CITY OF PUNTA GORDA

SHELL CREEK WTP ALUM & AMMONIA SYSTEM IMPROVEMENTS

CLIENT PROJECT NO. B2022180/B2022189

CONTRACT & TECHNICAL SPECIFICATIONS

BID SET

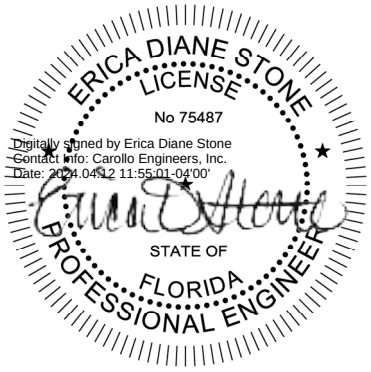
VOLUME 1 OF 1

APRIL 2024

301 NORTH CATTLEMEN ROAD, SUITE 302 ▪ SARASOTA, FLORIDA 34232 ▪ P 941-371-9832

CITY OF PUNTA GORDA

SHELL CREEK WTP ALUM & AMMONIA SYSTEM IMPROVEMENTS



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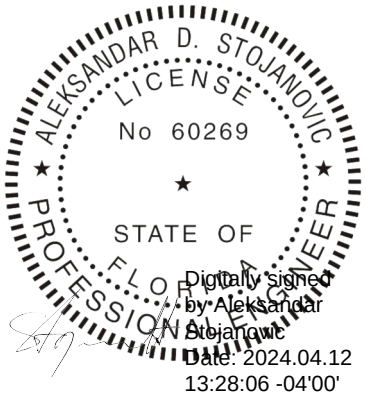
CITY OF PUNTA GORDA

SHELL CREEK WTP ALUM & AMMONIA SYSTEM IMPROVEMENTS



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CITY OF PUNTA GORDA

SHELL CREEK WTP ALUM & AMMONIA SYSTEM IMPROVEMENTS

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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 demolition and construction of the following items, all of which shall be constructed in accordance with the Drawings and Specification:
   1. The work consists of construction of alum and ammonia system improvements at the Shell Creek Water Treatment Plant.
   2. Work for the alum system improvements includes removal and proper disposal of all existing alum equipment including existing alum bulk storage tanks, feed equipment, and process piping; furnishing, installing, and testing new horizontal alum bulk storage tanks, transfer pumping system, alum day tank with supporting appurtenances, metering pumping system, transfer and metering process piping, valves, and appurtenances; and disinfection, testing and incidentals to complete the Work.
   3. Work for the ammonia system improvements includes removal and proper disposal of all existing anhydrous ammonia equipment including existing anhydrous ammonia storage tank, feed equipment, and process piping; furnishing, installing, and testing new liquid ammonium sulfate (LAS) bulk storage tanks, transfer pumping system, LAS day tank with supporting appurtenances, metering pumping system, transfer and metering process piping, valves, and appurtenances; and disinfection, testing and incidentals to complete the Work.

B. See Appendix A for project drawings, including Site Plan, and staging areas for construction and General Arrangement drawings.

C. See Appendix B for photographs of the existing alum and ammonia storage and distribution system.

D. See Section 01140 for construction (shutdown, washwater supply, and staging) constraints and protection of treatment plant processes during construction.

E. Obtain a construction permit from the Florida Department of Environmental Protection for construction of a PWS component.

F. Restore disturbed areas of the site when work is completed.

1.03 LOCATION OF PROJECT

A. The Work is located at the City of Punta Gorda's Shell Creek Water Treatment Plant. The address is 38100 South Washington Loop Road, Punta Gorda, Florida 33982.

1.04 COORDINATION MEETINGS

A. Contractor shall attend the following meetings:
   1. Construction kickoff meeting
   2. Weekly progress meetings

B. Prior to each meeting, Contractor shall distribute a three week look ahead schedule and updated progress schedule.

1.05 PARTIAL USE OR OCCUPANCY

A. Substantial Completion on the following portions of Work for Owner's occupancy including specified testing, training of Owner's personnel, and other preparations necessary for Owner's occupancy or use:
   1. The improved alum and ammonia systems are online, and are adequately delivering chemical, as defined by the design criteria, to the specified chemical injection points.

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:
   1. Requirements for sequencing and scheduling the Work affected by existing site and facility, access to the plant, work restrictions, and coordination between construction operations and plant operations.

1.02 SUBMITTALS

A. Baseline Schedule with MOP tasks.

B. Method of Procedure (MOP) Form.

C. Method of Procedure (MOP) Log.

D. Progress Schedule with MOP tasks.

1.03 GENERAL CONSTRAINTS ON WORK AND SCHEDULING OF WORK

A. Parking for Contractor shall be within the designated staging areas.

B. See Appendix A for project drawings, including Site Plan, and staging areas for construction and General Arrangement drawings.

C. See Appendix B for photographs of the existing alum and ammonia storage and distribution system.

D. Work shall be conducted between the hours of 7 am to 4 pm on Monday through Friday.

E. Work outside these hours and days is prohibited.

F. Water projects:
   1. The Shell Creek Water Treatment Plant is the Owner’s sole source of drinking water.
   2. Conduct Work such that the Owner’s ability to meet its customer's demands for treated drinking water shall not be impaired or reduced in terms of the required quantity or quality of treated water.
   3. Do not impair the operational capabilities of essential elements of the treatment process or reduce treatment capacity below levels sufficient to meet demands for water throughout the contract time.

4. The status of the treatment plant shall be defined as “operational” when the plant is capable of meeting the Owner’s customer’s demands for treated drinking water in terms of the required quantity or quality of treated water as defined in this Section.

1.04 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 plant 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 treatment 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.

1.05 WORK RESTRICTIONS

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

B. Piping:
   1. Provide temporary piping and/or chemical storage and supply during construction for existing and new equipment to maintain plant operation in service during construction as needed.

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 submits 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 completes 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/Drawing. Ref.:** _____

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. The Owner will not pay for off-site stored materials and will not pay for stored materials without invoice. No markup is allowed on stored materials.

1.02 REFERENCES

A. Occupational Safety and Health Administration (OSHA).

1.03 LUMP SUM ITEMS

A. Item 1: Mobilization
   1. Measurement:
      a. Limit amounts included under mobilization to the following items:
         1) Moving on the site any equipment required for first month operations.
         2) Installing any necessary temporary construction power, wiring, and lighting facilities.
         3) Establish and submit hurricane preparedness plan.
         4) Establish and submit fire protection plan and safety program.
         5) Provide temporary facilities as specified in Section 01500 - Temporary Facilities and Controls.
            a) Providing on-site sanitary facilities and potable water facilities as specified.
            b) Providing field office trailer for the Contractor, if desired.
         6) Arranging for and erection of Contractor's work and storage yard.
         7) Submit required insurance certificates and bonds.
         8) Obtaining required permits, licenses, and fees.
         9) Submit preliminary schedule of values of the Work.
         10) Submit preliminary schedule and develop baseline schedule.
         11) Submit Schedule of Submittals.
         12) Post OSHA, Department of Labor, state, and other required notices.
         13) Submit pre-construction photographs.
         14) Have Contractor's project manager and/or general superintendent on job site.
   2. Payment:
      a. Furnish data and documentation to substantiate the amounts claimed under mobilization costs.
      b. Payment for mobilization shall not be made until mobilization items listed above have been completed as specified.

c. Limit price for mobilization to no more than 5 percent of Contract Price.
d. Lump sum.

B. Item 2: Removal and Disposal of existing vertical alum bulk storage tanks, feed equipment, and process piping:
1. Measurement:
a. Remove and dispose of existing vertical alum bulk storage tanks, feed equipment, and process piping, as indicated in the construction documents.
2. Payment:
a. Lump sum.

