductors on terminal blocks.
   2. Terminal block enclosures:
      a. Suitable for the area classification.

F. Surge protection:
   1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments.
   2. Individually fuse each 4 to 20 mA DC loop with a 1/16-amp fuse between power supplies and receiver surge protectors.
   3. Provide voltage surge protection for 4-wire transmitters and analyzers:
      a. Protect both power source and signal loop.

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

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing:
   1. Right of observation: Owner retains the right to observe source test activities, including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.
   2. Owner reserves the right to test any specified function, whether or not explicitly stated in the test Submittal.
   3. Costs for repeating testing: Supplier shall pay for Engineer's and other Owner's representatives' travel, subsistence for witnessing the repetition of failed tests.
   4. Correction of deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
   5. Any changes and/or corrections shall be noted on the test forms. Engineer shall witness the revisions and/or corrections prior to leaving the test site.
   6. If the corrections and/or revisions are too extensive to be made while the Engineer is scheduled to be at the Source test site, the Source Test shall be, at the Engineer's sole discretion, considered failed, and the test shall be restarted at a later date. Costs for the re-test shall be borne by the Supplier.

C. Testing simulation:
   1. Source shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points of the PLCs and controllers provided. Inputs and outputs shall be simulated, and proper control and system operation shall be validated.

D. Panel inspections:
   1. Engineer to inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the approved Shop Drawings.
   2. Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.

E. I/O test:
   1. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and operator displays.
   2. Test methodology:
      a. Discrete inputs:
         1) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
      b. Discrete outputs:
         1) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
      c. Analog inputs:
         1) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
         2) Check each point at 0 percent, 50 percent, and 100 percent of scale.
      d. Analog outputs:
         1) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
   3. Test forms to include, but not be limited to:
      a. PLC and panel number.
      b. I/O type.
      c. I/O tag name.
      d. Panel terminal block numbers.
      e. Rack/slot/number of I/O point.
      f. Check-off for correct response for each I/O point.
      g. Space for comments.
      h. Initials of individual performing test.
      i. Date test was performed.
      j. Witness' signature lines.

F. Control logic test:
   1. Verify the PLC and LOI provides monitoring and control functionality based upon specified and designed control requirements.
   2. Testing requirements:
      a. Demonstrate in detail how each function operates under a variety of operating scenarios.
         1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.

b. Demonstrate the proper operation of the programming and configuration for each control strategy or loop description.
    1) Test each strategy or loop description on a sentence by sentence and function by function basis.
    2) Loops with similar or identical logic must each be tested individually.
    3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
c. Demonstrate the proper operation of digital communication links and networks.
    1) Verify each digital communication I/O point.
d. Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions, including, but not limited to: Equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.

3. Test forms:
    a. Include the fully revised and approved for the loop being tested.
    b. Identify the cause and effect as each I/O point is toggled through the simulator. Check boxes shall be provided to track proper and/or improper operation of the loop.
    c. Any deficiencies or operational changes shall be noted on the forms for correction and documentation:
    d. Include signature and date lines.
4. Engineer approval of the FAT Submittal is required prior to shipment of system components.

G. Installation Verification.

H. Functional Testing:
1. General:
    a. Commence pre-commissioning tests after completion of loop check/validation tests:
        1) Pre-commissioning to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
2. Control logic operational validation:
    a. The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the system, control panels (including vendor control panels), control circuits, control stations, monitored/controlled equipment, and final control elements.
3. Loop tuning:
    a. Optimally tune electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
4. Pre-commissioning validation sheets:
    a. Document each pre-commissioning test on an approved test form.
    b. Document loop tuning with a report for each loop, including 2-pen chart recordings showing the responses to step disturbance at a minimum of

3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Supplier and Engineer.

5. Pre-commissioning certification:
    a. Document via a certified report the completion of pre-commissioning and test activities:
        1) Including test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that pre-commissioning test requirements have been satisfied.

I. Owner Training:
1. Perform Owner training as specified in Section 01756 - Commissioning.
2. Number of sessions:
    a. Operations 1.
    b. Maintenance 1.

J. Training topics:
1. Provide system maintenance and operator training courses for all the instrumentation, control systems furnished.
2. Training course requirements:
    a. Operator training:
        1) Operator's training shall include:
            a) Control system overview: Architecture, equipment functions, software components, etc.
            b) Display navigation, overview, and types of displays.
            c) Process and equipment monitoring and control: Basic principles and operation.
            d) Logging ON and OFF the system and description of the security and access system.
            e) Alarm subsystem.
    b. PLC hardware training:
        1) Furnish training on PLC hardware and on related components, including battery backup equipment, UPSs, LOI hardware, control circuits, and analog circuits.
        2) Furnish training on PLC hardware principles, product features, proper installation, operation, troubleshooting, and maintenance.
        3) PLC training may be provided by manufacturer's certified trainers.
    c. PLC software configuration set up training:
        1) Furnish training on PLC software:
            a) Training covers the system set up, and documentation created for the work performed under this Contract.
    d. LOI hardware and software training:
        1) Provide the following:
            a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
            b) editing, and saving display screens.
            c) Troubleshooting.
    e. Instrumentation training:
        1) Furnish training covering all instruments and control panels.

2) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this project.
3) Furnish training on the operation of new hardwired controls.

3.04 FIELD QUALITY CONTROL

A. General:
1. Failure testing:
a. Demonstrate how the system reacts and recovers from abnormal conditions, including, but not limited to:
1) Equipment failure.
2) Communications sub-system error.
3) Power failure.
4) Process equipment failure.
5) High system loading conditions.

B. Loop check/validation:
1. Check all control loops under simulated operating conditions.
2. Provide “end-to-end” tests:
a. Test PLC/controller inputs and outputs from field device to operator displays and pilot devices.

3.05 ADJUSTING

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

3.06 CLEANING

A. Vacuum clean control panels and enclosures before start-up and again after final completion of the project.

B. Clean all panel surfaces.

C. Return to new condition any scratches and/or defects.

D. Wipe instrument faces and enclosures clean.

E. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
1. Neatly coil and label spare wiring lengths.
2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

END OF SECTION

SECTION 17201

LEVEL MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Conductivity level switch.
   2. Ball float level switch.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide complete documentation covering the traceability of calibration instruments.

1.04 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

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

C. Manufacture instrument facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

1.09 MAINTENANCE

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Conductivity level switch:
      a. Standard applications:
         1) Flygt Multitrode.
   2. Ball float level switch:
      a. E+H, Liquifloat T FTS20.
      b. Evoqua Water Technologies, 9G-EF.
      c. ITT Flygt, Model ENM-10.
      d. Anchor Scientific Inc., Ecofloat/Solofloat.

2.04 MANUFACTURED UNITS

A. As specified in this Section, including Attachment A - ISA Datasheet - Level Measurement: Switches.

B. Conductivity level switch:
   1. General:
      a. Probe type conductivity level switches integrating a control relay, control and reference electrode probes as required, and electrode probe holder. Electrode probes shall be rigid stainless steel and probe holder pressure tight.
      b. All components provided by the same manufacturer.
   2. Element:
      a. Rigid type:
         1) For probe lengths of 6 feet and less provide Type 316 stainless steel rigid probes.
         2) Electrode probe shall be threaded at one end to fit electrode holder threads and insulated with 1/32-inch PVC sheath down to 1 inch from the other end.
      b. Electrode probe holder.
      c. Suspended probes:
         1) For probe lengths longer than 6 feet, provide wire suspended probes within a protective plastic shield suspended and PVC insulated wires.
         2) Provide suitable adapters for fastening upper end to electrode fitting.
   3. Switch: The control relay senses the liquid level by conductance through electrode probes and the process liquid:
      a. Provide a solid-state general-purpose control relay designed for single level or differential control.
      b. Electrical connection: One 1/2-inch NPT conduit entry.
      c. Power supply:
         1) As indicated in the datasheets.
   4. Output:
      a. Relay outputs:
         1) As indicated in the datasheets.
         2) Enclosure:
            a) As indicated in the datasheets.
            b) Class I Division 1 area:
               (1) Explosion-proof/Class I Division 1 rated.
               (2) NEMA 4X with intrinsic safe circuits.
   5. Components:
      a. Adjustable time delay on increasing or decreasing level.

C. Ball float level switch:
   1. General:
      a. Encapsulated body with a switch to determine position of float.
   2. Outputs:
      a. Power supply.
      b. Relay outputs.
      c. 1 Form C contact.
      d. Rated at 6 amps at 120 VAC.
      e. Programmable for adjustable hysteresis.
   3. Element:
      a. Mechanical switch encapsulated in waterproof floating ball of nominal diameter, supported by flexible PVC cable and jacket or heavy neoprene.
      b. The length of the PVC cable shall be, at a minimum, equal to sump depth plus 5 feet.

c. Float: Provide Type 316 stainless steel or polypropylene, maximum 5.5 inches in diameter.
d. An operating temperature rating: -4 degrees Fahrenheit to +185 degrees Fahrenheit.
e. Mercury switches are not acceptable.
f. Suspend ball float and adjust for level setpoint as required.
g. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
h. Provide the number of floats per level system as indicated on the Drawings.

4. Switch:
   a. Power supply:
      1) None.
   b. Outputs:
      1) As indicated in the datasheets.
      2) Single pole double throw contacts rated 10 amps resistive at 120 VAC.
   c. Enclosure:
      1) As indicated in the datasheets.
      2) Class I Division 1 area:
         a) Explosion-proof/Class I Division 1 rated.
         b) NEMA 4X with intrinsic safe circuits.
      3) For more information, see Attachment A - ISA Datasheet - Level Measurement: Switches.
5. Components:
   a. Floats shall include Type 316 stainless steel clamp and brackets and 1/4-inch cable to allow testing of the float without entering the basin or wet well.
   b. Provide strain relief at both ends of the float cable.

D. Displacement float level switch:
   1. General: Float with a permanent magnet encircles a stationary stem. A hermetically sealed magnetically operated latching reed switch(es) mounted in the stem:
      a. Mercury switches are not acceptable.
   2. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
   3. Switch:
      a. As indicated in the datasheets.
      b. Single pole single throw (SPST).
   4. Rating:
      a. Class I Division 1 area:
         1) Explosion-proof/Class I Division 1 rated.
         2) NEMA 4X with intrinsic safe circuits.

E. The number of floats per level system shall be as indicated on the Drawings.

2.05 ACCESSORIES

A. Provide sunshades for outdoor installation.

2.06 SOURCE QUALITY CONTROL

A. FM approval certification or equal when installed in classified areas.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.04 SCHEDULES

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

END OF SECTION

ATTACHMENT A - ISA DATASHEET - LEVEL MEASUREMENT: SWITCHES

A/E:	Carollo Engineers	LEVEL MEASUREMENT: SWITCHES				Spec. No.	Rev.
Contractor:		No	By	Date	Revision	17201	
Project:	Calaroga Sanitary Sewer PS					Contract	Date
Customer:	City of West Linn						
Pump Station:	Calaroga					Req.	P.O.
Location:	West Linn, OR						
BOM No.:						By	Chk. App.
File:							

	1	Type	Conductance:	Capacitance:	Tuning Fork:	Ball Float: X	Displacement:	
	2	Setting	Field Set:	Factory Set: X				
G	3	Dead Band	Fixed: X	Adj:	Other:			
E	4	Material						
N	5	Dimensions	Field Set:					
E	6	Mounting	Flange:	Threaded:	Other: Suspended			
R	7	Operating Pressure /Temperature						
A	8	Connection	MFR STD: X	Other:				
L	9	Manufacturer						
	10	Other						
	11	Other						
S	12	Type	Mechanical: X	Reed:	Other:			
W	13	Quantity	Single: X	Dual:	Other:			
I	14	Form	SPST:	SPDT: X	DPDT:	Other:		
T	15	Rating: Amps Volts Hertz						
C	16	Load	Inductive:		Non-Inductive: X			
H	17	Other						
	18	Other						

Rev.	Tag Number	Model No.	Setpoint	P&ID	Service	Notes
	LE-103		See Sheet C04	N06	Wastewater	NL108/TYP

Notes: Refer to Section 17201 for additional level switch requirements.

A/E:	**Carollo Engineers**		**LEVEL MEASUREMENT: SWITCHES**					**Spec. No.**		**Rev.**	
Contractor:			**No**	**By**	**Date**	**Revision**		17201			
Project:	Calaroga Sanitary Sewer PS							**Contract**		**Date**	
Customer:	City of West Linn										
Pump Station:	Calaroga							**Req.**		**P.O.**	
Location:	West Linn, Oregon										
BOM No.:								**By**	**Chk.**	**App.**	
File:											

	1	**Type**	Conductance:	Capacitance: X	Tuning Fork:	Ball Float:	Displacement:		
	2	**Setting**	Field Set:	Factory Set: **X**					
G	3	**Dead Band**	Fixed: **X**	Adj:	Other:				
E	4	**Material**							
N	5	**Dimensions**	Field Set:						
E	6	**Mounting**	Flange:	Threaded:	Other: Suspended				
R	7	**Operating Pressure /Temperature**							
A	8	**Connection**	MFR STD: **X**	Other:					
L	9	**Manufacturer**							
	10	**Other**							
	11	**Other**							
S	12	**Type**	Mechanical:	Reed:	Other: Electrical				
W	13	**Quantity**	Single: **X**	Dual:	Other:				
I	14	**Form**	SPST:	SPDT: **X**	DPDT:	Other:			
T	15	**Rating:** **Amps** **Volts** **Hertz**		24VAC	50/60Hz				
C	16	**Load**	Inductive:		Non-Inductive: **X**				
H	17	**Other**							
	18	**Other**							

Rev.	Tag Number	Model No.	Setpoint	P&ID	Service	Notes
	LE-100		See Sheet C04	N06	Wastewater	NL111/TYP

Notes: Refer to Section 17201 for additional level switch requirements.

A/E:	Carollo Engineers	LEVEL MEASUREMENT: SWITCHES				Spec. No.	Rev.
Contractor:		No	By	Date	Revision	17201	
Project:	Calaroga Sanitary Sewer PS					Contract	Date
Customer:	City of West Linn						
Pump Station:	Calaroga					Req.	P.O.
Location:	West Linn, OR						
BOM No.:						By	Chk. App.
File:							

	1	Type	Conductance:	Capacitance:	Tuning Fork:	Ball Float:	Displacement: X
	2	Setting	Field Set:	Factory Set: X			
G	3	Dead Band	Fixed: X	Adj:	Other:		
E	4	Material					
N	5	Dimensions	Field Set:				
E	6	Mounting	Flange:	Threaded:	Other: Suspended		
R	7	Operating Pressure /Temperature					
A	8	Connection	MFR STD: X	Other:			
L	9	Manufacturer					
	10	Other					
	11	Other					
S	12	Type	Mechanical: X	Reed:	Other:		
W	13	Quantity	Single: X	Dual:	Other:		
I	14	Form	SPST:	SPDT: X	DPDT:	Other:	
T	15	Rating: Amps Volts Hertz					
C	16	Load	Inductive:		Non-Inductive: X		
H	17	Other					
	18	Other					

Rev.	Tag Number	Model No.	Setpoint	P&ID	Service	Notes
	LSH-200		3-inches	N07	Wastewater	NL101/TYP

Notes: Refer to Section 17201 for additional level switch requirements.

SECTION 17401

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Diaphragm seals.
   2. Annular seals.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. American National Standards Institute (ANSI).

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Manufacturer’s installation instructions.
      b. Seal type.
      c. Body materials.
      d. Diaphragm material.
      e. Fill fluid type.
      f. Seal size.
      g. Options.
      h. Process connection.

1.04 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions including:
   1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
   2. Physical conditions:
      a. Installation and mounting requirements.

b. Location within the process.
c. Accessories: Verify that required accessories are provided and are compatible with the process conditions and physical installation.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

1.09 MAINTENANCE

A. Furnish a spare annular seal for every size provided in the project.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide seals identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. Diaphragm seals:
   1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
      a. Ashcroft:
         1) Flushing connection: Type 201.
      b. Mansfield and Green:
         1) Flushing connection: Type SG.
      c. Wika:
         1) Type L990.10.

B. Annular seals:
    a. Not used.

2.04 MANUFACTURED UNITS

A. Diaphragm seals:
    1. General:
        a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
    2. Requirements:
        a. Seal type:
            1) Metallic diaphragm: Welded to upper housing.
            2) Elastomer diaphragm: Bonded to upper housing.
        b. Process connection:
            1) 1 inch NPT.
        c. Instrument connection: 1/2-inch NPT.
        d. Material Construction:
            1) Type 316 stainless steel.
        e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
        f. Flush port plug: Same material of construction as diaphragm lower housing.
        g. Provide fill/bleed connection.
        h. Mounting: As indicated in the Contract Documents.
        i. Provide Type 316 stainless steel armored capillary for remote installations.
        j. Nuts and bolts: Type 316 stainless steel.
        k. Materials of construction:
            1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
                a) Diaphragm: Type 316 stainless steel.
                b) Lower housing: Type 316 stainless steel.
                c) Upper housing: Manufacturer’s standard.
                d) Fill fluid: Silicone oil.

B. Annular seals:
    1. Not used.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation System.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances including weld-o-lets, valves, etc., for proper installation of instruments.

C. Do not use Teflon™ thread seal tape on pressure instruments with silicone oil fill fluid.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 17402

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve manifolds and instrument valves.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Additional requirements:
   1. Product data:
      a. Valve type.
      b. Body material.
      c. Size.
      d. Options.
   2. Shop drawings:
      a. Mounting details for all manifold valves.

1.04 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

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

C. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the valve manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

1.09 MAINTENANCE

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

PART 2 PRODUCTS

2.01 GENERAL

A. Provide all valves identified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide valves suitable for the installed site conditions including, but not limited to, material compatibility, process, and ambient temperatures.

2.03 MANUFACTURERS

A. Valve manifold:
   1. One of the following or equal:
      a. Anderson Greenwood.
      b. Hex Valve.
      c. Noshok.
      d. Emerson, Rosemount.

B. Block and bleed valve:
   1. One of the following or equal:
      a. Anderson Greenwood.
      b. Hex Valve.

C. Gauge valve:
   1. One of the following or equal:
      a. Anderson Greenwood.
      b. Hex Valve.

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

2.04 MANUFACTURED UNITS

A. Valve manifolds:
   1. General:
      a. Provide 2-valve, 3-valve manifolds as indicated on the Drawings.
      b. Valve manifolds shall have one piece bonnet with a metal-to-metal seal to the valve body below the bonnet threads.
   2. Requirements:
      a. Bonnet lock pin to prevent accidental loosening.
      b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
      d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
      e. Manifold valves shall allow for direct or remote instrument mounting.
      f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
      g. Materials of construction:
         1) Body material: Type 316 stainless steel.
         2) O-ring: Teflon™.
      h. 2-Valve manifolds:
         1) 1 isolation valve and 1 drain/vent and calibration valve.
      i. 3-Valve manifolds:
         1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
         2) Plugged vent connections used for vent/drain or calibration.

B. Block and bleed valves:
   1. General:
      a. Valve shall provide process isolation and venting/draining capabilities.
      b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
      c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
      d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.

2. Requirements:
    a. Materials of construction:
        1) Body material: Type 316 stainless steel.
        2) O-ring: Teflon™.

C. Gauge valves:
1. General:
    a. Valve shall provide process isolation from pressure instrument.
    b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
    c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
2. Requirements:
    a. Materials of construction:
        1) Body material: Type 316 stainless steel.
        2) O-ring: Teflon™.

2.05 ACCESSORIES

A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.

B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location and verify the valve will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of all valves.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 17404

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pressure/vacuum gauges.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Accessories.

1.04 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

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

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide instruments specified in the Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

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

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Ashcroft:
      a. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1009.
   2. Wika.
   3. Ametek U.S. Gauge.

2.04 MANUFACTURED UNITS

A. General:
   1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

B. Performance requirements:
   1. Pressure range:
      a. As specified in the Contract Documents.
   2. Accuracy:
      a. Grade 2A, as defined by ASME B40.100.
      b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
      c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.

3. Element:
    a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
    b. Socket tips for bellows and Bourdon® tube:
        1) Materials: Type 316 stainless steel.
    c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
    d. Wetted materials:
        1) Type 316 stainless steel.
4. Dial gauge:
    a. Dial size: 4-1/2 inches.
    b. Dial case material:
        1) As indicated in the datasheets.
        2) Maximum pressure greater than or equal to 10 pounds per square inch:
            a) Stainless steel.
    c. Provide safety gauge with safety blow out through the back or top of the unit.
    d. Dial face: Gasketed shatterproof glass or polycarbonate.
    e. Provide gauge locks on pressure gauges directly connected to diaphragm seals.
    f. Provide gauge locks where possible.
    g. Hermetically sealed.
    h. Connection and mounting:
        1) Direct mounted and suitable for outdoor installation.
        2) 1/2-inch NPT.
        3) Connection material:
            a) Stainless steel.
    i. Pointer: Externally adjustable.

2.05 ACCESSORIES

A. Pulsation dampeners and snubbers:
    1. As indicated in the datasheets.
    2. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
    3. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
    4. Mount pulsation dampener or snubber integrally to the pressure gauge.
    5. Connection: 1/2-inch NPT.
    6. Provide diaphragm seals as specified in the Contract Documents and/or as indicated in the datasheets.
    7. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

B. Provide means for gauge isolation as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves:
   1. Mount valve manifold integrally to the gauge.
   2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.06 SOURCE QUALITY CONTROL

A. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.

B. Provide complete documentation covering the traceability of calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

3.02 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Coordinate the installation with trades to ensure that the mechanical system has necessary appurtenances including weld-o-lets, valves, etc., for proper installation of instruments.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.04 ADJUSTING

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

3.05 SCHEDULES

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

END OF SECTION

ATTACHMENT A - ISA DATASHEET - PRESSURE/VACUUM MEASUREMENT: GAUGES

A/E:	**Carollo Engineers**	**PRESSURE/VACUUM MEASUREMENT: GAUGES**						
						Spec. No.		**Rev.**
Contractor:		**No**	**By**	**Date**	**Revision**	17404		
Project:	**Calaroga Sanitary Sewer PS**					**Contract**		**Date**
Customer:	City of West Linn							
Plant:	n/a					**Req.**		**P.O.**
Location:	3821 Calaroga Drive							
BOM No.:						**By**	**Chk**	**App**
File:								

1	**Type**	Direct Rdg.: √		Receiver:		Other:
2	**Mounting**	Surface:		Local:		Flush:
3	**Dial**	Diameter: 4.5”			Color:	
4	**Case**	**Cast Iron:**	**Aluminum:**	**Phenolic:**	**Polished SS √**	**Other:**
5	**Ring**	Screwed:	Hinged:	Slip:	Std:	Other:
6	**Blowout Protection**	None:	Disc:	Front:	Other:	Mfr. Std.
7	**Lens**	Glass: √			Plastic:	
8	**Options**	Siphon: N/A			Material:	
9	**Other**	Snubber:				
10	**Other**	Pressure Limit Valve: N/A				
11	**Other**	Movement Damping: N/A				
12	**Nominal Accuracy Required**					
13	**Pressure Element**	Bourdon®: √		Bellows:		Other:
14	**Element Material**	Bronze:	Steel:		Type SS: 316 √	Other:
15	**Socket Material**	Bronze:	Steel:		SS: 316	Other:
16	**Connection**	¼ in.:	½ in.: √		Bottom:	Other:
17	**Movement**	Dampened:	Standard: √		Other:	
18	**Diaphragm Seal**	Mfr.:		Wetted Part Mat’l:		Type:
19	**Other**	Other Mat’l:		Fill Fluid:		Model:
20	**Manufacturer**					
21	**Model No.**					

Rev	Tag Number	Range	P&ID	Service	Notes
		0-60 psi	**N07**	**Wastewater Pump Discharge**	**NP502/Typ**

Notes:
Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements.

SECTION 17710

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS
TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Design, fabrication and assembly of instrumentation enclosures, control panels and components provided under this contract, including, but not limited to:
      a. Custom built instrumentation and control panels, including enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
      b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
      c. Control components.
      d. Control panel installation.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE):
      a. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
      b. 802.3af - Standard for Information Technology Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
      c. 802.3at - Standard for Information Technology -- Local and Metropolitan area networks -- Specific requirements -- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements.
   2. International Electrotechnical Commission (IEC):
      a. 61643-11 - Low-Voltage Surge Protective Devices - Part 11: Surge Protective Devices Connected to Low-Voltage Power Systems - Requirements and test methods.
      b. 61643-21 - Low-Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications and Signaling Networks - Performance Requirements and Testing Methods.
   3. Underwriters Laboratories Inc. (UL):
      a. 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses.
      b. 497B - Standard for Protectors for Data Communications and Fire-Alarm Circuits.
      c. 508 - Standard for Industrial Control Equipment.
      d. 508A - Standard for Industrial Control Panel.
      e. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
      f. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.

g. 1077 - Standard for Supplementary Protectors for Use in Electrical Equipment.
h. 1283 - Standard for Electromagnetic Interference Filters.
i. 1449 - Standard for Surge Protective Devices.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Provide Submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Provide a control panel hardware Submittal for each control panel/enclosure being provided on this project, including, but not limited to:
1. Product data:
a. Enclosure construction details and NEMA type.
b. Manufacturer’s literature and specification datasheets for each type of equipment to be installed within or on the panel or enclosure.
2. Shop Drawings:
a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
1) Provide draft for review and approval by the Engineer. Engineer has the authority to substantially alter initial panel layouts.
b. Complete nameplate engraving schedule.
c. Structural details of fabricated panels.
3. Calculations:
a. Cooling calculations, including, but not limited to:
1) Highest expected ambient temperature for the enclosure’s location.
2) Internal heat load.
3) Exposure to direct sunlight.
4) Dimensions of the enclosure in inches.
5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria:
a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.

b. For equipment installed outdoors.
c. For wall mounted equipment weighing 125 pounds or more.

1.06 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Assemble panels, enclosures, and rack systems along with internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
   1. Provide components and equipment with UL 508 listing.
   2. Control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
   3. Provide fuses for equipment that is not UL or UR listed.
   4. Install intrinsically safe circuits and equipment in accordance with UL 698A.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide control panels identified in Contract Documents.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Panel dimensions:
   1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer’s non-certified information. It is the responsibility of the Contractor or manufacturer to design and size panels:
      a. Size panels to provide space for equipment, wiring, terminations, and other items in the panel, including 20 percent of the total back panel area shall remain empty.
      b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
      c. Maximum panel depth: 32 inches, unless otherwise indicated.

B. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in Section 01850 - Design Criteria and as indicated on the Drawings.

C. Non-conditioned spaces and outdoor installations:
   1. Provide additional temperature conditioning equipment to maintain the equipment temperature within a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature.

D. As listed below in the individual component paragraphs.
   1. Provide conditioning equipment incorporated into the equipment to maintain the enclosures within the equipment manufacturer's specified operating ranges.

2.03 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
   1. Enclosures shall have the following properties:
      a. NEMA Type 1: Steel.
      b. NEMA Type 4: Steel with gasketed door, raintight.
      c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
      d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
      e. NEMA Type 12: Steel with gasketed door, dusttight.
      f. NEMA Type 7: Cast aluminum.

B. Bolting material:
   1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
   2. Carriage bolts for attaching end plates.
   3. Other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/enclosures:
   1. Manufacturers: One of the following or equal:
      a. nVent/Hoffman.
      b. Saginaw Control & Engineering.
      c. Rittal.
   2. Panel assembly:
      a. General guidelines for panel fabrication include:
         1) Continuous welds ground smooth.
         2) Exposed surfaces free of burrs and sharp edges.
         3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.

b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 to 69	12	10
69 to 82	12, except 10 on back	10
82 or more	10	10

1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.

c. For Rittal or engineer-approved equal free-standing modular enclosure, construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	16	14
Up to 57	14	13
57 or more	16	11

d. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.

e. Provide stiffeners for back mounting or C folded back panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

f. Door construction:
   1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
   2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
   3) Heavy-gauge stainless steel hinges.
   4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
   5) Gasket installed to seal against roll lip on the enclosure opening.

g. Latches:
   1) For panels, provide each door with an oil tight 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
      a) Provide padlock for each enclosure with padlock provisions.

b) Provide 2 keys per panel.
c) All locks keyed alike.

2) For Rittal or engineer-approved equal free-standing modular enclosure, provide each door with a 4-point latching mechanism, if available, or a 2-point latching mechanism if a 4-point is not available.

3) For cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.

h. Panel cut-outs:

1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.

2) Allow a minimum of 3-inch envelope around displays, controllers, and monitors.

3) Reinforce around cut-outs with steel angles or flat bars for the following:

a) Large panel cutouts; for example, openings for local operator interfaces.

b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
   a. Minimum 16-gauge, Type 304 stainless steel.
   b. Captive stainless steel cover screws threaded into sealed wells.
   c. Inside finish: White polyester powder coating.
   d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
   a. Enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
   b. Door hardware: Stainless steel.
   c. Provide factory installed rain canopy and sun shield for enclosures with operator interface panels.
   d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.

B. Arrangement of components:
   1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
   2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
   3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
4. Control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

C. Overcurrent protection:
   1. Main overcurrent device:
      a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect

handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
1) Door-mounted disconnect handles are not acceptable.
2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
3) Provide means to defeat the interlock.
4) Lockable in the off position.

b. Control panels supplied with 120 VAC:
1) Provide an internal breaker with the line side terminals covered by a barrier.
2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
3) Provide a nameplate prominently positioned on the control panel stating “CAUTION Risk of Electric Shock - UPS equipment outputs remain energized with main disconnect in off position” for any panel containing a UPS.

2. Provide circuit breakers as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
3. Selection and ratings of protective devices:
a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
b. Voltage rating: Not less than the voltage of the application.
c. Select current rating and trip characteristics to be suitable for:
1) Maximum normal operating current.
2) Inrush characteristics.
3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
d. Circuit breakers, fuses, and motor overcurrent protection devices used for branch circuit protection must be UL 508A compliant.
1) Circuit breakers listed under UL 1077 Standard for Supplementary Protectors that do not comply with UL 508A requirements are not acceptable.
2) Miscellaneous, miniature, and micro fuses listed under UL 248 Part 14 that do not comply with UL 508A requirements are not acceptable.
3) Manual motor controllers provided with an instantaneous-trip overcurrent mechanism listed under UL 508 that do not comply with UL 508A requirements are not acceptable.
4. Provide a separate protective device for each powered electrical device:
a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
1) Size external fuse to open before any I/O-card-mounted fuses.
c. Individual discrete inputs shall use a 1/2-amp fuse.
1) Discrete output:
a) Size external fuse to open before any I/O-card-mounted fuses.

2) Analog loop powered from the control panel:
a) 0.25-amp fuse.
3) Analog loop powered from the control panel:
a) 0.25-amp fuse.

d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.