C. Item 3: Removal and Disposal of existing anhydrous ammonia storage tank, feed equipment, and process piping:
1. Measurement:
a. Remove and dispose of existing anhydrous ammonia storage tank, feed equipment, and process piping, as indicated in the construction documents.
2. Payment:
a. Lump sum.

D. Item 4: Supply, Install, Disinfect, and Test horizontal cradle alum bulk storage tanks:
1. Measurement:
a. Install, disinfect, and test the new horizontal bulk storage tanks as specified.
2. Payment:
a. Lump sum.

E. Item 5: Supply, Install, Disinfect, and Test alum transfer pumping system:
1. Measurement:
a. Install, disinfect, and test the new alum transfer pumping system as specified.
2. Payment:
a. Lump sum.

F. Item 6: Supply, Install, Disinfect, and Test alum metering system:
1. Measurement:
a. Install, disinfect, and test the new alum metering system as specified.
2. Payment:
a. Lump sum.

G. Item 7: Supply, Install, Disinfect, and Test alum day tank:
1. Measurement:
a. Install, disinfect, and test the new alum day tank as specified.
2. Payment:
a. Lump sum.

H. Item 8: Supply, Install, Disinfect, and Test alum process piping, valves, and appurtenances:
   1. Measurement:
      a. Install, disinfect, and test the new alum process piping, valves, and appurtenances as specified.
   2. Payment:
      a. Lump sum.

I. Item 9: Supply, Install, Disinfect, and Test liquid ammonium sulfate (LAS) bulk storage tanks:
   1. Measurement:
      a. Install, disinfect, and test the new LAS bulk storage tanks as specified.
   2. Payment:
      a. Lump sum.

J. Item 10: Supply, Install, Disinfect, and Test LAS transfer pumping equipment:
   1. Measurement:
      a. Install, disinfect, and test the new LAS transfer pumping equipment as specified.
   2. Payment:
      a. Lump sum.

K. Item 11: Supply, Install, Disinfect, and Test LAS metering equipment:
   1. Measurement:
      a. Install, disinfect, and test the new LAS metering equipment as specified.
   2. Payment:
      a. Lump sum.

L. Item 12: Supply, Install, Disinfect, and Test LAS day tank:
   1. Measurement:
      a. Install, disinfect, and test the new LAS day tank as specified.
   2. Payment:
      a. Lump sum.

M. Item 13: Supply, Install, Disinfect, and Test LAS process piping, valves, and appurtenances:
   1. Measurement:
      a. Install, disinfect, and test the new LAS process piping, valves, and appurtenances as specified.
   2. Payment:
      a. Lump sum.

N. Item 14: Demobilization:
   1. Measurement
      a. Removal of temporary facilities as specified in Section 01500 - Temporary Facilities and Controls.
      b. Completion of closeout submittals as specified in Section 01770 - Closeout Procedures.
   2. Payment:
      a. Shall not be less than 5 percent of Contract Price.
      b. Lump sum.

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.

D. Divide the work into following Major Items of Work:
   1. Mobilization.
   2. Removal and Disposal of existing vertical alum bulk storage tanks, feed equipment, and process piping.
   3. Removal and Disposal of existing anhydrous ammonia storage tank, feed equipment, and process piping.
   4. Supply, Install, Disinfect, and Test horizontal cradle alum bulk storage tanks.
   5. Supply, Install, Disinfect, and Test alum transfer pumping system.
   6. Supply, Install, Disinfect, and Test alum metering system.
   7. Supply, Install, Disinfect, and Test alum day tank.
   8. Supply, Install, Disinfect, and Test alum process piping, valves, and appurtenances.
   9. Supply, Install, Disinfect, and Test LAS bulk storage tanks.
   10. Supply, Install, Disinfect, and Test LAS transfer pumping equipment.
   11. Supply, Install, Disinfect, and Test LAS metering equipment.
   12. Supply, Install, Disinfect, and Test LAS day tank.
   13. Supply, Install, Disinfect, and Test LAS process piping, valves, and appurtenances.
   14. Demobilization.

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. For stored products with item number and identification on application, description of specific material, and proof of insurance coverage for offsite stored products.
   8. Submit “certified” payroll, if applicable.

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 01321

SCHEDULES AND REPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Schedules and reports.

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. Baseline schedule: A planned and approved timetable projection that illustrates the project execution strategy, key deliverables, planned activity dates and milestones.
   2. Critical path: The longest sequence of dependent tasks in a project.
   3. Near critical path: The longest path after the critical path.
   4. Weather day: The Contractor being prevented or inhibited from performing at least 4 hours of work on the critical path due to weather conditions.

1.03 SCHEDULING FORMAT

A. Utilize critical path method (CPM) format.

B. Provide a cost and labor loaded Schedule.

C. Engineer approval of the format is required.

1.04 SCHEDULING HARDWARE AND SOFTWARE

A. Scheduling software and hardware shall be located on-site.

B. Prepare computerized schedule utilizing the most current version of Oracle Primavera P6 or Asta Powerproject.

C. Contractor and Engineer must agree on the format.

1.05 SCHEDULE PREPARATION

A. Preparation and submittal of Progress Schedule represents Contractor’s intention to execute the Work within specified time and constraints.
   1. Failure to conform to requirement may result in termination for cause.

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

C. During preparation of the preliminary Progress Schedule, the Engineer will facilitate Contractor's efforts by answering 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 a 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 the 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 beginning with Notice to Proceed as 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 the 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. Payment for mobilization or payment for materials or equipment delivered to the site, not yet incorporated into the Work.
4. Owner acceptance of the Baseline Schedule creates the Schedule of Values required as specified in Section 01292 - Schedule of Values.
5. Provide updated Schedule of Values as the monthly Payment Application as specified in Section 01294 - Applications for Payment.
6. Payments will not be made until the 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. Major subcontractor, parallel prime contractor sign off:
1. Provide written confirmation of concurrence from all major subcontractors and independent prime contractors on site with all Schedule submittals.
2. Term “major subcontractor” as used in this Section means any subcontractor, at any tier, with a subcontract worth 5 percent or more of the total cost of the Work.

P. Schedule windows for Owner-furnished, Contractor-installed equipment or materials:
   1. Immediately after Award of Contract, obtain from Engineer anticipated delivery dates of Owner furnished equipment or materials.
   2. Show these dates in the Schedule in same manner indicated by the Engineer.

1.06 SUBMITTAL REQUIREMENTS

A. Preliminary and Baseline Progress Schedule.

B. Preliminary and Baseline Schedule of Values.

C. Preliminary and Baseline Schedule of Submittals.

D. On a monthly basis, updated Schedules as specified.

E. Final Schedules update as specified.

F. Revised Schedules and time impact analyses as specified.

G. Submit Schedules in the media and number of copies as follows:
   1. PDF format and in other formats specified in this Section.
   2. 2 sets of CPM Schedule data electronic files in a native backed-up file format.

1.07 GANTT CHART

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 Progress Schedule showing the critical path for the Project.

E. Provide report of Near Critical Path activities for the Project, when required by the Engineer.

F. Delineate the specified Contract Times 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 dates as milestones.

H. Include, in addition to construction activities:
   1. Any activity by the Owner or the Engineer that may affect progress or required completion dates.
   2. Equipment and long-lead material deliveries over 8 weeks.
   3. Approvals required by regulatory agencies or other third parties.

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

1.08 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.

1.09 PRELIMINARY SCHEDULE OF VALUES

A. Preliminary Schedule of Values as specified 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.

1.10 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.

1.11 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.

B. Preliminary Schedule of Submittals:
   1. Due date: After Preliminary Schedule has been submitted and accepted by the 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) Engineer will endeavor to provide early review of “Priority” Submittals where possible.
   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) Engineer will endeavor to provide early review of “Priority” Submittals where possible.
   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.

1.12 BASELINE PROGRESS SCHEDULE AND BASELINE SCHEDULE OF VALUES

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

B. Format:
   1. Progress 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 Progress 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.

1.13 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.

1.14 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.

1.15 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: As specified in Section 01292 - Schedule of Values.

1.16 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. Activity designations used in the weekly Schedule must be consistent with those used in the Baseline Schedule and the monthly Schedule updates.

1.17 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.

1.18 COMMISSIONING SCHEDULE

A. Commissioning activities and milestones, as specified, shall be an integral part of the overall Progress Schedule.
   1. Commissioning activities and milestones shall be extracted from the Progress Schedule to provide a separate Commissioning schedule that is submitted each time the Progress Schedule is submitted.

B. Proposed Commissioning Schedule:
   1. Schedule requirements: As specified.
   2. Submittal due date: Within 20 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.

C. 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.

D. 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.

1.19 REVIEW AND ACCEPTANCE OF SCHEDULES

A. Engineer will review preliminary Schedules, 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 Schedules 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 Schedules in accordance with Engineer's comments within 7 calendar days after receipt of such comments or request joint meeting to resolve objections.

E. If the Engineer requests a meeting, the Contractor and all major subcontractors shall participate.
   1. Revise and resubmit Schedule within 7 calendar days after meeting.

F. Use accepted Schedules for planning, organizing, and directing the Work and for reporting progress.

G. Engineer's Submittal review response:
   1. When Schedules reflects the Owner's and Contractor's agreement of project approach and sequence, Schedules will be accepted by the Owner.
   2. Engineer's Submittal review response for Schedule Submittals will be "Receipt Acknowledged - Filed for Record".
   3. Acceptance of the Schedules by the Owner is for general conformance with the Contract Documents and for the 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.

1.20 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.

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.
      e. Include a response in writing to each of the Engineer's comments or questions from the previous month's schedule review and number responses consistent with the Engineer's numbering.
   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.

1.21 REVISIONS TO SCHEDULES

A. Submit revised Schedules 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).

1.22 ADJUSTMENT OF CONTRACT TIME OR PRICE

A. Contract Time will be adjusted only for causes specified in Contract Documents.

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, in the form of a time impact analysis demonstrating the delay to the critical path.

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 Progress Schedule's critical path and completion date are impacted as a result of adding this delay event to the Progress 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. 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.

1.23 WEATHER DAY ALLOWANCE

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

B. Actual Weather Day:
   1. Insert a weather delay activity in the critical path to reflect actual weather day occurrences when weather days are experienced and accepted by the Engineer.
   2. Reduce duration of Weather Day Allowance activity as weather delays are experienced and inserted into the Schedule. Remaining weather days in the Weather Day Allowance at completion of the Project is considered float.
   3. Provide a written notice to the Engineer of the occurrence of a weather day within 2 days after the onset of such weather and 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. 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.

1.24 ALLOWANCE FOR OWNER-CAUSED DELAY

A. Allowance:
   1. Include as a separate identifiable activity on the critical path, an activity labeled “Allowance for Owner-Caused Delay.”
   2. Insert this activity at the end of the Schedule, following the Project Completion Milestone.
   3. Duration of this activity is specified in the Bid Form.
      a. The duration of this Owner-Caused Delay Allowance is in addition to the contractual time frame.

B. Actual delay:
   1. Insert an activity in critical path to reflect actual Owner-caused delay occurrences when Owner-Caused delay days are experienced and accepted by Engineer.
      a. Identify this activity as an Owner-Caused delay.
   2. Reduce duration of Owner-Caused Delay Allowance activity as Owner-caused delays are experienced and inserted into the Schedule. Remaining days in Owner-Caused Delay Allowance at completion of project is considered float.

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 01330

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 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 one Submittal per Specification section, but a single Submittal may not cover more than one Specification section:
      a. The only exception to this requirement is when one 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: 8 1/2 inches by 11 inches.
   2. Maximum: 11 inches by 17 inches.

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

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

J. Provide Submittal information from only one manufacturer for a specified product. Submittals with multiple manufacturers for one 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. 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. 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.
3. Check, verify, and revise Submittals as necessary to bring them into conformance with Contract Documents and actual field conditions.

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 the 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 a sequential numbering sequence. All Submittals must be assigned to a Specification section.

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 the Contractor from Contractor's responsibility for performance of requirements of Contract Documents. Neither shall the Engineer's review release the Contractor from fulfilling purpose of installation nor from the 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 the 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 the 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 the 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:
        1) Filed for Record:
            a) 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.

2) With Comments - Resubmit:
a) 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 the 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 the Engineer in writing.
4. Review costs:
a. Costs incurred by the Owner as a result of additional reviews of a particular Submittal after the second time it has been reviewed shall be borne by the Contractor.
b. Reimbursement to the Owner will be made by deducting such costs from the 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 01410

REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Regulatory authorities and codes.

1.02 AUTHORITIES HAVING JURISDICTION (AHJ)

A. Also referred to as the permitting agency.

B. Building Department.

C. Florida Department of Environmental Protection.

1.03 APPLICABLE CODES

A. Products in contact with drinking water
   1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.
      a. Certification by an independent ANSI accredited third party, including, but not limited to, NSF International, as being lead free.

B. Florida Building Commission (FBC):
   1. Building code:
      a. Florida Building Code, 7th Edition, 2020.

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. 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.

C. 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.

1.10 CONTRACTOR'S RESPONSIBILITIES

A. 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.

B. 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.

C. Submit product test reports electronically.

D. 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.
   5. For shipping or delivery of samples.

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. The Owner will provide electrical power for use during construction.
   2. Contractor shall provide and maintain adequate jobsite power distribution facilities conforming to applicable Laws and Regulations.

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:

C. Temporary water:
   1. The Owner will supply water used for construction.

D. 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.

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

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

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

H. 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. Submit information at least 28 days prior to when each temporary piping system is scheduled to be installed and allow 14 days for review and comment.

I. Temporary pumping systems:
   1. Submit pump data, performance curves, and other operating information as specified in Section 15050 - Common Work Results for Mechanical Equipment.
   2. Submit sketches showing layout of temporary pumping system, including pump quantity, configuration in wet well, and proposed piping layout specified in this Section.
   3. Submit piping headloss calculations based on proposed temporary piping system layout.
   4. Submit information at least 28 days prior to when the temporary pumping system is scheduled to be installed and allow 14 days for review and comment.

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. 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.

F. 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.

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 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.

1.08 CONTRACTOR FIELD OFFICES AND SHEDS

A. The Contractor has the option to maintain a field office on the Project Site, in a location designated by the Engineer.

B. Connection of temporary utilities for the Contractor’s field office will be paid for by the Contractor.

1.09 SITE RESTORATION

A. Restore disturbed areas of the site.

B. Staging areas shall be regraded if necessary and resodded with St. Augustine sod.

1.10 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 01600

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 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.
   4. Products:
      a. Raw materials, finished goods, equipment, systems, and shop fabrications that will become part of the Work.
   5. 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.
   6. 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.
   7. 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.

8. Spare parts and materials:
    a. Duplicate parts necessary to replace a damaged or worn part of the product.
    b. Consumables such as operating fluids.
9. Special tools:
    a. Special wrenches, gauges, circuit setters, and other similar devices required for the proper operation or maintenance of a product 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.
10. 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 SHIPMENT

A. Requirements prior to shipment of equipment:
    1. Engineer approved Submittals or other written documentation.
    2. Engineer approved Manufacturer’s Certificate of Source Testing as specified in the Technical Sections.
    3. Draft operations and maintenance manuals, as specified in Section 01782 - Operation and Maintenance Manuals as specified in the Technical Sections.