5. Fuses for analog and discrete control loops:
   a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
      1) Label shall not cover or interfere with equipment manufacturer's instructions.
   b. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
   c. Manufacturers: One of the following or equal:
      1) Ferraz Shawmut.
      2) Littelfuse.
      3) Bussmann.
6. Fuse holders:
   a. Modular type:
      1) DIN rail mounting on 35-millimeter rail.
      2) Touch-safe design: Connection terminals to be protected against accidental touch.
      3) Incorporates blown-fuse indicator.
      4) Plug-in style fuse terminals and fuse plugs are not acceptable.
   b. Provide nameplate identifying each fuse:
      1) As specified in Section 16075 - Identification for Electrical Systems.
   c. Manufacturers: One of the following or equal:
      1) Phoenix Contact, UT4-HESI Series.
      2) Allen-Bradley, 1492-FB Series B.
7. Control circuit breakers:
   a. DIN rail mounting on 35-millimeter rail.
   b. Manual OPEN-CLOSE toggle switch.
   c. Rated for 250 VAC.
   d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
   e. Current ratings: As required for the application.
   f. Provide nameplate identifying each circuit breaker:
      1) As specified in Section 16075 - Identification for Electrical Systems.
   g. Manufacturers: One of the following or equal:
      1) Phoenix Contact, TMC Series.
      2) ABB.
      3) Allen-Bradley.
      4) Square D.
8. Electronic circuit protectors:
   a. Used where a NEC Class 2 power circuit is required.
   b. Confirms to NEC Class 2 according to UL 1310.
   c. DIN rail mounting on 35-millimeter rail.
   d. Power source:
      1) Operating voltage: 24 VDC.
      2) Output current ratings: As required for the application.

3) Maximum output current: 4 A.
4) Maximum nameplate rating: 100 VA.

e. LED for status indication.
f. Remote status contact.
g. When using multi-channel electronic circuit protectors, distribute devices such that a failure is limited to a single network or segment.
h. Provide nameplate identifying each circuit electronic circuit protector module:
1) As specified in Section 16075 - Identification for Electrical Systems.
i. Manufacturers: One of the following or equal:
1) Single channel:
a) Phoenix Contact, PTCB E1 series.
b) Allen-Bradley, 1694 series.
2) Multi-channel:
a) Phoenix Contact, CBMC series.
b) Puls PISA11 series.

D. Conductors and cables:
1. Power and control wiring:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 VAC type MTW.
c. Minimum sizes:
1) Primary power distribution: 12 AWG.
2) Secondary power distribution: 14 AWG.
3) Control: 16 AWG.
d. Color:
1) AC power (line and load): Black.
2) AC power (neutral): White.
3) AC control: Red.
4) AC control: Orange for foreign voltages.
5) DC power and control (ungrounded): Blue.
6) DC power and control (grounded): White with Blue stripe.
7) Ground: Green.
2. Signal cables:
a. Materials: Stranded, soft annealed copper.
b. Insulation: 600 VAC, PVC outer jacket.
c. Minimum size: 18 AWG paired triad.
d. Overall aluminum shield (tape).
e. Copper drain wire.
f. Color:
1) 2-conductor:
a) Positive (+): Black.
b) Negative (-): White and red.
2) 3-conductor:
a) Positive (+): Black.
b) Negative (-): Red.
c) Signal: White.
g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:
   1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
   2. Readily identified without twisting the conductor.

F. General wiring requirements:
   1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
   2. Install components in accordance with the manufacturer's instructions included in the listing and labeling.
   3. Provide a nameplate on the cover of the control panel identifying sources of power supply and foreign voltages within the control panel.
   4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
   5. Provide power surge protection for control panels.
   6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
   7. Provide non-metallic ducts for routing and organization of conductors and cables:
      a. Provide wiring separation plan.
      b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
      c. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
         1) 120 VAC: Grey colored ducts.
         2) 24 VDC: White colored ducts.
   8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
      a. Screw-on cable tie mounts.
      b. Hammer-on cable-tie mounting clips.
      c. Fingers of the nonmetallic duct.
   9. Wire ties:
      a. No wire ties inside wire duct.
      b. Use Panduit cable tie installation tool, with tension control/cutoff.
      c. Verify cut ends are cut flush filed smooth after installed.
   10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
   11. Support panel conductors where necessary to keep them in place.
   12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
   13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
      a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
   14. Control panel shall be the source of power for 120 VAC devices interconnected with the control panel, including, but not limited to:
      a. Solenoid valves.
      b. Instruments both mounted in the control panel and remotely connected to the control panel.

G. Provide power circuits for Contractor- and vendor-furnished PLC cabinets in accordance with the PLC and instrument power wiring diagrams indicated on the Drawings or as specified.

H. Thermal management:
   1. Provide heating, cooling, and dehumidifying devices in order to maintain instrumentation and control devices to within a range as specified in Section 17050 - Common Work Results for Process Control and Instrumentation.
   2. Air conditioner:
      a. Provide solid-state cabinet coolers or air conditioning units on outdoor panels containing electronic components such as local operator interfaces, panel instruments, programmable logic controllers, or remote I/O.
      b. Provide filters on intake and exhaust openings.
      c. Increase panel sizes as needed to accommodate cooling units.
      d. Enclosure rating: NEMA Type 4X.
      e. Closed-loop design.
      f. Power supply: 120 VAC.
      g. Manufacturers: The following or equal:
         1) Kooltronic, Guardian DP Series.
         2) ICEqube, Blade series or IECEx/ATEX for Zones 1 and 2.
   3. Heating:
      a. Provide panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
         1) Panel is not supplied with 120 VAC power.
         2) There are no electronics or moisture-sensitive devices in the enclosure.
         3) Panel is smaller than 38-inches high.
   4. Heat exchanger:
      a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
      b. Filterless design to facilitate easy cleaning of the core.
      c. Mounting: As indicated on the Drawings.
      d. Manufacturers: The following or equal:
         1) Noren, CC Series.
         2) ICEqube, Blade series.
   5. Enclosure temperature sensor as indicated on the Drawings**:**
      a. Provide wall mounted RTD transmitter (to measure internal cabinet temperature) in enclosures containing electrical components such as PLCs, RTUs, RIO, and VFDs.
      b. Platinum RTD.
      c. 4 to 20 mA DC output.
      d. Sensor and electronic enclosure.
      e. Accuracy: Within 2 degrees Fahrenheit.
      f. Manufacturers: One of the following or equal:
         1) Omega, EWS Series.
         2) TCS Basys Controls, TS Series as indicated on the Drawings**.**

6. Enclosure temperature switch:
    a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
    b. Sensor and electronic enclosure.
    c. Accuracy: Within 2 degrees Fahrenheit.
    d. Single contact:
        1) Manufacturers: One of the following or equal:
            a) nVent/Hoffman ATEMNC.
            b) Pfannenberg FLZ.
            c) Rittal.
    e. Dual contact:
        1) Manufacturers: The following or equal:
            a) nVent/Hoffman ADLTEMP.
            b) Rittal.
7. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
    a. Provide as indicated on the Drawings or as specified.
8. Fan ventilation:
    a. Provide nVent/Hoffman or Rittal fan speed control:
        1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
        2) Provide finger-guard kit.
        3) Filter kit with 2 spare filters for each intake fan.
        4) Provide bezel and gasket kit.
        5) Automatically adjust fan speed depending on remote temperature sensor input.
        6) 120 VAC, 60 hertz.
        7) NEMA Type 5-15R cord connections.

I. Panel meters:
1. Pointer type:
    a. Suitable for panel mounting.
    b. Minimum scale length: 3 inches.
    c. Calibrated in engineering units.
    d. Accuracy: Within 2 percent of span.
    e. NEMA Type 4/IP65 sealed front metal bezel.
    f. Manufacturers: One of the following or equal:
        1) Yokogawa.
        2) Red Lion.
2. Digital process indicators:
    a. General:
        1) Integral provisions for scaling.
        2) Scale to process engineering units.
        3) Switch-programmable decimal points.
        4) NEMA Type 4/IP65 sealed front bezel.
    b. Current and voltage indicators:
        1) 3-1/2-digit minimum.
        2) Minimum character height: 0.5 inches.

3) Accuracy:
a) AC/DC volts: Within 0.1 percent of reading plus 2 digits.
b) DC current: 4-to-20 mA; within 0.1 percent of reading plus 1 digit.
c) DC voltage: 0 to 10 volts; within 0.1 percent of reading plus 1 digit.

c. Operating voltage: 120 VAC.
d. Operating temperature: 32 degrees to 140 degrees Fahrenheit.
1) Manufacturers: One of the following or equal:
a) Red Lion.
b) Action Instruments, Visipak.

3. Digital bar graph meter:
a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
b. Suitable for panel mounting.
c. LED display:
1) Not less than 3 decimal digits.
2) Not less than a 101-segment LED bar graph.
d. Input signal:
1) Conventional current loops and voltage control signals.
e. Minimum sample rate of once per second.
f. Provisions for field-adjustable scaling and/or offset.
g. Accuracy shall be within 1 least-significant digit.
h. Manufacturers: One of the following or equal:
1) Ametek Dixson.
2) Yokogawa.
3) Weschler Instruments.

4. Counters:
a. 6 digits.
b. Switch-selectable inputs:
1) Switch contacts.
2) CMOS.
3) TTL.
4) Magnetic pickup.
5) RLC sensors.
c. Selectable up/down control via external signal.
d. Remote reset.
e. Remote inhibit to prevent accumulating counts.
f. Programmable to enable or disable front panel reset.
g. Non-volatile memory to retain all data upon loss of supply power.
h. Sunlight readable.
i. Operating temperature: 32 degrees to 122 degrees Fahrenheit.
j. Manufacturers: The following or equal:
1) Red Lion, PAX Series.

J. Pilot devices:
1. General:
a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
b. Size:
1) 30.5 millimeters.
c. Heavy duty.

d. Pushbuttons:
    1) Contacts rated:
        a) NEMA Type A600.
    2) Furnish 1 spare normally open contact and normally closed contact with each switch.
e. Selector switches:
    1) Contacts rated:
        a) NEMA Type A600.
        b) Knob type.
    2) Furnish 1 spare normally open contact and normally closed contact with each switch.
    3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
f. Pilot lights:
    1) Type:
        a) LED for interior installations.
    2) Push to test.
    3) Lamp color:
        a) On/Running/Start: Red.
        b) Off/Stop: Green.
        c) Power: White.
        d) Alarm: Amber.
        e) Status or normal condition: White.
        f) Opened: Red.
        g) Closed: Green.
        h) Failure: Red.

2. Indoor and outdoor areas:
    a. NEMA Type 4/13.
    b. Manufacturers: One of the following or equal:
        1) Allen-Bradley, Type 800T.
        2) Schneider Electric, Class 9001, Type K.
        3) General Electric, Type CR104P.
        4) IDEC, TWTD Series.
3. Corrosive areas:
    a. NEMA Type 4X.
    b. Corrosion resistant.
    c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
    d. Manufacturers: One of the following or equal:
        1) Cutler Hammer, Type E34.
        2) Schneider Electric, Class 9001, Type SK.
        3) Allen-Bradley Type 800H.
        4) IDEC, TWTD Series.
4. Hazardous (classified) areas/Class I Division 2:
    a. NEMA Type 4X.
    b. Corrosion resistant.

c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
    1) Contacts contained within a hermetically sealed chamber:
        a) Pushbuttons.
        b) Selector switches.
        c) Push-to-test contacts on pilot lights.
    2) UL listed and labeled for Class I Division 2 areas.
d. Manufacturers: One of the following or equal:
    1) Cutler Hammer, Type E34.
    2) Allen-Bradley, Type 800H.

K. Potentiometer and slidewire transmitters:
1. Provide a DC output in proportion to a potentiometer input.
2. Potentiometer input:
    a. 100 ohms to 100 K ohms.
    b. Impedance greater or equal to 1 M ohms.
    c. Zero turn-up: 80 percent of full-scale input.
    d. Span turn-down: 80 percent of full-scale input.
3. Field-configurable output:
    a. Voltage and current: Conventional current loops and voltage control signals.
4. Accuracy including linearity and hysteresis within 0.1 percent maximum at 77 degrees Fahrenheit.
5. Operating temperature: 32 degrees to 131 degrees Fahrenheit.
6. Supply power: 9 to 30 VDC.
7. Manufacturers: The following or equal:
    a. Phoenix Contact, Mini Analog Pro.
    b. Allen Bradley Type 800T-U29.

L. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
    a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
    b. Adjustable span and zero.
    c. Accuracy: Within 1.0 percent of span.
    d. Ambient temperature range: -4 degrees to 149 degrees Fahrenheit.
2. Manufacturers: One of the following or equal:
    a. Phoenix Contact, Mini Analog Pro.
    b. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
    c. Action Instruments, Q500 Series or Ultra SlimPakII.
    d. AGM Electronics, Model TA-4000.
    e. Moore Industries, MIT 4-Channel.

M. Relays:
1. General:
    a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
    b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
    c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.

2. Control:
    a. Magnetic style.
    b. For use as standard control relay for motor and starter relay logic.
    c. NEMA ratings:
        1) 300 volts.
        2) 10 amps thermal continuous test current.
        3) 60 amps make.
        4) 6 amps break.
    d. Plug-in type.
    e. LED indication for energization status.
    f. Coil voltages: As required for the application.
    g. Minimum poles: DPDT.
    h. Touch-safe design: Connection terminals to be protected against accidental touch.
    i. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
    j. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
    k. Relays with screw-type socket terminals.
    l. Provide additional relays when the following occurs:
        1) Number or type of contacts shown exceeds the contact capacity of the specified relays.
        2) Higher contact rating is required in order to interface with starter circuits or other equipment.
    m. DIN rail mounting on 35-millimeter rail.
    n. Ice-cube-type relays with retainer clips to secure relay in socket.
    o. Integrated label holder for device labeling.
    p. Manufacturers: One of the following or equal:
        1) Potter and Brumfield: Type KRP or KUP.
        2) IDEC: R* Series (* = H, J, R, S, U).
        3) Allen-Bradley: Type 700 HC.
        4) Square D: Type K.
3. Isolation:
    a. Electromechanical style.
    b. For use as an interposing relay for PLC based discrete I/O signals.
    c. NEMA ratings:
        1) Switching voltage: 250 volts AC/DC.
        2) Limiting current: 6 amps continuous.
        3) Interrupt: 1,500 volt-amperes.
    d. Plug-in type.
    e. LED indication for energization status.
    f. Coil voltages: As required for the application.
    g. Minimum poles: SPDT.
    h. Touch-safe design: Connection terminals to be protected against accidental touch.
    i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
    j. Relays with screw-type socket terminals.
    k. DIN rail mounting on 35-millimeter rail.
    l. Integrated label holder for device labeling.

m. Manufacturer: One of the following or equal:
    1) Phoenix Contact PLC-INTERFACE Series.
    2) Eaton XR TBR Series.
    3) IDEC RV8H Series.
    4) Allen-Bradley Type 700 HL TBR Series.