B. Transport products by methods that avoid product damage.

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

1.04 DELIVERY AND HANDLING

A. Handle equipment 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 equipment.

E. 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.
    a. Protect parts subject to deterioration, such as ferrous metal items and electrical components with appropriate lubricants, desiccants, or hermetic sealing.
3. With Owner's written request for advanced delivery of spare parts, maintenance products, and special tools.
    a. Deliver requested items and deduct them from the inventory list.
    b. Provide transmittal documentation.
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.
        4) Store smaller items in spare parts box:
    d. Weight: Less than 50 pounds.
    e. Size: Less than 24 inches wide by 18 inches high by 36 inches long.
    f. Clearly labeled:
        1) Equipment tag number.
        2) Equipment manufacturer.
        3) Subassembly component, if appropriate.
        4) Spare parts and special tools box:
    g. Box material: Waterproof, corrosion resistant.
    h. Hinged cover:
        1) Locking hasp.
    i. Spare parts inventory list taped to underside of cover.
    j. Clearly labeled:
        1) “Spare Parts and/or Special Tools”.
        2) Equipment tag number.
        3) Equipment manufacturer.
        4) Subassembly component, if appropriate.

1.05 STORAGE

A. Storage of equipment to be in accordance with the manufacturer’s instructions.
    1. Including connection of motor heaters, lubrication, manually rotating shafts, etc.
    2. Contractor shall furnish a copy of the manufacturer’s instructions for storage to the Engineer prior to storage of equipment and materials.

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

C. Furnish covered, weather-protected storage structures providing a clean, dry, noncorrosive environment for mechanical equipment, valves, architectural items, electrical and instrumentation equipment and special equipment to be incorporated into this project.

D. Store products with seals and legible labels intact.

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

F. 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.

G. 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.

H. Store moisture sensitive products in watertight enclosures.

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

J. Provide an equipment log and stored products log with monthly pay applications.
   1. Include: Storage location, equipment or product identification, date stored, date of inspection/maintenance, date removed from storage, copy of manufacturer’s recommended storage guidelines, description of inspection/maintenance activities performed, and signature of party performing inspection/maintenance.

K. 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.

L. Payment will not be made for equipment 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.

2.04 SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. Provide spare parts and maintenance products as required by Technical Sections.
   1. Submit completed Attachment A - Spare Parts, Maintenance Products, and Special Tools Inventory List.

B. Provide one set of special tools required to install or service the equipment.

C. Box, tag, and clearly mark items.

D. Contractor is responsible for spare parts, maintenance products, and special tools until acceptance by Owner.

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 equipment, product, or parts before acceptance of the project.

B. Update equipment log with monthly pay applications.
   1. Data includes as a minimum: Description of maintenance activities performed in accordance with the manufacturer’s recommendation and industry standards and signature of party performing maintenance.

END OF SECTION

ATTACHMENT A - SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS INVENTORY LIST

SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS INVENTORY LIST

Owner: _____ **Date:** _____

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

Project Name: _____

Inventory List				
Spec Number: _____		Spec Title _____		
Equipment Tag No.: _____		Equipment Manufacturer: _____		
Quantity	**Subassembly Component**	**Description**	**Manufacturer's Part Number**	**Storage Location**

SECTION 01757

DISINFECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Cleaning and disinfection requirements for new and existing facilities affected by the Work.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C651 - Disinfecting Water Mains.
   2. C652 - Disinfection of Water Storage Facilities.
   3. C653 - Disinfection of Water Treatment Plants.

B. U.S. Environmental Protection Agency (EPA):
   1. Method 524.2 Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry.
   2. Safe Drinking Water Act (SDWA).

1.03 SUBMITTALS

A. Submit disinfection test plan, which details procedure to be utilized to disinfect the facilities, including:
   1. Method and locations of disinfectant application.
   2. Locations of sampling points.
   3. Method of flushing and location of flushing ports (as appropriate for method of chlorination).
   4. Method of dechlorination (as appropriate for method of chlorination).
   5. Disposal location for chlorinated water (as appropriate for method of chlorination).

B. Submit disinfection reports and include the following:
   1. Date issued.
   2. Project name and location.
   3. Treatment subcontractor’s name, address, and phone number.
   4. Type and form of disinfectant used.
   5. Time and date of disinfectant injection start.
   6. Time and date of disinfectant injection completion.
   7. Test locations.
   8. Initial and 24-hour disinfectant residuals in milligrams per liter for each outlet tested.
   9. Time and date of flushing start.
   10. Time and date of flushing completion.
   11. Disinfectant residual after flushing in milligrams per liter for each outlet tested.

C. Submit bacteriological reports and include the following:
   1. Date issued.
   2. Project name and location.
   3. Laboratory name, certification number, address, and phone number.
   4. Time and date of water sample collection.
   5. Name of person collecting samples.
   6. Test locations.
   7. Time and date of laboratory test start.
   8. Coliform bacteria test results for each outlet tested.
   9. Certification that water conforms or fails to conform to bacterial standards of SDWA.
   10. Bacteriologist's signature and bacteriological laboratory's evidence of certification.

D. Submit required permits, including, but not limited to, permit clearance.
   1. Coordinate with Owner and Engineer to obtain any necessary signatures.

1.04 QUALITY ASSURANCE

A. Bacteriological and physical chemistry laboratory: Certified by state in which Project is located.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Protect chlorine and bacteriological samples against damage and contamination.

B. Maintain caution labels on hazardous materials.

C. Maintain storage room dry and with temperatures as uniform as possible between 60 degrees Fahrenheit and 80 degrees Fahrenheit.

1.06 PROTECTION

A. Provide necessary signs, barricades, and notices to prevent persons from accidentally consuming water or disturbing system being treated.

PART 2 PRODUCTS

2.01 MATERIALS

A. Disinfectant: Free chlorine in liquid, powder, tablet, or gas form in accordance with AWWA C653.

B. Dechlorination agent: Sulfur dioxide, sodium bisulfate, sodium sulfite, or sodium thiosulfate in accordance with AWWA C655.

PART 3 EXECUTION

3.01 DISINFECTION OF WATER TREATMENT PLANTS

A. Perform disinfection of water treatment plants in accordance with AWWA C653 and as specified in this Section.

B. Complete hydrostatic/leakage tests prior to disinfection.

C. Clean newly constructed and/or modified facilities, including filters and conveyance facilities, such as pipes and channels at the plant, in accordance with AWWA C653 and the following:
   1. Remove debris and material not associated with the structure or process prior to disinfection.
   2. Clean wall, floor, ceiling, and attached surfaces by use of high-pressure water jet, sweeping, scrubbing, or equally effective means.
   3. Remove water, paint flakes, sediment, dirt, and foreign material accumulated during cleaning.
   4. Remove by flushing or other means, soil and debris from water pipes and channels in accordance with AWWA C651.
   5. Protect surfaces from adverse environmental exposure between the preliminary cleaning and the disinfection stages.

D. Prior to chlorination, clean newly constructed and/or modified facilities to be disinfected in accordance with AWWA C651, C652, or C653, as applicable.

E. Provide necessary blind flanges, hoses, sample taps, or any other appurtenances that may be required to clean and disinfect the piping and wetted surfaces.

F. System treatment:
   1. Start disinfection when conditions are satisfactory.
   2. Perform disinfection of water lines and structures in accordance with AWWA C651, C652, and C653, and as specified in this Section.
   3. Starting at outlet closest to water source, bleed water from each outlet until water produces odor of disinfectant. Repeat process at each outlet throughout system.
   4. Test for disinfectant residual at each of following locations and other locations in accordance with submitted disinfection test plan:
      a. Ends of piping runs.
      b. Remote outlets.
      c. Tanks.
      d. At least 2 outlets on each building floor where directed.
      e. Drain lines.
      f. Filters and effluent channels and piping.
   5. Maintain disinfectant in system for appropriate 6-hour or 24-hour interval in accordance with AWWA C652.
   6. When disinfectant residual is less than 10 milligrams per liter after 24 hours, repeat system treatment.

3.02 DISINFECTION OF WATER MAINS

A. Perform disinfection in accordance with AWWA C651 and as specified in this Section.

B. Cleaning:
   1. Remove, by flushing or other means, soil and debris from the water tanks in accordance with AWWA C652 prior to chlorination.

C. Inspection:
   1. Verify that water system is completed and cleaned of soil and debris prior to chlorination.

3.03 REPAIRS OR CONNECTIONS TO EXISTING LINES

A. Perform disinfection in accordance with AWWA C651 and as specified in this Section.

B. Clean and sterilize the interior surfaces of new piping, fittings, equipment, and appurtenances to be installed in an existing potable water system or connected to an existing system.

C. Clean and sterilize the existing pipe or facilities for a minimum distance of 3 pipe diameters back from the ends of the pipe. Plug the ends of the line when work is not being performed on the pipe.

D. Perform sterilization by swabbing each item with a concentrated chlorine solution.
   1. Each piece is to be disinfected prior to being assembled for installation in the existing pipe.
   2. Disinfect each piece just prior to assembly to help prevent recontamination.
   3. Plug the ends of the assembly until a new item is to be added to the assembly.
   4. Store disinfected materials on blocks to prevent contact with the ground.

3.04 FLUSHING

A. Remove disinfection water from the facilities as appropriate for the type of disinfectant and method used for disinfection.

B. Flush facilities with potable water containing no more disinfectant residual than the active distribution system or 1.0 milligrams per liter, whichever is greater (as appropriate for method of chlorination).

C. Continue flushing until water at designated flushing ports contains disinfectant residual equal to concentration specified above.

3.05 DISPOSAL OF CHLORINATED WATER

A. Dispose in accordance with AWWA C655 and as specified in this Section.

B. Dispose of chlorinated water in accordance with the submitted disinfection test plan and applicable requirements of federal, state, county, and city having jurisdiction over disposal of hazardous wastes in location of the Project and disposal site.

C. Chlorinated water may only be disposed of in a sanitary sewer system with the written permission of the Owner. If allowed, discharge the chlorinated water at a low rate so it does not surcharge the sewer line.

3.06 BACTERIOLOGICAL TEST

A. Instruct bacteriological laboratory to collect water samples no sooner than 24 hours after start of disinfection of each facility.

B. A minimum of 24 hours after flushing system and within 24 hours before the water main is placed in service, collect bacteriological quality samples at each of following locations and other locations in accordance with the submitted disinfection test plan and Standard Methods for the Examination of Water and Wastewater:
   1. Where water enters system.
   2. Inlet piping.
   3. Ends of piping runs.
   4. Drain lines.
   5. Remote outlets.
   6. Tanks.
   7. At least 2 outlets on each building floor.

C. Analyze water samples in accordance with Standard Methods for Examination of Water and Wastewater.

D. When bacteriological test proves water quality to be unacceptable, repeat disinfection treatment process until water meets quality standards for disinfection.

END OF SECTION

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 Substantial 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. Clean permanent filters and replace disposable filters when heating, ventilation, and air conditioning units were operated during construction.

K. Clean ducts, blowers, and coils when units were operated without filters during construction.

L. Clean light fixtures and replace burned-out or dim lamps.

M. 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 Substantial 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. Completed contract requirements for commissioning and process start-up.

B. Submit the following Closeout Submittals before final completion of the Work and at least 7 days prior to submitting Application for Final Payment:
   1. Punch list of items have been completed and Engineer and Owner are satisfied that all deficiencies are corrected.
   2. Evidence of Payment and Release of Liens or Stop Payment Notices as outlined in Conditions of the Contract.
   3. Release of claims as outlined in Conditions of the Contract.
   4. Submit certification of insurance for products and completed operations, as specified in the General Conditions.
   5. Final statement of accounting.
   6. Submit Final (As-Built) Schedule as specified in Section 01321 - Schedules and Reports.

1.07 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.

1.08 MAINTENANCE SERVICE

A. Maintenance service as specified in technical specifications.

1.09 SUBSTANTIAL COMPLETION

A. Obtain Certificate of Substantial Completion.

1.10 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.

1.11 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.

1.12 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

2.01 SPARE PARTS

A. Owner may request advanced delivery of spare parts, maintenance products, and special tools.
   1. Deduct the delivered items from the inventory list and provide transmittal documentation.

B. Prior to Substantial Completion, arrange to deliver spare parts, maintenance products, and special tools to Owner at a location on site chosen by the Owner.
   1. Provide itemized list of spare parts and special tools that matches the identification tag attached to each item.
   2. Owner and Engineer will review the inventory and the itemized list to confirm it is complete and in good condition prior to signing for acceptance.

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 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 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 and indicated on the Drawings.
   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).

PART 2 PRODUCTS

2.01 DESIGN CRITERIA - SITE INFORMATION

A. Site name: Shell Creek WTP.
   1. Street address: As specified in Section 01110 - Summary of Work.
   2. Site elevation (approximate):
      a. 18 feet above mean sea level.
   3. Groundwater elevation:
      a. For design of buried and partially buried construction:
         1) Assume groundwater level approximately 1 feet below finished 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. 2023 Florida Energy Conservation Code: Climate Zone 2A.
   2. ASHRAE site climatic data location: Punta Gorda Airport, WMO 722034.
   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

Condition	Warm-humid
Hottest Month DB Range:	15.7 degrees Fahrenheit.
Winter:	At or above this temperature 99.6 percent of the time: 38.7 degrees Fahrenheit dry-bulb.
Summer:	At or above this temperature 0.4 percent of the time: 93.4 degrees Fahrenheit dry-bulb.

   4. Rainfall intensity:
      a. Reference: 2023 Florida Plumbing Code:
         1) 4.5 inches per hour (100-year, 1-hour rainfall).

2.04 DESIGN CRITERIA - STRUCTURAL

A. General:
   1. Criteria for structural design of:
      a. Equipment exposed to outdoor environments.
      b. Equipment supports and bracing, and anchorage of such items to building and non-building structures.
      c. Structures provided for the Work through Delegated Design.
      d. 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 in “Design Criteria” notes on the Drawings for each structure.

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. 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) 159 miles per hour (33 feet, 3 second gust).
      b. Exposure category: C.
      c. Topographic factor, Kzt: 1.0.

D. 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.

E. 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 the equipment manufacturer.
   3. Design for loads indicated in the Technical Sections for equipment and appurtenances.

F. Serviceability considerations: ASCE 7-16, Attachment **[ ]:**
   1. Deflection, unless otherwise indicated on the Drawings, or specified:
      a. Beam deflection as fraction of span:
         1) Walkways and platforms: Total load = L/240; live load = L/360.
         2) Equipment supports: L/450.

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.

3.02 DELEGATED DESIGN

A. 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 wind design calculations will be waived for the following:
      a. Equipment and components located inside structures, and away from the effects of wind loads.

B. 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) 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 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 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: f'c = 4,500 pounds per square inch.
    2) Existing concrete in place prior to this Work: f'c = 4,000 pounds per square inch.
c. Anchors in masonry: Design based on minimum specified compressive strength, f'm, as follows, unless otherwise indicated on the Drawings for the Work area:
    1) Existing concrete masonry in place prior to this Work: f'm = 1,500 pounds per square inch.

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 03055

ADHESIVE-BONDED REINFORCING BARS AND ALL THREAD RODS IN CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 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. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

G. 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. 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.
   4. Evidence of current listing under NSF-61 for use in contact with potable water.

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.

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 of ACI 355.4 and 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.