4. Latching:
    a. Magnetic-latching control relays.
    b. NEMA ratings:
        1) 300 volts.
        2) 5 amps continuous.
        3) 360 volt-amperes make.
        4) 320 volt-amperes break.
    c. Plug-in type.
    d. DIN rail mounting on 35-millimeter rail.
    e. Coil voltage: As required for the application.
    f. Minimum contacts: DPDT; as required for the application. Plus 1 spare contact.
    g. Touch-safe design: Connection terminals to be protected against accidental touch.
    h. Clear cover for visual inspection.
    i. Provide retainer clip to secure relay in socket.
    j. Manufacturers: One of the following or equal:
        1) Square D, 8501, Type K.
        2) IDEC, RR2KP Series.
5. Time delay:
    a. Provide time-delay relays to control contact transition time.
    b. Contact rating:
        1) 240 volts.
        2) 10 amps continuous.
        3) 3,600 volt-amperes make.
        4) 360 volt-amperes break.
    c. Coil voltage: As required for the application.
    d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
        1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
    e. Minimum contacts: DPDT.
    f. Units include adjustable dial with graduated scale covering the time range in each case.
    g. Minimum timing range: 0.1 second to 10 minutes, or as required for the application.
    h. Manufacturers: One of the following or equal:
        1) IDEC, RTE Series.
        2) Tyco Electronics, Agastat 7000 Series (pneumatic).
        3) Allen-Bradley, Type 700-HR.

N. Terminal blocks:
    1. DIN rail mounting on 35-millimeter rail.
    2. Rated for 15 amps at 600 volts.

3. Screw terminal type.
4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
5. Finger-safe protection for terminals for conductors.
6. Construction: Polyamide insulation material capable of withstanding temperature extremes from -40 degrees to 221 degrees Fahrenheit.
7. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine-printed terminal identification.
8. Disconnect-type field signal conductor terminals with socket/screw for testing.
9. Identify terminals suitable for use with more than 1 conductor.
10. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
11. Manufacturers: One of the following or equal:
    a. Phoenix Contact, UT4 Series.
    b. Phoenix Contact UT6 Series, Allen-Bradley Bulletin 1492 Double-level, Weidmuller Klippon W-series, multi-level (screw terminal) terminal blocks.
    c. Allen-Bradley, 1492 Series.

O. DIN rail grounding:
1. Grounding terminal blocks used exclusively for bonding each DIN rail section to panel grounding busbar shall:
    a. Mount to DIN rail via grounding foot with mounting screw.
    b. Connect to the panel grounding busbar shall be via a green insulated conductor sized in accordance with NEC.
    c. Not be used for grounding signal cable shields.
2. Screw terminal type.
3. DIN rail mounting on 35-millimeter rail.
4. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
5. Finger-safe protection for terminals for conductors.
6. Terminals: Plainly identified to correspond with markings on the diagrams:
    a. Permanent machine-printed terminal identification.
7. Manufacturers: One of the following or equal:
    a. Phoenix Contact, USKLG Series.
    b. Allen-Bradley, 1492-JG Series.

P. Wire duct:
1. Provide flame retardant plastic wiring duct, slotted with dust cover.
2. Type:
    a. Wide slot.
    b. Narrow slot.
    c. Round hole.
3. Manufacturers: The following or equal:
    a. Panduit.
    b. Phoenix Contact.
    c. Thomas & Betts.
    d. Iboco.

Q. DIN rail:
   1. Perforated steel.
   2. 35 mm width.
   3. 15 mm deep.
   4. Provide 2-inch offset using one of the following:
      a. Offset brackets.
      b. Preformed standoff DIN Rail Channel.

R. Surge protection devices (SPD):
   1. 120 VAC control panel power SPD:
      a. Provide SPD for panel 120 VAC power entrances:
         1) Non-faulting and non-interrupting design.
         2) Provide line to neutral and neutral to ground surge protection.
      b. Provide surge protection at secondary of main circuit breaker:
         1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
         2) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
      c. DIN rail mounting.
      d. Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
         1) Gastight connections.
         2) Visual status indication of MOV status on the input and output circuits.
         3) Dry contact rated for remote status indication.
      e. Approvals:
         1) Tested in accordance with IEC 61643-11.
         2) Tested in accordance with UL 1283.
         3) Tested in accordance with UL 1449.
         4) Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 µs waveform in accordance with IEEE C62.41.1 Category C Area.
      f. Manufacturers: One of the following or equal:
         1) Phoenix Contact, Type SFP Filter.
         2) Sola HD, STFE Elite series.
         3) Rockwell, 4983-DC series.
         4) ASCO, Model 277.
   2. 24 VDC control panel power SPD:
      a. Provide SPD for 24 VDC power circuits.
      b. Provide surge protection at DC power supply output.
      c. DIN rail mounting.
      d. Attach wiring to the SPD by means of a screw-type cable clamping terminal block:
         1) Optical status indicator.
         2) Dry contact rated for remote status indication.
      e. Approvals:
         1) Tested in accordance with IEC 61643-11.

f. Manufacturers: One of the following or equal:
    1) Field instruments that require auxiliary power:
        a) Emerson, Model 265 (SLAC) series.
        b) Phoenix Contact, Plugtrab PLT--SEC-T3-24-FM-UT.
    2) Loop powered field instruments:
        a) Emerson/Edco, Model SS65-036-2.

3. Panel mounted control, signal, and data line SPD:
    a. General:
        1) This section applies to SPD located in a control panel, field panel, network junction box, or marshalling panel.
        2) Approvals:
            a) Tested in accordance with IEC 61643-21.
            b) Tested in accordance with UL 497B.
        3) SPD shall consist of 2 parts:
            a) Base module:
                (1) DIN rail mounting.
                    (a) Grounded to DIN rail via mounting rail foot.
            b) Plug protection module:
                (1) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
        4) Provide indirect shield ground style SPD unless otherwise noted.
        5) Provide ability to locally identify and indicate SPD health.
        6) SPD shall be provided with controller module with dry contact for remote status monitoring of SPD device health.
        7) SPD modules shall be compatible with signal, communication bus type, data type, or control power being protected.
        8) Provide dedicated SPD for each signal, communication bus type, or data line being protected.
    b. Manufacturers: One of the following or equal:
        1) Phoenix Contact, Plugtrab PT-IQ Series.
        2) Dehn, Blitzductor XTU Series.

4. Copper Ethernet SPD:
    a. Protects network equipment from lightning or other surge events.
    b. Suitable for Gigabit networks.
    c. Shielded RJ-45 ports.
    d. Compliant with PoE standards IEEE 802.3af and 802.3at.
    e. Nominal discharge surge current: 10 kA.
    f. Approvals:
        1) Tested in accordance with IEC 61643-21.
        2) Tested in accordance with UL 497B.
    g. Manufacturers: One of the following or equal:
        1) Phoenix Contact, DT-LAN-CAT6+.
        2) Citel, MJ8-C6A.
        3) Weidmuller, VDATA CAT6.
        4) Eaton/MTL, ZoneBarrier High Energy Ethernet.

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

S. Horns and beacons:
    1. Beacons/horn combination units:
        a. Manufacturers: The following or equal:
            1) Edwards, Multi-Status LED 108i with tone module.
            2) Federal Signals, AV1ST Strobe Combination Audible/Visual Signal.
        b. LED Colors: Red, Green, and Amber.
        c. Power: 120 VAC.
        d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.
        e. Horn rated 80 dB minimum at 10 feet.
    2. Dedicated beacon unit:
        a. Manufacturers: One of the following or equal:
            1) Federal Signal Corp., Starfire Series.
            2) Allen-Bradley, 855 B *-* 10 Series.
            3) Edwards, 102 Series.

3. Dedicated horn unit:
    a. Electromechanical:
        1) Manufacturers: One of the following or equal:
            a) Federal Signal, 350 or 31X Series.
            b) Edwards, 878EX or 879EX Series.
    b. Electronic:
        1) Manufacturers: One of the following or equal:
            a) Federal Signal, 300GCX or 300X Series.
            b) Allen-Bradley, 855H or 855XH Series.
            c) Edwards, 5530M or 5533MD Series.
    c. Rated for 80 dB minimum at 10 feet.

T. Power supplies:
1. Configure power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
    a. Provide automatic switchover upon module failure.
    b. Alarm contacts monitored by the PLC.
5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
6. Sized to provide 40-percent excess rated capacity.
7. UL 508 listed to allow full-rated output without de-rating.
8. Provide fuse or short-circuit protection.
9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
11. Operating temperature range: 32 degrees to 140 degrees Fahrenheit.
12. Touch-safe design: Connection terminals to be protected against accidental touch.
13. DIN rail mounting on 35-millimeter rail:
    a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
15. Manufacturers: One of the following or equal:
    a. Fully redundant:
        1) Phoenix Contact, Quint Power Supply with SFB technology.
            a) Phoenix Contact, Quint.
        2) IDEC, PS5R Series:

3) Sola.
4) PULS.

b. Redundancy module:
1) Phoenix contact, O-ring redundancy module.

U. Intrinsic safety barriers:
1. Transformer isolated barrier:
a. Containing a transformer to provide complete:
1) Isolation between the safe and hazardous areas for loop-powered devices.
2) 3-way isolation between the safe area, hazardous area, and power supply powered devices.
b. Resistor for current limitation.
c. Fuses for short-circuit protection.
d. Provide barriers with pluggable connectors that are coded for easy replacement.
e. Transmission error shall be less than or equal to 0.1 percent of full-scale.
f. DIN rail mounting on 35-millimeter rail.
g. Approvals:
1) FM.
2) UL 913.
2. Types:
a. Switch isolators:
1) Designed and approved for use with discrete inputs.
2) Supply power: 20 to 30 VDC.
3) Output to track input.
4) LED in the cover to indicate the status of the input.
5) Selector switch to change the logic of the input.
6) Input: Dry contact.
7) Output: SPDT relay.
b. Transmitter and converters for use with 4- to 20-mA signals without Hart® communications capability:
1) Designed and approved for use with 4- to 20-mA analog signals.
2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
3) Supply voltage: 20 to 30 VDC.
c. Transmitter and converters for use with 4- to 20-mA signals with Hart® communications capability:
1) Designed and approved for use with 4- to 20-mA analog signals.
2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
3) Transfer digital signals from the hazardous area to the safe area.
4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.
5) Supply voltage: 20 to 30 VDC.
3. Manufacturers: One of the following or equal:
a. Phoenix Contact, MACX Series.
b. Pepperl + Fuchs.

V. Starters:
   1. Magnetic motor starters:
      a. As specified in Section 16422 - Motor Starters.
   2. Integral self-protected starters:
      a. As specified in Section 16422 - Motor Starters.

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

X. Proximity switches:
   1. Power supply: 24 VDC supply voltage.
   2. 1 normally open and normally closed contacts.
   3. LED optical sensing, polar-retro.
   4. Distance: 6 meters (19.8 feet).
   5. Manufacturers: The following or equal:
      a. Banner T30 or equal.

Y. Current switches:
   1. Power supply: 120 VAC supply voltage.
   2. 1 normally open and normally closed contacts.
   3. Adjustable current setting.
   4. Manufacturers: The following or equal:
      a. Zelio®, RM35.
      b. Phoenix Contact, EMD Series.

Z. Current transmitters:
   1. Input current range: As indicated on the Drawings.
   2. Output: 16950
   3. Power supply: 24 VDC supply voltage.
   4. Output overload protected.
   5. Accuracy: Within 0.5 percent full-scale.
   6. Ripple and Noise: 1 percent max., peak to peak.
   7. Frequency: 50/60 hertz.
   8. Manufacturer:
      a. Phoenix Contact: Mini Analog Pro Series.
      b. CR Magnetics: CR4320 series.
      c. American Aerospace: 1070 Series.

AA. Panel mount quick connector:
    1. Keyed insertion plug.
    2. Threaded cap to protect connection when not in use.
    3. Material: Stainless steel.
    4. Pre-wired pigtails.
    5. Indoor/outdoor:
        a. Rating: Meets or exceeds panel rating.
        b. Manufacturers: One of the following or equal:
            1) Amphenol.
            2) Sealcon.
    6. Hazardous (classified) areas:
        a. UL listed and labeled for area as indicated on the Drawings.
        b. Manufacturers: The following or equal:
            1) Amphenol HDE Series.

2.05 ACCESSORIES

A. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings, including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

B. Provide floor stands or legs with a minimum height of 12 inches where needed or as indicated on the Drawings.

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

D. Provide nameplate to each panel as indicated on the Drawings:
    1. As specified in Section 16075 - Identification for Electrical Systems on internal and external instruments and devices.
    2. With the following markings that is plainly visible after installation:
        a. Manufacturer’s name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
        b. Supply voltage, phase, frequency, and full-load current.
        c. Power source or circuit ID.
        d. Short-circuit current rating of the panel based on one of the following:
            1) A listed and labeled assembly.
            2) Established utilizing an approved method.

E. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. Window shall meet the following requirements:
    1. Safety plate glass.
    2. Secured by rubber locking seal.
    3. Allow full viewing of devices issuing visual process data or diagnostics.

F. Lighting:
   1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
      a. Covered or guarded.
      b. Provide On-Off door-activated switches where indicated on the Drawings.
      c. 120-volt, single-phase, 15-amp style plug.
      d. Provide 4,000 K, 900 Lumens LED fixture.
         1) Provide additional fixtures for every 36 inches of width.

G. Receptacles:
   1. Provide 1 duplex receptacle located every 6 feet of enclosure width, spaced evenly along the back mounting panels.
   2. GFCI, 120-volt, single-phase, 15-amp style plug.
   3. Provide circuit breaker or fuse to limit receptacle draw to 5 amps.

H. Grounding:
   1. Provide the following:
      a. Grounding strap between enclosure doors and the enclosure.
      b. Equipment grounding conductor terminals.
      c. Provide equipment grounding busbar with lugs for connection of equipment grounding wires.
      d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding busbar.
   2. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND”, the letter “G”, or the color green.
   3. Signal cable shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
   5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
   6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
   7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
   8. Unless otherwise noted, connect exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
   9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
      a. Control Panel ground lugs and ground bar shall be copper mechanical or compression connection type. Aluminum connectors or lugs are not acceptable for use with copper conductors.

I. Provide sunshades and insulation for outdoor installations.

2.06 FINISHES

A. Finishes:
   1. Metallic (non-stainless):
      a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
      b. Scratches or blemishes shall be filled before finishing. 1 coat of zinc phosphate shall be applied according to the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
      c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
      d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
   2. Stainless steel:
      a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:
   1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
   2. Exterior of panels mounted outdoors shall be manufacturer's standard light gray.
   3. Panel interiors shall be manufacturer's standard white.

PART 3 EXECUTION

3.01 PREPARATION

A. Equipment support and anchoring to structures:
   1. As specified in Section 01850 - Design Criteria, including, but not limited to:
      a. Anchor bolt layout.
      b. Equipment templates.
      c. Anchor installation.

3.02 INSTALLATION

A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel: Anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.

B. Install the equipment in accordance with the accepted installation instructions and anchorage details.

C. Provide floor stand kits for wall-mounted enclosures larger than 48-inches high.

D. Provide concrete housekeeping pads for freestanding enclosures.
   1. Refer to the structural typical details.

E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
   1. Undercoat floor-mounted panels.

F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

G. Holes for field conduits, etc., shall be cut in the field. No additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miscut holes shall require that the entire enclosure be replaced.

H. Protect wiring from sharp edges and corners.

I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule but shall be shown on the loop drawings prepared by the Contractor.

J. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.

K. Side panels:
   1. Side panels shall be kept free of control equipment and devices. Any deviation must be sent to the Engineer in writing asking for a deviation.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 17721

CONTROL SYSTEMS: LOCAL OPERATOR INTERFACE (LOI)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Local Operator Interface (LOI) control systems hardware and software.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 SUBMITTALS

A. Furnish submittals in accordance with Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Product data:
   1. Complete manufacturer's brochures for each item of equipment.
   2. Complete manufacturer's brochures that identify LOI software and options. Mark up to clearly show options and components to be provided, and cross out any options or components that will not be provided.
   3. Manufacturer's operation and installation instructions.
   4. Additional requirements:
      a. Display type and size.
      b. Operator input.
      c. Processor type and speed.
      d. Memory size.
      e. Programming protocols.
      f. Communication protocols.
      g. Power requirements.
      h. Operating temperature and humidity ranges.
      i. NEMA ratings.