D. For locations where adhesive will be in direct contact with potable water in the finished work, provide documentation of testing and listing under NSF-61. Testing shall be by a nationally recognized agency acceptable to 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-3G.

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 03301 - Concrete Work.

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 the 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 the 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 the 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 the 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 the 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 the 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 the 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 the 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 the 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.

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.

B. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

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.
   3. Submit documentation confirming listing under NSF-61.

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.
   2. Listed under NSF-61 for use in direct contact with potable water.

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. 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 3, Class C.
   1. Manufacturers: One of the following, or equal:
      a. Sika Chemical Corp., Sikadur 31 Hi-Mod Gel.
   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 100 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 03301

CONCRETE WORK

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Concrete formwork, concrete accessories, concrete reinforcement, batching and mixing of concrete to be cast-in-place, concrete placement and curing, and tooled concrete finishes.

1.02 REFERENCES

A. American Concrete Institute (ACI):
   1. CODE-318 - Building Code Requirements for Structural Concrete and Commentary.
   2. MNL-66 - ACI Detailing Manual.
   3. PRC-305 - Specification for Hot Weather Concreting.
   4. PRC-306 - Standard Specification for Cold Weather Concreting.
   5. SPEC-117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
   6. SPEC-301 - Specifications for Concrete Construction.

B. ASTM International (ASTM):
   1. A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   2. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
   3. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   4. C33 - Standard Specification for Concrete Aggregates.
   5. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   6. C94 - Standard Specification for Ready-Mixed Concrete.
   7. C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
   8. C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete.
   9. C150 - Standard Specification for Portland Cement.
   10. C156 - Standard Test Method for Water Loss from a Mortar Specimen Through Liquid Membrane-Forming Curing Compounds for Concrete.
   11. C171 - Standard Specification for Sheet Materials for Curing Concrete.
   12. C172 - Standard Practice for Sampling Freshly Mixed Concrete.
   13. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
   14. C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
   15. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   16. C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
   17. C494 - Standard Specification for Chemical Admixtures for Concrete.
   18. C595 - Standard Specification for Blended Hydraulic Cements.
   19. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

20. C989 - Standard Specification for Slag Cement for Use in Concrete and Mortars.
21. C1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
22. C1218 - Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
23. C1260 - Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
24. C1293 - Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
25. C1567 - Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
26. C1778 - Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete.
27. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
28. D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
29. D2103 - Standard Specification for Polyethylene Film and Sheeting.

C. 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. Alkali load: Amount of alkalies contributed by the cement in a concrete mixture, expressed in lb/yd^3, and calculated by multiplying the cement content of the concrete in lb/yd^3 by the alkali content of the Portland cement; or the Portland cement portion of a blended cement, divided by 100.
2. Average daily temperature: The average of the highest and lowest temperatures during a 24-hour period from midnight to midnight.
3. Cementitious materials: Portland cement or blended cement and supplementary cementitious materials.
4. Green concrete: Concrete whose current compressive strength is less than 100 percent of the minimum specified compressive strength, f'c.
5. Hand mixed concrete: Concrete mixed at or near the point of placement using shovels, hoes, or other similar manually operated tools.
6. Hot weather: A period when project conditions such as low humidity, high temperature, solar radiation, and high winds promote rapid drying of freshly placed concrete.
7. Neat cement grout: Grout made from a mixture of Portland cement and water.
8. Supplementary cementitious material: Inorganic material such as fly ash, natural pozzolans, silica fume, or slag cement that reacts pozzolanically or hydraulically.

1.04 SUBMITTALS

A. General:
   1. Submittal as specified in Section 01330 - Submittal Procedures unless modified in this Section.

B. Product data:
   1. Formwork:
      a. Formwork facing materials. Data on facing materials for concrete exposed to view in the finished work, if different from that specified in this Section.
      b. Form release agent. Manufacturer's name and catalog data, including materials safety datasheet and documentation of suitability for use in contact with potable water.
   2. Joint materials:
      a. Preformed expansion joint material: Manufacturer's name and catalog data with documentation of conformance to materials standards specified for each type and thickness of material.
   3. Reinforcement:
      a. Mill certificates for each heat of steel provided.
      b. Reinforcement placement drawings:
         1) Show anchor bolt locations based on anchor bolt templates for approved equipment.
      c. Concrete bar supports:
         1) Precast concrete bar supports ("dobies"): Manufacturer's product data indicating compression strength of concrete supports and material used for tie wires.
         2) Wire chairs and slab bolsters: Manufacturer's product data.
   4. Concrete materials:
      a. Cement:
         1) Mill certificate in accordance with ASTM C150 or ASTM C595. Include "Type" and results of testing for alkali content measured as equivalent alkalies.
      b. Supplementary cementitious materials:
         1) Fly Ash: Identify source and provide testing results documenting compliance with ASTM C618 and any additional requirements of this Section.
         2) Slag cement: Identify source and provide testing results documenting compliance with ASTM C989 and any additional requirements of this Section.
      c. Aggregates:
         1) Type, pit or quarry location, and producer's name.
         2) Commercial laboratory test reports for samples of each aggregate proposed for use. Tests shall have been made not more than 24 months prior to the date of the Submittal.
            a) Fine aggregate: Gradation analysis, specific gravity, reactivity, and reports of deleterious materials to document compliance with ASTM C33.
            b) Coarse aggregate: Gradation analysis, specific gravity, soundness, reactivity, and reports of deleterious materials to document compliance with ASTM C33 for each size used.

d. Admixtures:
    1) Manufacturer's catalog cuts and product data indicating compliance with the standards specified.

5. Concrete mixes: Submit full details, including:
    a. Mix proportions measured by both weight and volume and concrete properties for each class of concrete proposed for use.
        1) Information on correction of batching for varying moisture contents of fine aggregate.
    b. Data to establish the average compressive strength:
        1) If established by field test records, submit:
            a) Product and test data for the materials actually used in the mix.
            b) Actual mix proportions used in the mix producing the record.
            c) Field test data for slump, air content, and 28-day compressive strength. Include not less than 15 tests in accordance with ACI SPEC-301.
        2) If established by testing of trial batches, submit:
            a) Confirmation that the materials and proportions used in the trial batches are those that will be provided for the mix.
            b) Mix test data for slump, air content, and 28-day compressive strength.
        3) For either method, include calculations for:
            a) Standard deviation: Calculated in accordance with ACI SPEC-301 requirements.
            b) Required average compression strength (f'cr) using the standard deviation calculated in accordance with ACI SPEC-301 requirements.
            c) Statement demonstrating that the average compression strength from field test records or from trial batch testing for each mix ($f'c_{avg}$) exceeds the required average compressive strength (f'cr) for that mix.
    c. Data to establish alkali load:
        1) Determine and include the alkali load of the proposed mix.
    d. Data to establish chloride content:
        1) 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 B of this Section. Test shall be performed in accordance with ASTM C1218 at age between 28 and 42 days after mixing.
6. Concrete finishing and curing materials:
    a. Manufacturer's name and product datasheets.

C. Shop Drawings:
    1. Reinforcement:
        a. Submit Drawings showing bending and placement of reinforcement.
            1) Drawings shall be in accordance with ACI MNL-66.
            2) Clearly show placement, shapes, and dimensions of each bar listed in the bill of materials, including additional reinforcement at corners and openings required by details in the Contract Documents.
            3) Show splice locations and bar lengths reflecting Contractor's intended placement sequence.

D. Samples:
   1. Form ties: If requested by the Engineer.
   2. Concrete bar supports: If requested by the Engineer, provide samples of:
      a. Precast concrete bar supports (“dobies”).
      b. Wire chairs and slab bolsters.

E. Procedures:
   1. Contractor’s plans for production, placement, finishing, curing, protection, and temperature monitoring of concrete during the following environmental conditions:
      a. Hot weather.

F. Project record documents:
   1. For the following items, note location of concrete in the structure, and include tag numbers of associated cylinders for compression strength tests.
   2. Concrete delivery tickets. Submit copies of concrete delivery tickets within 24 hours after delivery.
   3. Field test reports: Results of field-testing for slump, temperature, unit weight, and air entrainment.
   4. Testing laboratory reports for compression strength.

G. Notifications:
   1. Modifications to concrete mixes:
      a. Submit notification of any adjustments to mixture proportions and any changes in materials made during the course of the Work for Engineer’s review.
      b. Include details of the changes and supporting documentation.
   2. Joint locations:
      a. Where joint locations other than those indicated on the Drawings are requested, submit proposed locations for Engineer’s review.
      b. Provide Drawings showing proposed joint locations with joint types labeled and joint details referenced.
   3. Reinforcement placement: Where necessary to move reinforcement beyond the specified placing tolerances to avoid interference, submit the proposed arrangement for Engineer’s review.
   4. Concrete placements: Submit notification of readiness for each concrete placement at least 24 hours in advance.
   5. Concrete repairs:
      a. Where concrete surfaces or sections exhibit defects after removal of forms, submit description of existing conditions and of proposed repair procedures and materials.
      b. Include photos of existing conditions with Submittal.

1.05 QUALITY ASSURANCE

A. Tolerances on concrete construction: In accordance with ACI SPEC-117 unless more stringent requirements are specified in the Contract Documents.

B. Concrete mixtures:
   1. Ensure that concrete produced has the specified characteristics in the freshly mixed state, and that those are maintained to during transport and delivery and to the point of final placement.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle concrete materials in manner as to prevent damage and inclusion of foreign substances.

B. Deliver reinforcing steel bundled and tagged with identifying tags marked in a legible manner with waterproof markings showing the same designations as indicated on the submitted Shop Drawings.
   1. Store off the ground and protect from moisture, dirt, oil, and other injurious contaminants.

C. Protect concrete accessories from weather and direct exposure to sunlight before installation.

1.07 PROJECT CONDITIONS

A. Environmental requirements:
   1. Hot weather concreting: Construct in accordance with ACI PRC-305 during conditions when the ambient air temperature is above 90 degrees Fahrenheit.
   2. Conditions that promote rapid drying of freshly placed concrete, such as low humidity, high temperature, and wind: Take corrective action to minimize loss of water from the concrete.

1.08 SEQUENCING AND SCHEDULING

A. Schedule placing of concrete in such a manner that completes any single placing operation to a construction or expansion joint as indicated on the Drawings or accepted by the Engineer in advance of the placement.

PART 2 PRODUCTS

2.01 FORMWORK

A. Forms:
   1. Design and performance requirements:
      a. Design and performance of formwork shall be the responsibility of the Contractor, subject to the requirements of the Contract Documents.
      b. Design, construct, and brace formwork to:
         1) Carry all loads applied or transmitted, including the pressure resulting from placement and vibration of plastic concrete.
         2) Remain tight to prevent loss of mortar.
         3) Maintain specified tolerances and provide finished surfaces as specified.

c. Maximum deflection of facing materials and supporting members on surfaces exposed to view in the finished work: 0.0042 times the clear span (span/240).
d. Maximum deviation from alignment (horizontal or vertical): In accordance with ACI SPEC-117.

2. Form facing materials:
   a. Surfaces exposed to view in the finished work:
      1) Facing materials shall produce a smooth, uniform texture on the concrete.
      2) Do not use materials with raised grain, tears, worn edges, patches, dents, or other similar defects.
      3) Acceptable materials: Plywood with “C” or better face, plastic-faced plywood, tempered concrete form grade hardboard, or steel.
   b. Surfaces not exposed to view in the finished work:
      1) Special form facing material not required.
3. Forms for chamfers and keyways:
   a. Uniform steel, plastic, or lumber section of dimensions shown or specified.
   b. Provide adequate stiffness and support to maintain a true line at the concrete surface.
   c. Treated to eliminate bond with the concrete if required to produce a smooth, uniform, and undamaged finish upon removal.

B. Form ties:
1. General:
   a. Provide form ties fabricated by recognized manufacturer of concrete forming equipment and suitable for use with the forming system selected.
   b. Provide ties that accurately tie, lock, and spread forms:
      1) Do not use wire ties or wood spreaders.
   c. Provide form ties manufactured such that, when forms are removed, the tie leaves no metal or other material within 1-1/2 inches of the surface of the concrete.
   d. Do not allow tie holes through forms for ties to leak during concrete placement.
2. Cone snap ties: Tie with removable plastic cone leaving a tapered depression having a minimum diameter of 1 inch at the surface of the concrete and a depth of 1-1/2 inches below the surface.

C. Dry-pack mortar for filling cone snap tie holes:
1. Proportioned mix of 1 part of Portland cement to 1 part plaster sand with potable water added to provide a stiff consistency that can be driven into holes and properly compacted.
2. For repairs in concrete exposed to view in the finished work, mix repair mortar using the same cement and sand as that used for the concrete being patched.
   a. Mix a trial batch and confirm color compatibility with the surrounding material.
   b. Adjust color to match that of the surrounding concrete by adding white Portland cement if necessary.
3. Admixtures or additives to mortar are not permitted.

D. Form release agent: Commercially manufactured, non-staining formwork release agent that will prevent absorption of water by the formwork and will prevent bond between the formwork and the concrete.
    1. Form release agent to comply with local air quality management regulations.

2.02 JOINT MATERIALS

A. Synthetic sponge rubber expansion joint material:
    1. Elastic sponge rubber compound in accordance with ASTM D1752, Type I.
    2. Concrete-gray color unless otherwise noted.
    3. Thickness: As indicated on the Drawings.
    4. Manufacturers: One of the following or equal:
        a. Williams Products Inc., Everlastic 1300.
        b. WR Meadows, Seal Tight Sponge Rubber Expansion Joint.

B. Bituminous fiber expansion joint material:
    1. Thickness: To match joint width indicated on the Drawings.
    2. Asphalt-impregnated fiberboard in accordance with ASTM D1751.
        a. Manufacturers: One of the following or equal:
            1) Durajoint.
            2) W.R. Meadows, SealTight Fibre Expansion Joint.

C. Sealants and caulking: As specified in Section 07900 - Joint Sealants.

2.03 REINFORCEMENT

A. Materials:
    1. Deformed bars: In accordance with ASTM A615 Grade 60**.**
    2. Welded wire fabric: Sheets of plain wire in accordance with ASTM A1064.
    3. Bar supports:
        a. Over ground or “mud mat”:
            1) Precast concrete blocks with cast-in annealed steel tie wires, 16 gauge or heavier.
                a) Compressive strength of blocks equal to or exceeding the compressive strength of the surrounding concrete.
            2) Height as required for minimum 3 inches of clear concrete cover below reinforcement.
            3) Minimum block “footprint” of 4 square inches, or as required to supporting load from reinforcement while maintaining the required concrete cover.
        b. Wire supports: Class 3, bright basic wire with galvanized coating in accordance with CRSI Manual of Standard Practice.
    4. Tie wire: Annealed steel.

B. Fabrication:
    1. Cut and cold-bend bars in accordance with provisions of ACI MNL-66 and ACI CODE-318.
    2. Fabricate reinforcement to the tolerances in accordance with ACI SPEC-117.
    3. Provide bars free from defects and kinks and from bends not indicated on the Drawings.

2.04 SOURCE QUALITY CONTROL

A. Submit documentation that the proposed concrete mixes will conform to the requirements of this Section and will produce concrete having the required proportions and properties specified.
   1. Do not place concrete until the design for that mix and the results of any trial batch testing have been accepted by the Engineer.
   2. If the Engineer requires changes to the mix design, modify mixes within limits set forth in this Section and submit new mix design for Engineer's review.