C. Shop drawings:
   1. Furnish the following:
      a. System block diagram showing relationship and connections between devices. Include manufacturer and model information, and address settings.
      b. Mounting drawings with dimensions and elevations for each equipment location, including identification of all components, preparation and finish data, and nameplates.
      c. Electrical connection diagrams.
      d. Complete grounding requirements.

2. Graphic screens:
    a. Color printouts of each graphic screen and all control pop-ups.
3. Furnish data sheets for each component together with a technical product brochure or bulletin:
    a. Manufacturer's model number.
    b. Project equipment tag.
4. Complete and detailed bills of materials identified by each cabinet. Include with each bill of material item the following:
    a. Quantity.
    b. Description.
    c. Manufacturer.
    d. Part numbers.

D. Operation and maintenance manuals:
1. Complete installation, operations, calibration, and testing manuals as described in Section 01756 - Commissioning.

E. Record documents:
1. Electrical connection diagrams revised to reflect any changes made in the field and submitted as record Drawings.

1.04 QUALITY ASSURANCE

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Examine the complete set of Contract Documents and verify that the LOI equipment is compatible with the installed conditions.

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

D. Provide LOI hardware manufactured at facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

E. System compatibility:
1. The software must be the standard operating software system designed specifically for use with the LOI hardware.
2. The software must be furnished and developed by the manufacturer of the LOI hardware.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.06 PROJECT OR SITE CONDITIONS

A. Project environmental conditions as specified in Section 01850 - Design Criteria:
   1. Provide LOI equipment suitable for the installed site conditions including, but not limited to, site altitude, site seismic conditions, humidity, and ambient temperatures.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

1.08 MAINTENANCE

A. Provide system upgrades and maintenance fixes for a period of 2 years from substantial completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide all LOI hardware identified in the Contract Documents.

2.02 MANUFACTURERS

A. One of the following or equal:
   1. Flygt Multismart.

B. Provide the LOI graphic software system manufactured by the LOI hardware manufacturer.

2.03 MANUFACTURED UNITS

A. Local Operator Interface:
   1. General:
      a. Provide Local Operator Interface located on the face of the PCM as indicated on the Drawings.
      b. Local Operator Interface consists of graphical display screen with operator input capabilities.
      c. Capable of stand-alone operation in conjunction with 1 PLC.
      d. Equipped with data network communication capabilities.
   2. Display:
      a. Type:
         1) As indicated on the Drawings.
      b. Size: As indicated on the Drawings.
      c. Easy display viewing at any angle in various ambient light conditions.
      d. Operator input:
         1) Configurable touch screen with programmable function keys.
      e. Screen update speed: The screen update speed and screen change speed less than 1 second.

f. Provide following features for outdoor use:
1) Anti-glare screen overlay.
2) Luminescence: Minimum 1,000 Nits.

3. Memory:
a. Application:
1) 64 MB Flash EPROM.

4. CPU: Minimum 100 MHz.
5. Communications:
6. Ethernet. Environment:
a. Temperature: 0 to 50 degrees Celsius.
b. Relative humidity: 10 to 90 percent.

7. Electrical:
a. Power supply:
1) 24 VDC.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

C. Provide panel support bracing if more than 25 percent of the area has been removed to allow for the mounting of the LOI.

D. All tags used and/or assigned as part of the application programming work are to use the tag and loop identifications found on the P&IDs.

E. Station graphics:
1. Configure the graphic display for each device in the pump station, including but not limited to:
a. Symbols for:
1) Pumps.
2) Valves.
3) Major instruments.
4) Flowmeters.
5) Pressure transmitter.
6) Major equipment.
b. Alarm symbols including intrusion alarm.
c. Relevant test and operational data.
d. Status for each controller or controlled device:
1) Hand-Off-Auto Status.
2) Local-Off-Remote Status.
3) Run.
4) Call.
5) Fail.
6) Open.

7) Close.
8) Hold.
9) Modulate.
10) Running.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Owner Training:
   1. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

END OF SECTION

SECTION 17722

CONTROL SYSTEMS: REMOTE TELEMETRY UNIT HARDWARE

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Managed, cellular-based communication system for alarm monitoring and remotely controlling water and wastewater collection systems equipment with data collection and reporting services.

B. System Components:
   1. Remote terminal units to collect and transmit data from Project site to central server location.
   2. Cellular communications via Manufacturers specified carriers between remote terminal units and central server location.
   3. Central server location to receive, record, and analyze telemetry reported by remote terminal units.
   4. Alarm notification system to alert operating personnel about system alarms and malfunction conditions.
   5. Secure web-based user interface to access recorded data, generate system reports, and control local equipment through remote terminal unit.

1.02 DEFINITIONS

A. Remote Terminal Unit (RTU): Microprocessor-controlled electronic device that interfaces between equipment and SCADA system by transmitting telemetry and object status data to central server center, and by using messages from central server center to remotely control connected objects.

B. Supervisory Control and Data Acquisition (SCADA): Managed system operating with coded signals over cellular communication channels to acquire information about remote equipment status for display, recording, and alarm signaling functions and to provide control of remote equipment.

1.03 SUBMITTALS

A. Product Data: For each type of device and system:
   1. Include product data sheets and equipment brochures showing standard products and specified accessories.
   2. Include list of owners, locations, and duration of service, where products are in use upon request.

B. Manufacturer's installation instructions.

C. Terms and Conditions.

D. Warranty.

E. Operation and Maintenance Manual: For remote terminal units, data communication system, and support service.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firm must have be engaged in manufacture of cellular-based remote terminal units (RTUs) and operation of managed SCADA service for a minimum of 20 years. System with ample experience will not be accepted.

B. Supplier Qualifications: Manufacturer, or firm that is manufacturer's authorized and trained agent, or combination of both, that provides, maintains, and warrants on-site monitoring equipment and web-based data reporting system.
   1. Provide required monitoring-related services with field equipment. Maintain ongoing cellular service agreements through relationships with cellular carrier provider(s).
   2. Provide specified server center and server infrastructure.
   3. Provide continuous technical support, at all times.
   4. Demonstrate similar services are currently provided to minimum 1,000 United States public agencies.
   5. Demonstrate products and services are in conformance with American Recovery and Reinvestment Act requirements.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the Project site, unless otherwise indicated.

B. Label products with manufacturer’s name, product, or product brand name. Assign unique, original identifier (serial number) to each RTU.

1.06 WARRANTY

A. Provide a minimum of 1 year of warranty from substantial completion date for all equipment.

1.07 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Notify the Engineer promptly if any installation condition does not meet the equipment manufacturer’s recommendations or specifications.

1.08 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS AND SERVICES

2.01 MANUFACTURES

A. Basis-of-Design: Subject to compliance with requirements, provide products and systems by basis of design manufacturer or comparable products and systems:
   1. Manufacturer: Mission Control Systems, Model M150.

2.02 REMOTE TERMINAL UNITS (RTU) - GENERAL

A. RTU: Factory assembled and programmed data collection and reporting device, contained within electrical enclosure designed for 25-year life expectancy.

B. Data Cellular Radio: Communicate with central server location via cellular radio transmitting data through Transmission Control Protocol (TCP) socket connection.
   1. Provide encrypted and end-to-end acknowledged transmissions. Short Message Service (SMS), User Datagram Protocol (UDP), and satellite-based data transmission methods are not permitted.
   2. Accommodate radios from various cellular carriers; field-interchangeable within 10 minutes.
   3. Support LTE, FirstNet, HSPA+ and NBIOT networks.
      a. LTE: Quad Band LTE: 700/850/AWS (1700/2100)/1900 MHz; FDD-Band (17,5,4,2); Tri Band UMTS (WCDMA): 850/AWS (1700/2100)/1900 MHz; FDD-Band (5,4,2) Quad Band GSM/GPRS/EDGE: 850/900/1800/1900 MHz.
      b. GSM: Quad-band (850/900/1800/1900 MHz) GSM/GPRS/EDGE, 3GPP release 99/4 improved SAIC.
      c. RMDT1 CAT1: B12 - AT&T, T-Mobile; B14 - AT&T/ FirstNet; B4 - AT&T, Verizon, T-Mobile; B2 - AT&T, Verizon, T-Mobile; B5 - AT&T, Verizon, T-Mobile; B13 – Verizon; B66 - AT&T, T-Mobile, Verizon; B71 - T-Mobile (600MHz).

C. Basis-of-Design Product: Subject to compliance with requirements, provide basis of design product or comparable product by one of the following:
   1. Mission Communications, Model M150; as basis-of-design.

D. Power Requirements: UL Recognized, 120 VAC to 12 VAC transformer. Includes back-up battery capable of powering RTU for 20 to 48 hours.

E. Digital Inputs:
   1. 16 inputs shall detect normal, off-normal and wire fault (supervised) state changes.

F. Analog Inputs:
   1. Two inputs measuring 4-20 mA or 0-5 VDC at 10-bit resolution.
      a. Transmit values in real time when alarm threshold is breeched. Transmit hourly: value and minimum and maximum value over the hour for each input.
   2. Alarm Threshold: Four, user configurable alarm points for each input.
   3. Input Option Board: Includes four (4) additional analog inputs and two (2) pulse inputs.

G. Pulse Inputs:
   1. Input Option Board: Includes two (2) pulse counting inputs.
      a. Transmit data every fifteen minutes when change in pulse data occurs.
   2. Input Type: Open collector circuits or dry switch state changes of up 60 Hz and duration as low as 18 milliseconds.
   3. Input Scaling: Based on unit of measurement.

H. Digital Outputs:
   1. Number: Three, form C, dry contact relay outputs
      a. Rated at 5 amperes at 12 or 24VDC.
   2. Type: Single pole double throw (SPDT) for NO or NC.
   3. Circuit Logic: Fail-safe.

I. Analog Outputs:
   1. Output Option Board: Two capable of transmitting a 4-20 mA output signal.
   2. Output Scaling: Accessible from web portal.
   3. Output Value Changes: Performed by manual page from remote interface, or automatically via intertie to analog value from another RTU.

J. On-Board Telemetry Data: Report AC voltage, battery voltage, signal strength and printed circuit board temperature, hourly. Dispatch alarms for AC failure, low battery voltage, elevated and low temperature, and loss of communications.

K. Electronic Key: Provide electronic key reader, accessible without opening RTU enclosure to record personnel site visits to RTU. Sound audible tone confirming key reading.
      1) Key Functions: Place RTU in service state for one hour; acknowledge alarms; and/or document site personnel's presence.
      2) Service Status Light: Activates optional local light indicating RTU service state when connected to an unused digital relay output configured for that purpose.
      3) Key Identity: Code keys uniquely identifiable to Owner assigned personnel.

2.03 COMMUNICATIONS

A. RTU Communication: Transmit data through cellular radios that communicate through third and fourth generation GSM, CDMA, CAT, CAT M1, FirstNet, and NBIOT cellular networks.
   1. Provide cellular radios with private IP addresses.
   2. Communication Link Structure: TCP socket connection from RTU through cellular system to the Supplier’s servers. Short Message Service (SMS), User Datagram Protocol (UDP), and satellite-based data transmission methods are not permitted.
      a. Provide private gateways through respective cellular networks.
   3. Data Encryption: Transmit data after application layer encryption and with carrier level encryption.
   4. End-to-End Data Acknowledgment: Confirm every data packet from RTU to central server with central server acknowledgement back to RTU in real-time.

5. Communication Failure Alarms: Dispatch communication failure alarm.
    a. Monitor and report secure socket connections for end-to-end uptime.
    b. Report interruption durations 15 seconds and greater, and every disconnect/reconnect event.

B. Cellular Service:
1. Provide relationships with cellular providers.
2. Included in annual managed service fee.
3. Maintain cellular data contract with cellular carrier and interface with carrier when technical support is required.
4. Obtain approval from cellular provider, accepting cellular radios for use on respective cellular network in accordance with FCC requirements.

C. Data Transmission Rates:
1. Off-normal conditions: Transmit data on occurrence to initiate alarm notifications. Ability to delay alarm notifications via the web portal user interface.
2. The data transmission rates shall be configurable over-the-air by Manufacturer.

2.04 SERVER CENTER AND SERVER INFRASTRUCTURE

A. Provide and maintain central server center that will house redundant and linked servers, interconnects, databases, power supplies, inbound cellular connections, and outbound internet hubs and providers.

B. Server Center Performance Requirements:
1. Survivability: Server center structure sufficient to maintain continuous operations following direct hit by F-3 tornado.
2. Redundancy: N+1 with at least six separate and redundant, on-site power generating facilities to back up local utility power for stand-alone operation of center for minimum 24 hours.
3. Security: Provide security guards at server center entrances at all times. Require at least two forms of identification, retina scan, and fingerprint validation to secure entry into facility.

C. Data:
1. Ownership: Data is Owner's property and will not be disclosed, unless authorized by Owner in writing.
    a. Provide historical RTU data storage forever.
    b. Manufacturer shall backup and archive databases daily.
2. Data Export and Data Links: Provide the following capabilities.
    a. Interfacing to Open Platform Communications (OPC) compliant Human Machine Interface (HMI) for client/server SCADA systems.
    b. Connection will support up to OPC-UA 1.04
    c. Security:
        1) User must be authenticated before a connection can be established.
        2) Authentication must support X.509 certificates before connection is allowed.
        3) Provide support for Basic256 or higher security policy.

4) All messages must be signed to ensure that they are received exactly as they are sent.
5) Owner's firewalls must be configured for OPC.
6) Allow for multiple concurrent OPC connections to provide redundant HMI database operation at Owner's locations.
7) Auditing and logging must be available for all user activities.

D. Security: Provide access to web portals via TLS crypotographic security protocol. SSL methods must be disabled. Web portal must receive an A rating from https://www.ssllabs.com/ssltest/

E. The following or equal:
1. Motorola, ACE3600 RTU.

2.05 MANUFACTURED UNITS

A. Alarms:
1. Provide alarm notifications for off-normal conditions and upon return-to-normal conditions.
a. Provide capability to transmit return to normal alarms to different notification group.
2. Alarm Notification: Via telephone (voice call), fax, pager (numeric or alphanumeric - short alpha or long alpha format), text message, email, or any combination, simultaneously.
3. Provide capability to allow alarm notification cycles with configurable delay between each cycle and with each cycle containing multiple notification destinations.
4. Provide capability to acknowledge alarms at time of initial alarm delivery or by a toll-free return phone call, text message, two-way pager, email or via Owner's web portal.
5. Provide system capability to cease alarm notification when user acknowledges alarm event, with capability to re-initiate alarm notification when alarm input remains off-normal after user settable time.
6. Provide capability for specific users to be notified of individual alarm events.
7. Provide capability for alarm notifications to be configured based on time of alarm. Permit alarm notification groups to switch between groups at different hours of the day and different days of week.
a. Provide alarm notification groups that accommodate multiple teams within each group to easily facilitate rotation of teams of on-call personnel.

B. Alarm Message Formats:
1. Alarm Notifications: Describe alarm condition, time, location at time of off normal condition. Also provide the following:
2. Provide capability for alarms to be delivered individually or grouped into one message so multiple, simultaneous alarms (like AC Fail at multiple sites) can be delivered and acknowledged in one phone call.
3. Deliver alarm with added introductory message asking for specific person, when calling a phone where the person answering is not known.

C. Voice Alarm Delivery Capacity:
   1. Provide capacity to deliver minimum 20 outbound simultaneous voice phone lines.

D. Alarm Dispatch Logs: Document each alarm event with the following:
   1. Event information:
      a. Date.
      b. Time.
      c. Station name.
      d. Alarm condition.
   2. Notification information:
      a. Date.
      b. Time.
      c. Name of person notified.
      d. Notification method (phone, text message, email, fax etc.).
      e. Status of Notification: "Success", "Failure", or "Event Acknowledged".
         1) For notification failure, log failure reason (i.e., line busy, call dropped, etc.).
   3. Provide recording of each voice notification attempt, to document notification.

E. Alert Notification System:
   1. Provide email and/or fax alerts for less critical items, such as low battery voltage and communication failure reminder.
   2. Provide analyses for daily pump runtimes over 30 days, with an alert triggered if pump runtime falls outside 30-day high or low average runtime pattern.
   3. Provide analyses of hourly pump runtimes and automatically compare runtimes to two user-set thresholds. Dispatch an alert next day when alert threshold is exceeded. Dispatch alarm immediately when alarm threshold is exceeded.
   4. Provide analysis of hourly pump starts and automatically compare starts to two user-set thresholds. Dispatch an alert next day when alert threshold is exceeded. Dispatch alarm immediately when alarm threshold is exceeded.

2.06 REMOTE DATA ACCESS

A. Remote Data Access Format:
   1. Provide remote access to system collected data via web browser, through smartphone app, tablet, laptop, or desktop computer.
      a. UI must be optimized for viewing both on small screens and large monitors.
      b. Mobile app must be compatible with iOS and Android.
   2. Provide secure access through specified phone that does not require web access (Voice SCADA). This will require user login credentials, with minimum of numeric five-digit login and associated phone number for that site to maintain site security.
   3. Provide access to web portals via TLS crypotographic security protocol. SSL methods must be disabled. Web portal must receive an A rating from https://www.ssllabs.com/ssltest/

4. Provide web portal display of graphs, reports, alarms, and RTU setup.
    a. Optimize data to minimize page loading times.
    b. Windows (reports, graphs) must update automatically when new data is available.
    c. Utilize Responsive Design patterns where the Graphical User Interface (GUI) automatically adapts to the screen size.
5. System Access: Require username and password credentials for access to web portal.
    a. Provide five levels of access:
        1) Public: Limited view of pages as set by superadmin.
        2) Read only: Can view pages but cannot make changes.
        3) Read only + ACK: Can view pages but cannot make changes. Can acknowledge alarms as set by superadmin.
        4) Administrator: Can view pages, can make system changes, and alter control functions.
        5) Superadmin: Can view pages, make system changes, alter control functions and add, modify or remove user credentials.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install remote terminal units in accordance with Manufacturer and Supplier's recommendations and provided turn key from the representative.
    1. Delineate timing of RTU installation and commissioning.
    2. Conform to National Electric Code and local codes.
    3. Label inputs as to their purpose on enclosure lid schematic.
    4. Terminations inside RTU enclosure: Low voltage.
    5. Provide Manufacturer's Representative inspection of sites prior to completion.
    6. Test inputs for successful transmission prior to municipality acceptance.
    7. Adjust antenna placement or elevation to obtain consistent, stable system operation.

3.02 DEMONSTRATION AND TRAINING

A. Startup Training by factory trained representative.

B. Demonstrate proper methods for operating and maintaining equipment and explain contents of operation and maintenance manual to Owner's personnel.

C. Ongoing Training: Provide ongoing training at no charge throughout initial year of service, in form of weekly webinars, online videos, white papers, and other documents.
    1. A training library shall be available on the Supplier's website.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Representative approval that installed equipment operates satisfactorily and in compliance with the requirements of this Section.

3.04 SERVICE AGREEMENT

A. Beginning at Substantial Completion, provide continuous, renewable annual service agreement including:
   1. Data Services: Cellular data connections, servers and infrastructure that acts on and stores Owner's data, and administration of same. No separate overage charges or early termination fees shall apply.
   2. Notifications: Provide real-time alarm notifications and alarm notification recording.
   3. Provide record of success or failure of each event including audio recording of voice alarm callouts.
   4. Web Portal: Web portals optimized for personal computers and mobile devices.
   5. Technical support: Provide live telephone technical support from 8 AM to 6 PM eastern time. Provide emergency technical support at all times at no additional charge.

3.05 MONITORING POINT SCHEDULE

A. RTU-1 Inputs and Outputs:
   1. Digital inputs:
      a. DI-1: Level High Alarm
      b. DI-2: Level Low Alarm
      c. DI-3: Level Hi-Hi Backup/Alarm
      d. DI-4: Pump 1 Running
      e. DI-5: Pump 1 Fault
      f. DI-6: Pump 1 Seal Fail Alarm
      g. DI-7: Pump 1 Temp High
      h. DI-8: Pump 2 Running
      i. DI-9: Pump 2 Fault
      j. DI-10: Pump 2 Seal Fail Alarm
      k. DI-11: Pump 2 Temp High
      l. DI-12: Intrusion Alarm Wet Well
      m. DI-13: Intrusion Alarm Valve Well
      n. DI-14: Flood Alarm Valve Fault
      o. DI-15: Spare
      p. DI-16: Spare

END OF SECTION

SECTION 17751

CONTROL SYSTEMS: WIRELESS COMMUNICATIONS - CELLULAR

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General and design requirements applicable to industrial wireless cellular communication system Work and submittals.
   2. General requirements for supply, installation, and commissioning of an industrial wireless cellular communication system, including but not limited to the following:
      a. Materials, hardware, software, equipment fabrication, installation, configuration, programming, hardware and software testing, start-up, commissioning, training, and documentation.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Abbreviations:
   1. AGL: Above ground level.
   2. ASL: Above sea level.
   3. CPM: Critical path method.
   4. FCC: Federal Communications Commission.
   5. FRN: FCC Registration Number.
   6. ITS: Institute for Telecommunications Science.
   7. WLAN: Wireless local area network.

C. Definitions:
   1. Antenna CL: Antenna center line mounting height.
   2. BER: Bit error rate, a unitless measure of the number of bit errors that occur in a given number of bit transmissions.
   3. Cellular Signal Strength Survey: Report from the third-party cellular service provider showing the cellular signal strength for 2G, 3G, 4G, 5G, LTE Technology at each of the site.
   4. dB: Decibel, a relative expression representing a change in radio frequency power.
   5. dBd: A decibel referenced to a dipole antenna.
   6. dBi: A decibel referenced against an isotropic radiator.
   7. dBm: A decibel referenced to 1 milliwatt (mW).
   8. Receiver Sensitivity: The minimum signal power level with an acceptable Bit Error Rate (in dBm or mW) that is necessary for the receiver to accurately decode a given signal.

D. Standards:
   1. American Concrete Institute (ACI):
      a. 318 - Building Code Requirements for Structural Concrete.
   2. International Electrotechnical Commission (IEC).
   3. National Electrical Manufacturers Association (NEMA).
   4. Telecommunications Industry Association (TIA).

1.03 SUBMITTALS

A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Cellular communication submittal:
   1. Product data for the following:
      a. Cellular modem.
      b. SIM card(s).
      c. Antenna.
      d. Cable between cellular modem and antenna.
      e. All other related accessories.
      f. Certification for outdoor installation.
      g. Communication port type and quantity.
      h. Power sources such as an internal battery to supply power to the device when external power source is not available.
   2. Additional certification requirements recommended by the cellular network service provider/carrier.
   3. Installation details for each component indicated above.
   4. Type of cellular service that will be provided.
      a. Provide setup/configuration information for the service.
   5. Certificate of approval of cellular modem by the cellular network service provider/carrier.
   6. Installation details for each component indicated above.
   7. Block diagram showing the location of each component of the cellular communication system.
   8. Cellular coverage map associated with each site.

C. Furnish commissioning submittals listed below and specified in this Section as specified in Section 01756 - Commissioning:
   1. Manufacturer’s representative qualifications.
   2. Owner training.

1.02 QUALITY ASSURANCE

A. Procedure for verifying the communications between sites shall be as follows:
   1. Perform communication signal strength analysis study to verify the theoretical performance of the proposed paths.
   2. Field verify the cellular signal strength using field measurement and obtain an approval from the Owner and the Engineer prior to installation.

B. After installation, verify using field collected data that the installed equipment conforms to reliability benchmark developed as part of the field testing.

1.04 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.05 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.06 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate with the cellular communication service provider to obtain the latest cellular signal strength report at each of the locations to meet the requirements indicated in this Section, and submit results for Engineer's approval prior to the procurement and installation of wireless cellular communication infrastructure.
   2. For a private, third party-owned cellular network, coordinate with the service provider and refer to the contract specification and drawings for proper procurement and installation of cellular equipment and associated appurtenances.
   3. Coordinate with the cellular communication service provider to obtain the latest cellular signal strength report at each of the locations to meet the requirements indicated in this Section and submit results for engineer's approval prior to the procurement and installation of wireless cellular communication infrastructure.
   4. Coordinate cellular modem configuration and encryption options with the Owner and cellular service provider. Adjust configuration and encryption settings as deemed necessary by the Owner and the cellular service provider.
   5. Configure the cellular modem using a secure username and password authentication by the Owner.
      a. Alerts shall be sent to defined list of recipients via pre-configured SMS text message.
      b. Alerts shall be sent to defined list of recipients via SMTP (email) message.

B. Meetings:
   1. Prepare and submit an agenda for 2 mandatory coordination meetings.
      a. First meeting:
         1) Summarize their understanding of the Project.
         2) Discuss any proposed alternatives.
         3) Schedule access to Owner sites.
         4) Schedule the remaining coordination meetings.
         5) Request any additional information required from the Owner.
         6) Review the preliminary design and plan the site surveys.
         7) Select the hardware to be used during the on-site cellular signal strength measurement.
         8) Understand the project construction sequence.
         9) Understand municipal ordinance and other construction restrictions associated with the sites.
         10) Schedule meeting to coordinate with the Owner and the cellular service provider to understand the details of the cellular service contract.

b. Second meeting:
    1) Work with the cellular service provider to understand cellular modem requirements, signal strength and bandwidth details, and installation requirements.
    2) Outline the recommended and optimal configuration for the Owner's wireless cellular system architecture.
    3) Discuss any exceptions or deviations from design document installation details, models, and site locations.
c. Discuss construction and work progress schedule.

1.03 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Provide a minimum of 1 year of warranty from substantial completion date for all wireless communication equipment.

1.04 MAINTENANCE

A. Furnish all parts, materials, and additional components necessary for maintenance and calibration purposes for 1 year:
    1. Deliver all supplies before Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. System overview:
    1. Furnish and install an industrial wireless communication system that will serve the site.
    2. Data shall be transmitted and received wirelessly at each site using the cellular technology identified as indicated on the Drawings.
    3. The wireless cellular communication system shall be configured as indicated on the Drawings and as described in this Section.
    4. The Contract Documents for the components of the wireless cellular communication system are based on the cellular signal strength report. Verify site conditions and provide a completely functional wireless cellular communication system.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. The ICSC performs all of the Work related to the industrial wireless cellular communication system described in the Contract Documents.

B. System must be in accordance with the following:
    1. ACI 318.
    2. TIA.

C. Performance requirements for cellular communication:
    1. The following are the requirements for the cellular communication system:
        a. Data Rate: 50-80Mbps.
        b. Signal Strength: -90dB.

2.03 MANUFACTURERS

A. Wireless cellular modem:
    1. Refer to specification 17722: Control Systems: Remote Telemetry Unit Hardware.

B. Antenna:
    1. Refer to specification 17722: Control Systems: Remote Telemetry Unit Hardware.

C. Power adapter:
    1. Refer to specification 17722: Control Systems: Remote Telemetry Unit Hardware.

D. Transmission cables:
    1. Provide the manufacturer's recommended transmission cable.

E. Surge protectors:
    1. Manufacturers: One of the following or equal:
        a. CommScope:
            1) T Series Surge Arrestors.
            2) Gas Tube Surge Arrestors.
        b. Phoenix Contact, Trabtech Series.
    2. As specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

2.04 MANUFACTURED UNITS

A. Cellular communication system:
    1. General:
        a. The wireless cellular system comprises the following:
            1) Cellular modem with SIM card(s).
            2) Omni antenna.
            3) Software/Documentation and other accessories as specified in the Accessories article.
        b. Performance requirements:
            1) Cellular modem and omni antenna to operate in quad-band range: 850/900/1,800/1,900 MHz.
            2) Operating temperature range: -25 to 60 degrees Celsius.
    2. Cellular modem:
        a. Transmission power:
            1) 1 W at 850 MHz.
        b. LTE enabled.
        c. Provide 1 SIM card for each cellular modem.
        d. Communication with equipment to be monitored:
            1) Ethernet RJ-45.

e. Power supply: 12 VDC.
f. LED indication for status and alarm.
g. Mounting:
    1) As indicated on the Drawings.
h. Housing:
    1) As indicated on the drawings**.**
i. Antenna Connection: 3 SMA connectors (primary, diversity, gps).
j. Network and routing:
    1) Network Address Translation.
    2) Port Forwarding.
    3) IPsec and OpenVPN with up to 5 tunnels.
k. Shall be capable of connecting an antenna with SMA type connector.
l. Remote Authentication: LDAP.
m. Port, IP, and MAC Filtering.
n. Network Management: SNMP.
o. Discrete I/O: 1 input, minimum.
p. Device shall support stateful inspection firewall. Firewall rules shall be configurable by the user and include inspection on Source/Destination IP address, protocols and/or Source/Destination TCP/UDP port.
q. Support Virtual Private Network (VPN) functionality up to 3 licenses with ability to act as client or server of VPN requests:
    1) IPSec and Open VPN shall be the supported VPN protocols with encryption meeting the military standard of AES-256.
    2) Capable of initiating VPN via hard-wired contact or remotely through SMS text message.
r. Support static routing between two or more networks, port forwarding and IP masquerading.
s. Support 1 to 1 Network Address Translation (NAT) routing.

3. Antenna:
    a. Omni-directional type antenna.
    b. Antenna gain: 3 dB.
    c. Mounting: Surface.
    d. Rated for outdoor installation.
4. Cable between cellular modem and antenna: Manufacturer’s standard and rated for outdoor installation if the modem is installed outdoors.
5. Software and documentation: Manufacturer’s standard.

2.05 ACCESSORIES

A. Mounting Accessories:
    1. Provide all required mounting accessories required for antenna mounting, such as clamps, brackets adapters, and related hardware for a complete installation.
    2. Mounting guidelines shall be provided as indicated on the Drawings and as recommended by the manufacturer.
    3. The terminal blocks, cellular modem/antenna, and associated wiring shall be clearly tagged, as indicated on the Drawings, and labeled for providing easy reference.

B. Provide lightning surge arrestors for cellular modems/antennas located outdoors.

C. Provide antenna connectors, cable fittings, and related hardware as necessary for installation.

D. Provide din-rail mounting adapters required for installation of cellular modems in control panels/communication cabinets, as needed for each application.

E. Software:
   1. Provide software package for cellular diagnostic testing.
   2. Provide cellular modem configuration via a secured wireless or wired ethernet network.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Tag and label terminal blocks, cellular system components and associated wiring as indicated in the Drawings and as specified in Section 16075 - Identification for Electrical Systems.

3.02 COMMISSIONING

A. As specified in Sections 01756 -- Commissioning and 17950 - Commissioning for Instrumentation and Controls for communications testing requirements.

B. Functional Testing:
   1. Hardware and communications testing:
   2. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   3. Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.
   4. Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to:
      a. Equipment failure.
      b. Operator error.
      c. Communications subsystem error.
      d. Communications failure.
      e. Simulated/forced software lockups.
      f. Power failure (both utility power and power to HMI and/or SCADA hardware).
      g. High system loading conditions.

C. Owner Training:
   1. Perform Owner training as specified in Section 01756 - Commissioning.
   2. Cellular communication initial training:
      a. Cellular communication system hardware, setup, basic working principle of the installed system and basic troubleshooting and diagnostics.

3. Cellular communication follow-up training:
    a. Radio communication system configuration, encryption, advanced troubleshooting and diagnostics.
4. Number of sessions:
    a. Operations 2.
    b. Maintenance 2.

3.03 FIELD QUALITY CONTROL

A. Verify using field-collected data that the installed equipment conforms to reliability benchmarks developed as part of the field testing.

B. Submit a report to document field-verified transmit and receive signal strength and any RF interference after installation of final communication elements:
    1. Troubleshoot issues and assist Owner if interference is detected during startup and commissioning.

C. The installation shall follow the cellular equipment manufacturer's recommended installation practices and comply with all applicable codes.

D. Upon completion of installation, provide the services of a factory-certified local service technician to perform start-up testing. Record test results and compare to factory testing to confirm proper operation of equipment. Submit test results with operation and maintenance manuals.

3.04 ADJUSTING

A. Orient directional antennas as required for maximum receive strength signal intensity during startup.

B. Orient directional antennas as required for maximum receive strength signal intensity (RSSI) during startup.

END OF SECTION

SECTION 17950

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Abbreviations:
   1. PTO: Profibus Trade Organization.

C. Definitions:
   1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
   2. Loop validation tests - Signals are tested from the field device to the PLC.
   3. Platform testing: Testing of the PLC and SCADA/HMI at the manufacturer's or programmer's shop to demonstrate the program's functionality based upon specified and designed control requirements.
   4. Permanent link: The fixed portion of cabling installed between an equipment outlet and its immediate distributor or between 2 distributors.

D. Standards:
   1. Electronics Industries Alliance (EIA).
   2. Telecommunications Industry Association (TIA).

1.03 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. General:
   1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Overall test plan:
   1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
   2. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
   3. Describe the test phases as they apply specifically to this Project and each process system.
   4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.

5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
6. Provide examples of proposed forms and checklists.

D. Test procedures:
   1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   2. Provide a statement of test objectives for each test.
   3. Prepare specific procedures for each process system.
   4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
   5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
   6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
   7. Provide the forms and checklists to be used.

E. Test forms:
   1. Submit completed calibration forms, test forms, and checklists.
      a. Test forms shall include the detailed test procedures or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
      b. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
      c. Sample test forms at the end of this Section show the minimum required content:
         1) The sample test forms have not been customized for this Project.
         2) Contractor shall develop and submit test forms customized for the Project and meeting the specified test and submittal requirements.

F. FAT procedure additional minimal requirements:
   1. Prepare and submit a FAT procedure which includes:
      a. Control system testing block diagram.
      b. Estimated test duration.

G. Details on the simulator construction, components, and operation. Testing binders:
   1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
   2. Fill out in advance headings and all other information known before the test.
   3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.

4. Include or list reference material and provide separately at the time of the test.
5. Record test results and verify that all test requirements and conditions have been met.

H. Furnish commissioning submittals listed below and specified in this Section as specified in Section 01756 - Commissioning:
   1. Manufacturer's representative qualifications.
   2. Owner training.

I. Test reports:
   1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
   2. Include all completed test binders, forms, and checklists.
   3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

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

1.04 QUALITY ASSURANCE

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

PART 2 EXECUTION

2.01 INSTALLATION

A. Installation supervision:
   1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

2.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Testing and training phase:
   1. Source testing:
      a. Manufacturer services: Provide as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
17055 - Packaged Control System	Packaged Control System	Witnessed
17710 - Control Systems - Panels, Enclosures, and Panel Components.	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
17950 - Commissioning for Instrumentation and Controls	Commissioning for Instrumentation and Controls	Witnessed

b. Prerequisite requirements:
   1) Engineer approval of the hardware and equipment source testing submittal, Manufacturer Certificate of Source Testing, is required before proceeding to Preliminary FAT.

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

d. FAT hardware and communications testing:
   1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
   2) The complete PCIS system including operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.
   3) For any fault tolerant networks such as ring topology networks, disconnect each segment of the network individually to demonstrate proper failover and alarming at the HMI.

4) Testing simulation:
    a) Inputs and outputs shall be simulated and proper control and system operation shall be validated.
    b) Whenever supplied equipment is available, such as devices internal to the control panel, test input and output signals using the equipment. Simulation is not acceptable.
    c) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system:
        (1) The simulator may consist of a PLC, operating under an HMI/SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points.
        (2) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
5) Additional source tests are specified in other sections of the Instrumentation and Control Specifications.
6) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
7) Verify communications between the hardware and the programmer's software comply with specified requirements:
    a) For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio-based telemetry systems.
8) Panel inspections:
    a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings:
        (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
    b) Inspection forms:
        (1) Provide panel inspection forms as part of the FAT procedures submittal.
        (2) A sample FAT control panel form has been provided at the end of this Section.
9) I/O test:
    a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices:
    b) Test methodology:
        (1) Discrete inputs:
            (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe

data received at field wiring terminals or operator interface screen.

(2) Discrete outputs:
  (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.

(3) Analog inputs:
  (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
  (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.

(4) Analog outputs:
  (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
  (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.

c) Test forms to include, but not be limited to the following data:
  (1) PLC and panel number.
  (2) I/O type.
  (3) I/O tag name.
  (4) Rack/slot/number of I/O point.
  (5) Check-off for correct response for each I/O point.
  (6) Comments field.
  (7) Initials of individual performing test.
  (8) Date test was performed.
  (9) Witness signature lines.

10) System configuration test:
  a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.
  b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
  c) Demonstrate the proper operation of peripheral hardware.
  d) Demonstrate general HMI/SCADA functions.
  e) Demonstrate proper operation of log-on and other security access functions.
  f) Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
  g) Test automatic fail over of redundant equipment.
  h) Demonstrate the proper operation of the alarm display and acknowledgement functions.
  i) For any fault tolerant networks, such as ring topology networks, disconnect each segment of the network individually to demonstrate proper failover and alarming.
  j) Test forms:
    (1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.

(2) List the specific tests and steps to be conducted.
(3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
(a) Include signature and date lines.

11) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.

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

2. Owner Training:
   a. Perform Owner training as specified in Section 01756 - Commissioning.

Table 1			
Course Title	**Minimum Course Length (hours per session)**	**Personnel (Estimated Number of Students)**	**Minimum Number of Sessions**
System Overview	8	10	1
Operator Training - Basic	24	10	2
Operator Training - Advanced	16	5	2
PLC Hardware	16	4	1
PLC Software	32	6	1
LOI Hardware and Software	16	5	1
Network Equipment	16	4	1
Follow-Up Training	8	5	5

3. Training course requirements:
   a. System overview training:
      1) Furnish training courses that give the Owner's supervisory level personnel and overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
      2) Furnish a training course that gives the Owner's supervisory level personnel and overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.
   b. Operator training:
      1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
      2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
      3) Operator's training shall include the following for each vendor package and programmable device:
         a) Control system overview: Architecture, equipment functions, software components, etc.
         b) Display navigation, overview, and types of displays.
         c) Process and equipment monitoring and control: Basic principles and operation.
         d) Logging ON and OFF the system and description of the security and access system.
         e) Alarm subsystem.

f) Trending: Provide a thorough session on how to use all trending functions.
g) Reports: How to access, print, and review content.
h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.

c. PCS computer equipment maintenance training:
1) Furnish training courses that will enable maintenance technicians to perform troubleshooting and repair of all system computer equipment. Include the theory of operation of the system as a whole, including related operating system and utility software.

d. PLC software training:
1) Furnish training on PLC software.
2) 2 types of training are required, basic and project-specific:
a) Basic PLC software training covers the principles of PLC programming and the specific features and function of the PLC products used on this Project, provided by one of the PLC manufacturer's certified trainers.
b) Project-specific PLC software training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the Work performed under this Contract. This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified individual who is thoroughly familiar with the delivered system, and is one of the senior programmers who programmed the PLCs for this Project.

e. LOI hardware and software training:
1) Provide the following:
a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
b) Configuration of tag database.
c) Creating, editing, and saving display screens.
d) Troubleshooting.
2) Wireless networks:
a) Discuss parameters specific to wireless networks including, but not limited to, remote resetting options, bandwidth availability, channel speed, and ultimate channel capacity.

f. Follow-up training:
1) Provide a series of on-site follow-up training classes beginning after process start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.

2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:
    a) Schedule at the Owner's discretion on non-consecutive days spaced out over the process start-up and warranty period.

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

2) Cabling installed, terminated, and labeled.
3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
4) Complete loop check form for each device.
5) Submit loop check test results before proceeding to the next step.

c. Loop validation tests:
1) Performed by the Contractor, ICSC, and manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
a) The PLC may or may not be connected to the network.
3) Engineer approval of the loop validation test submittal is required before proceeding to CEET.

d. Copper Ethernet cable acceptance testing:
1) All testing procedures and field-test instruments shall comply with applicable requirements of:
a) TIA-1152 - Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling.
b) TIA-568.0-E - Generic Telecommunications Cabling for Customer Premises.
c) TIA-568.1-E - Commercial Building Telecommunications Infrastructure Standard.
d) TIA-568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
e) Copper Ethernet cable installation testing as specified in Section 16950 - Field Electrical Acceptance Tests.
2) Testing shall be performed by trained technicians who have successfully completed an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
a) Manufacturer of the connectors or cable.
b) Manufacturer of the test equipment used for the field certification.
c) Training organizations (e.g., BICSI).
3) Submit the following information before testing begins:
a) Manufacturer’s catalog sheets, specifications, and the most recent calibration report for the test equipment.
b) Certificate of testing technician’s training.
c) A schedule of all balanced twisted-pair copper links to be tested, including:
(1) Cable identification as it appears on the cable records.
(2) Cable identification as it appears on the individual test reports.
(3) Cable identification as specified in Section 16075 - Identification for Electrical Systems.
d) Sample test reports.

e) All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described below:
   (1) Any Permanent Link that fails these requirements shall be diagnosed and corrected.
   (2) Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements.
   (3) The final and passing result of the tests for all Permanent Links shall be provided in the test results documentation in accordance with the testing requirements.

f) Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Engineer.

4) Cable field-test instruments:

a) The field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.

b) Certification tester requirements:
   (1) Level III in accordance with TIA-1152.
   (2) Independent verification of accuracy.
   (3) Must be capable of storing more than 10,000 results for all required measurements.
   (4) Manufacturer: The following or equal:
      (a) Fluke CableAnalyzer Industrial Ethernet Kit, DSX2-5-IE-K1.

c) Permanent Link adapters:
   (1) Use manufacturer's adapter for connecting to tested equipment.
      (a) Patch cables shall not be used for testing.
   (2) RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with TIA-568.2-D Annex C.

d) Measurement capabilities:
   (1) Wire Map.
   (2) Length.
   (3) Propagation Delay.
   (4) Delay Skew.
   (5) DC Loop Resistance.
   (6) DC Resistance Unbalance.
   (7) Insertion Loss.
   (8) NEXT (Near-End Crosstalk).
   (9) PS NEXT (Power Sum Near-End Crosstalk).
   (10) ACR-N (Attenuation to Crosstalk Ratio Near-End).
   (11) PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End).
   (12) ACR-F (Attenuation to Crosstalk Ratio Far-End).
   (13) PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End).
   (14) Return Loss.
   (15) TCL (Transverse Conversion Loss).
   (16) ELTCTL (Equal Level Transverse Conversion Transfer Loss).

(17) Time Domain Reflectometer.
(18) Time Domain Xtalk Analyzer.

5) Testing requirements:
   a) Field-test instruments shall have the latest software and firmware installed.
   b) Permanent Link test results including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
   c) Testing shall be performed on each cabling segment from connector to connector:
      (1) Sampling is not acceptable.
   d) The installer shall build a reference link:
      (1) All components shall be anchored so it is not possible to disturb them.
      (2) The technician is to conduct a Permanent Link test each day, for each type of category cable used, to ensure no degradation of the tester or its Permanent Link adapters.
   e) Unless noted otherwise tests shall use the following frequency resolution:
      (1) 1 - 31.25 MHz: 150 kHz.
      (2) 31.25 - 100 MHz: 250 kHz.
      (3) 100 - 250 MHz: 500 kHz.
   f) Wire Map measurement:
      (1) Wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
         (a) Continuity to the remote end.
         (b) Shorts between any two or more conductors.
         (c) Reversed pairs.
         (d) Split pairs.
         (e) Transposed pairs.
         (f) Distance to open on shield.
         (g) Any other miss-wiring.
         (h) The correct connectivity of telecommunications outlets/connectors is defined in TIA-568.2-D:
            - 2 color schemes are permitted.
            - User shall define which scheme is to be used.
            - Field tester shall document which color scheme was used.
   g) Length measurement:
      (1) Record the length of each cable. Use the physical length of the link calculated using the pair with the shortest electrical delay for reporting and to determine pass/fail.
      (2) Pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in TIA-568.D-2 plus the nominal velocity of propagation (NVP) uncertainty of 10 percent. For a Permanent Link, the length measurement can be 325 feet before a fail is reported.

h) Propagation Delay measurement:
   (1) Is the time it takes for a signal to reach the end of the link.
   (2) The measurement shall be made at 10 MHz in accordance with TIA-1152.
   (3) The propagation delay of each balanced twisted pair shall be recorded.
   (4) Is not to exceed 498 ns in accordance with TIA-568.2-D Section 6.4.21.
i) Delay Skew measurement:
   (1) Is the difference in propagation delay at 10 MHz between the shortest delay and the delays of the other wire pairs.
   (2) The delay skew of each balanced twisted pair shall be recorded.
   (3) Is not to exceed 44 ns in accordance with TIA-568.2-D Section 6.4.22.
j) DC Resistance:
   (1) Often reported as Resistance, is the loop resistance of both conductors in the pair.
   (2) Is not specified in TIA-1152 but shall be recorded for all 4 pairs.
k) DC Resistance Unbalance:
   (1) Often reported as Resistance Unbalance, is the difference in resistance of the 2 wires within the pair.
   (2) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 4 pairs.
l) Insertion Loss:
   (1) Is the loss of signal strength over the cabling (in dB).
   (2) Worst case shall be reported for all 4 pairs in one direction only.
   (3) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk.
   (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.10.
m) NEXT (Near-End Crosstalk):
   (1) Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
   (2) Shall be measured in both directions (12 pair to pair possible combinations).
   (3) Both worst case and worst margins shall be reported.
   (4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.11.
   (5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
   (6) The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.
n) PS NEXT (Power Sum Near-End Crosstalk):
   (1) Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.

(2) Shall be measured in both directions (8 pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.12.
(5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
(6) Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

o) ACR-N (Attenuation Crosstalk Ratio Near-End):
(1) Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.
(2) Shall be calculated in both directions.
(3) Is not specified in TIA-1152 but shall be recorded for all 12 possible combinations.

p) PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End):
(1) Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.
(2) Shall be calculated in both directions.
(3) Is not specified in TIA-1152 but shall be recorded for all 8 possible combinations.

q) ACR-F (Attenuation Crosstalk Ratio Far-End):
(1) Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.
(2) Shall be measured in both directions (24 pair to pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.14.
(5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

r) PS ACR-F (Power Sum Attenuation Crosstalk Ratio Far-End):
(1) Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.
(2) Shall be measured in both directions (8 pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.16.
(5) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

s) Return Loss:
(1) Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
(2) Shall be measured in both directions (8 pair possible combinations).
(3) Both worst case and worst margins shall be reported.
(4) Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.
(5) Is not to exceed the Category 6 Permanent Link limits in accordance with TIA-568.2-D Section 6.4.9.

(6) Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
(7) Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

t) TCL (Transverse Conversion Loss):
(1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
(2) Shall be measured in both directions.
(3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.

u) ELTCTL (Equal Level Transverse Conversion Transfer Loss):
(1) Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
(2) Shall be measured in both directions.
(3) Is not specified in TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.

6) Test results documentation:
a) The detailed test results documentation data is to be provided in an electronic database for each tested balance twisted pair and shall contain the following information:
(1) The overall Pass/Fail evaluation of the link-under-test.
(2) The date and time the test results were saved in the memory of the tester.
(3) The identification of the customer site as specified by the end-user.
(4) The name of the test limit selected to execute the stored test results.
(5) The name of the personnel performing the test.
(6) The version of the test software and the version of the test limit database held within the test instrument.
(7) The manufacturer, model and serial number of the field-test instrument.
(8) The adapters used.
(9) The factory calibration date.
(10) Wire Map.
(11) Propagation Delay values, for all 4 pairs.
(12) Delay Skew values, for all 4 pairs.
(13) DC Resistance values, for all 4 pairs.
(14) DC Resistance Unbalance, values for all 4 pairs.
(15) Insertion Loss, worst case values for all 4 pairs.
(16) NEXT, worst case margin and worst case values, both directions.
(17) PS NEXT, worst case margin and worst case values, both directions.
(18) ACR-F, worst case margin and worst case values, both directions.
(19) PS ACR-F, worst case margin and worst case values, both directions.

(20) Return Loss, worst case margin and worst case values, both directions.
(21) TCL, worst case values both directions.
(22) ELTCTL, worst case values, both directions.
(23) Time Domain Crosstalk data if the link is marginal or fails.
(24) Time Domain Reflectometer data if the link is marginal or fails.

b) Maintain a set of “red-line” throughout during construction:
(1) Drawings shall be available for review at any time as requested by Owner or Engineer.
(2) Provide record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point.
(3) The as built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details.
(4) The as-builts shall include all field changes made up to construction completion:
(a) Field directed changes to pull schedule.
(b) Horizontal cable routing changes.

7) Associated detail drawings. Engineer approval of the copper Ethernet cable acceptance-testing submittal is required before proceeding to CEET.

e. Complete End-to-End Testing (CEET):
1) Performed by Contractor, ICSC, and manufacturer's representative working together, with assistance from the Owner or the inspection staff, as needed:
a) The participants need to be dedicated full-time to CEET.
b) ICSC will provide staff to verify input signals at, and create output signals from, an HMI or Engineering Workstation.
c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.
2) Prerequisites:
a) CEET cannot begin until the successful completion of the preceding tests:
(1) Calibration.
(2) Loop check.
(3) Loop validation tests.
(4) Copper Ethernet cable acceptance testing.
(5) Industrial network testing.
3) Testing description:
a) This testing is to ensure all I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.

b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. The outputs will be energized for a duration long enough to verify proper operation of the final control element.
c) SCADA screens:
(1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
(2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
(3) Retest any loop following any necessary corrections.

4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system:
a) Use actual process inputs wherever available.
b) Issue commands from the HMI/SCADA system and verify proper responses of field devices:
(1) Test SCADA system inputs from field device to SCADA system operator workstations:
(a) Track responses through trend charts in the HMI/SCADA system.
(2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.

5) Discrete device testing:
a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
(1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
(2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
(3) Calibrate and test instruments supplying discrete inputs and observe proper operation.
b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
(1) Stroke valves through outputs from the HMI/SCADA system and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
(2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.
(3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.

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

d) Analog output devices:
(1) Calibration range.
(2) Test value at each test point.
(3) Analog output associated PLC register address.
(4) Control variable value at field device at each test point.
(5) Physical device response at each test point:
(a) Response to be actual valve position, or motor speed, etc.
(6) Test equipment used and associated serial numbers.

10) Failure testing:
a) Demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
(1) Equipment failure.
(2) Communications sub-system error.
(3) Power failure.
(4) Process equipment failure.
(5) High system loading conditions.

11) Engineer approval of the CEET submittals is required before proceeding to Functional Testing.

5. Functional Testing:
a. General:
1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
2) Performed by Contractor, ICSC, and manufacturer's representativeworking together, with assistance from the Owner or the inspection staff, as needed.
3) Additional tests are specified in other Instrumentation and Control Sections.
4) Follow approved detailed test procedures and check lists for Functional Test activities.

b. Control logic operational validation:
1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
3) Test in detail on a function-by-function and sentence-by-sentence basis.
4) Thoroughly test hardware and software functions:
5) Including all hardwired and software control circuit interlocks and alarms.

6) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
7) Control logic validation tests to include, but not limited to, a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.

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

5) Functional certification:
a) Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning:
(1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.

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

4) Failures:
    a) Classify failures as either major or minor:
        (1) Minor failure:
            (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
            (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for nonacceptance.
            (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
            (d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made, and equipment returned to service within 3 working days.
        (2) Major failure:
            (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
            (b) Cause termination of the PCIS Optimization and Fine-Tuning.
            (c) Start a new acceptance test when the causes of a major failure have been corrected.
            (d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
5) Technician report:
    a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
    b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
    c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
    d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

2.03 SCHEDULES

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

END OF SECTION

ATTACHMENT A - FACTORY ACCEPTANCE TEST - CONTROL PANELS

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

1. GENERAL INSPECTION

A. Structural Inspection

- ☐ Verify Lifting Lugs Installed
- ☐ Verity enclosure has lock and lock is functional
- ☐ Confirm that seismic bracing components are provided per manufacturer's installation instructions

B. Exterior Inspection

- ☐ Cabinet exterior is clean, scratch, and dent free
- ☐ Inspect externally for corrosion and damage
- ☐ Verify enclosure door opens and closes easily
- ☐ Verify enclosure has a 3-point latch
- ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet)
- ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.)
- ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant)

Nameplates

- ☐ Cabinet has identification nameplate
- ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract
- ☐ Cabinet has a nameplate that includes the following:
  - ☐ Power source(s)
  - ☐ Integrator's Logo
  - ☐ Circuit ID(s)
  - ☐ Short Circuit KAIC ratings
- ☐ If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.)

Door Devices

- ☐ All devices penetrating the outside of panel have gaskets, silicone or both
- ☐ All door devices are installed (HMIs, Pilot Devices, etc.)
- ☐ Door mounted equipment is mounted straight and square
- ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened
- ☐ NEMA classification has not been violated due to penetrations
- ☐ Door mounted equipment has the same NEMA rating as the panel
- ☐ All door mounted equipment installed at the correct height
- ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner)
- ☐ Doors with multiple penetrations have adequate bracing (if needed)
- ☐ Visually check condition of indicators , controllers and annunciators
- ☐ Check that pilot lights illuminate correctly
- ☐ Check the Push-To-Test function
- ☐ Ensure correct pilot light color

Peripheral Devices

- ☐ Horn / Beacon is installed (where required)
- ☐ Silence and Reset pushbutton

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	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

1. GENERAL INSPECTION (continued)

C. Interior Inspection

- ☐ Cabinet is cleaned of marks and dirt.
- ☐ Inspect internally for corrosion and damage.
- ☐ Back panel is clean of marks and dirt.
- ☐ Interior of panel vacuumed and shall be free of all debris.
- ☐ Check that the panel roof is clean and clear of foreign materials.
- ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed.
- ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open.
- ☐ Check that a document pocket has been provided.
- ☐ Intrusion alarms (where required).

Interior Labeling

- ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags.
- ☐ Verify that door mounted components are mounted square and symmetrical.
- ☐ Verify that nameplates are straight, legible, and spelled correctly.
- ☐ All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps.
- ☐ All wiring shrink labeled and or phased correctly to the specifications.
- ☐ All wire labels shrunk completely rotated and aligned alike for easy identification.
- ☐ All fuses and circuit breakers are labeled with ID and current rating.
- ☐ System Integrator’s label or labels installed on door.
- ☐ Panel manufacturer model/serial number tag is present.
- ☐ All required safety/warning tags installed and straight.
- ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.).

Wireways

- ☐ Plastic wire way covers installed properly.
- ☐ Plastic wireways have no sharp edges.
- ☐ No wire Ties inside the wireways.
- ☐ No sharp edges on wire ties.
- ☐ Separation: White duct is used for DC voltages; Gray duct is used for AC voltages.
- ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.

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	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

1. GENERAL INSPECTION (continued)

C. Interior Inspection (continued)

Wiring

- ☐ Visually check terminals and condition of internal wirings
- ☐ Verify that the control panel has been assembled and wired as designed
- ☐ Verify that all components are operational and perform the functions intended
- ☐ Verify that all components are sized appropriately for the application
- ☐ Verify that equipment control circuits function as intended
- ☐ Back of door wiring is labeled and neatly formed
- ☐ Back panel to door wiring has sufficient bending radius with spiral wrap
- ☐ Wire connection has been verified wired to correct points within the panel
- ☐ Individual wires have been given a pull test to verify a good terminal connection
- ☐ Wire and cable minimum bending radius have not been violated
- ☐ All equipment installed straight and square to back panel
- ☐ Wire colors are correct:
  - ☐ Black and White > AC hot and neutral, respectively
  - ☐ Red > AC control signals
  - ☐ Blue > DC power and control (Blue w/White stripe for DC ground)
  - ☐ Yellow > Foreign voltages (those still present when panel power is disconnected)
  - ☐ Green > AC equipment ground
  - ☐ Black > TSP (+)
  - ☐ White> TSP(-)
- ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields)
- ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself
- ☐ Discrete inputs are separately fused or protected by a circuit breaker on a “per loop” basis
- ☐ Intrinsic Safety Wiring
  - ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring
- ☐ Verify all spare terminals are installed according to the percentage listed in the specifications

Grounding

- ☐ Equipped with “Blackburn” or other grounding type lug
- ☐ Lug is securely fastened to the panel structure
- ☐ Verify Grounding bar is installed
- ☐ Verify Isolated ground bar is installed

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2. POWER TEST

A. AC Power

- ☐ AC Power is routed correctly within the panel and is isolated from DC and network wiring.
- ☐ All fuses are installed and sized properly.
- ☐ All breakers are installed and sized properly.
- ☐ 24 VDC Power Supplies are functional.
- ☐ 24 VDC Power fail contacts are functional.
- ☐ 24 VDC power supplies are redundant and have diode modules enabling the hot swap-over between supplies.
  - ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional.
- ☐ Dedicated receptacle is wired to receive a dedicated AC supply.
- ☐ Verify continuity for all DC commons, ground and AC neutrals.
- ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage.
- ☐ Close the CP main circuit breaker(s).
- ☐ Verify that voltages at subsequent circuit breakers are correct.
- ☐ Close circuit breakers.
- ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct.
- ☐ Turn on power supplies if they are not already on.
- ☐ Verify that voltages at distribution terminals are correct.
- ☐ Energize any remaining hardware such as the PLC.

B. Uninterruptible Power Supply (UPS)

- ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel.
- ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit).
- ☐ Test all UPS alarms (on inverter, failure, battery failure etc.)
- ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel.

3. CONTROLS & AUXILIARY DEVICES TEST

- ☐ Verify all interposing and auxiliary relays are functioning.
- ☐ Verify panel lights are functioning.

Ventilation and Heating

- ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked.
- ☐ Verify components are installed in the correct orientation for proper air flow.

4. HARDWIRED INTERLOCK AND SAFETY TEST

- ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump.
- ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.

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5. PLC TEST

A. Components

☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional.

☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used.

☐ TVSS is installed across the main incoming 120 VAC.

PLC and PLC Rack

☐ Verify all cards are securely seated.

☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the “no encroachment” area. Confirm with manufacturer clearance recommendations.

B. PLC I/O Test

☐ Furnish **I/O test forms** and test all the listed input and output points as follows:

☐ Discrete Inputs: Simulate a field contact closure by “shorting” across the appropriate terminal blocks. Observe the transition between a logical “0” and “1” in the PLC software.

☐ Discrete Outputs: Force the output bit to toggle between logical “0” and logical “1” using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the “ohms” setting.

☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred.

☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter.

C. Redundant Controllers (where required) Test

☐ Remove Communication cable from primary PLC to verify switching to backup PLC

☐ Remove Communication cable from backup PLC to verify switching back to primary PLC

☐ Remove Power cable from primary PLC to verify switching to backup PLC

☐ Remove Power cable from backup PLC to verify switching back to primary PLC

D. PLC Control Logic Verification

☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below.

☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal.

☐ For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.

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5. PLC TEST (continued)

D. PLC Control Logic Verification (continued)

Typical Fault Logic

- ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.
- ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.

Typical Fail to Start Logic

- ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.

6. HMI OR OIT TEST

HMI / OIT Functionality

- ☐ Communication with PLC
- ☐ Screen Layouts
- ☐ Screen Navigation
- ☐ Set Point Entry
- ☐ Animation
- ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention)
- ☐ Alarms
- ☐ Acknowledge and Reset
- ☐ Security / Access Levels / Passwords

7. NETWORK COMMUNICATION TEST

A. Network Components

- ☐ Fiber optic cabling terminates in a patch panel
- ☐ Media converters are installed and functional
- ☐ Terminating resistors have been installed for trunk/tap topologies or where required
- ☐ Wire and cable bending limitations have not been violated

B. Networking Functions

- ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams
- ☐ Verify network traffic rate and error margin is acceptable

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	FACTORY ACCEPTANCE TEST - CONTROL PANELS	

8. FAT DOCUMENTATION AND RECORD

Panel Documentation

- ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material.
- ☐ Panel schematic and interconnection drawings.
- ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested.
- ☐ I/O list test forms of the process area to be tested.
- ☐ FAT procedure of the process area to be tested.
- ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel.
- ☐ Hard copy of the PLC application program of the process area to be tested.
- ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested.

9. FAT TOOLS AND SOFTWARE

- ☐ Simulation software if required
- ☐ Digital volt meter Fluke 87
- ☐ Process meter Fluke 787
- ☐ Laptop computer with PLC application program
- ☐ Temporary SCADA computer with HMI software and applicable graphic screens
- ☐ Jumper wires

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ATTACHMENT B - INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

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

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

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

REMARKS: _____

CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____

ATTACHMENT C - SWITCHES INSTALLATION AND CALIBRATION CHECKLIST

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ No ☐ Yes

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

FIELD CALIBRATION CHECK

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

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

REMARKS: _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT D - TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

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

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

BENCH CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

HEAD CORRECTION = _____ ☐ LINEAR

CALIBRATED SPAN = _____ ☐ SQUARE ROOT

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK

INPUT RANGE = _____ OUTPUT RANGE = _____

% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT _____ SPAN

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

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

REMARKS _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT E - ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST

	ANALYZERS **INSTALLATION AND CALIBRATION CHECKLIST**	

☐ No ☐ Yes

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

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

ATTACHMENT F - CONTROL VALVES
INSTALLATION AND CALIBRATION CHECKLIST

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ No ☐ Yes

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

☐ VALVE TAG NO. _____ SERIAL NO. _____

☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____

☐ SOLENOID TAG NO. _____ SERIAL NO. _____

☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____

☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

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

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____

- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

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

REMARKS _____

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

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____