B. After acceptance, do not change mixes or mix proportions without prior acceptance by the Engineer.
   1. Exception: At all times, adjust batching of water to compensate for free moisture content of aggregates. Total water content in the mix shall not exceed that specified.

C. If there is change in source of cement or aggregate, or if there is a significant change in the characteristics or quality of any constituent material received from a source accepted to supply materials, submit new design mixes for each class of concrete affected.

D. Testing of materials and mixes before placement to demonstrate that they comply with the requirements of this Section shall be at the Contractor's expense.

2.05 CONCRETE MIXES

A. Constituent materials:
   1. Cement:
      a. Portland cement: In accordance with ASTM C150, Type I or II:
         1) Cement for finishes or repairs: Provide cement from same source and of same type as concrete to be finished.
   2. Blended hydraulic cement:
      a. In accordance with ASTM C595:
         1) Type IL (MS).
   3. Supplementary Cementitious Materials (SCM):
      a. Fly ash:
         1) In accordance with ASTM C618, Class F.
         2) Sampling and testing: In accordance with ASTM C311.
         3) Loss on ignition: Not to exceed 4 percent.
      b. Slag cement:
         1) Grade 80, 100, or 120 in accordance with ASTM C989, except as modified below:
            a) Fineness: Amount retained on a No. 325 sieve: 20 percent maximum.
            b) Total alkalies $Na_2O + 0.658\ K_2O$:
               (1) Minimum: 0.60 percent.
               (2) Maximum: 0.90 percent.

4. Aggregates:
    a. General:
        1) Provide normal weight concrete aggregates that are sound, uniformly graded, and free of deleterious material in excess of the amounts specified.
        2) Do not use aggregate made from recycled materials such as crushed and screened hydraulic-cement concrete, brick, or other construction waste.
        3) Obtain aggregate from source that is capable of providing uniform quality, moisture content, and grading during any single day's operations.
        4) Alkali-silica reactivity:
            a) Provide fine and coarse aggregate classified as aggregate-reactivity class of R0 in accordance with ASTM C1778 and 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.
    b. Fine aggregate:
        1) Provide fine aggregate consisting of clean, natural sand or of sand prepared from crushed stone or crushed gravel.
        2) In accordance with ASTM C33.
    c. Coarse aggregate:
        1) Provide coarse aggregate consisting of gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter, or other foreign substances; and in accordance with ASTM C33, Class 4S.
        2) Grading: Unless otherwise specified or accepted in writing by the Engineer, provide the following:
            a) Aggregate for Class Class A, C, and PM Concrete: ASTM C33, Size Number 57.
            b) Aggregate for Class CE Concrete: ASTM C33, Size Number 8.
            c) Where a combination of 2 or more sizes of coarse aggregate are used, the gradation of the blend shall conform to the grading requirements in accordance with ASTM C33 for the size number specified.
5. Water:
    a. Water for concrete mixes, for washing aggregate, and for curing concrete: Potable water, clean and free from oil and deleterious amounts of alkali, acid, organic matter, or other substances.
    b. Do not exceed the optional chemical limits of ASTM C1602.
6. Admixtures:
    a. General:
        1) Do not use admixtures, except those specified, unless written authorization has been obtained from the Engineer.
        2) Admixtures shall be compatible with concrete and other admixtures. Admixtures (other than fly ash) shall be the products of a single manufacturer to ensure compatibility.
        3) Do not use admixtures containing chlorides in excess of 0.5 percent by weight of cement when calculated as chloride ion.
    b. Air entraining admixture: In accordance with ASTM C260.

c. Water reducing admixture:
    1) In accordance with ASTM C494, Type A or Type D.
    2) Not containing air-entraining agents.
d. High range water reducing admixtures/plasticizing admixtures:
    1) High-range water reducing admixtures: In accordance with ASTM C494, Type F.
    2) Use shall produce non-segregating concrete mixture with little bleeding that remains in a plastic state for not less than 2 hours.

B. Mix design and proportioning:
    1. Proportion mixes to provide compression strength, workability, and durability as specified in this Section.
    2. Submit documentation that the proposed mixes will conform to the requirements of this Section and will produce concrete having the required properties.
    3. Compression strength:
        a. Proportion each concrete mix to provide the required average compressive strength (f'cr) determined in accordance with the provisions of ACI SPEC-301.
        b. Determine required average compressive strength (f'cr) for each class of concrete using the specified compressive strength of the mix, f'c, and the standard deviation determined in accordance with ACI SPEC-301.
            1) Establish the standard deviation in accordance with ACI SPEC-301 and based on either field test records or based on trial batches.
            2) Documentation of standard deviation based on field test records:
                a) Calculate standard deviation in accordance with ACI SPEC-301 procedures using test records that:
                    (1) Represent materials, quality control procedures, and conditions similar to those expected for this Work.
                    (2) Do not include provisions for materials and proportions that are more restrictive than the materials proposed for use in this Work.
                    (3) Represent a mix proportioned to provide a specified compressive strength (f'c) within 1,000 pounds per square inch of that specified for the corresponding mix in this Section.
            3) Documentation of standard deviation based on trial batches plus empirical code requirements:
                a) When records including at least 15 consecutive tests that span a period of at least 45 calendar days are not available, determine required average compressive strength (f'cr) from Table A:

Table A: Required Average Compressive Strength

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

4. Workability:
    a. Provide concrete with workability and consistency that 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 the surface.
5. Cement content:
    a. Cementitious materials content: Conform to values specified in Table B of this Section.
    b. Ratio of water to cementitious materials:
        1) Conform to values specified in Table B of this Section.
        2) Total water, including that from moisture content of aggregates and admixtures, shall not exceed that specified in Table B of this Section.
6. Supplementary Cementitious Materials:
    a. Fly ash:
        1) Maximum of 20 percent by weight of total weight of cementitious materials (cement plus fly ash).
        2) Other supplemental cementitious materials shall not be used without prior acceptance by the Engineer.
    a. Slag cement:
        1) Minimum slag cement content: 20 percent of the total weight of cementitious materials.
        2) Maximum slag cement content: 30percent of the total weight of cementitious materials.
7. Aggregates:
    a. Ratio of coarse aggregate to fine aggregate: Not less than 1.0 or more than 2.0 for all concrete classes, with exception of Class CE.
8. Admixtures:
    a. Use in accordance with manufacturer’s instructions.
    b. Air entraining admixture:
        1) Provide concrete with entrained air content indicated in Table B of this Section and consisting of evenly dispersed air bubbles.
    c. Water reducing admixture:
        1) Required in all concrete mixes.
        2) No decrease in cementitious materials content is permitted as a result of use of water-reducing admixture.
    d. High range water reducing admixture/plasticizing admixture:
        1) Proportion for a slump of 2 to 4 inches before the admixture is added, and a maximum slump of 8 inches after the admixture is added.
9. Concrete mix design requirements by class:
    a. Provide concrete mixes for each “class” specified in this Section and indicated in Table B of this Section.
    b. Use each class at the locations specified in the following paragraphs or indicated on the Drawings.
        1) “Class A” concrete: General use. Use at all locations unless otherwise indicated on the Drawings or listed in the following paragraphs.
        2) “Class C” concrete: May be used as fill for unauthorized excavation, for thrust blocks and ground anchors for piping, for bedding of pipe, and elsewhere as indicated on the Drawings.
        3) “Class CE” concrete: Use for electrical conduit and duct bank encasements.

4) Class PM concrete: Use for concrete pavement, cart paths, curbs, gutters, and sidewalks.

c. Pumped concrete: Provide a separate mix design and substantiation testing for each “class” to be placed by pumping.

Table B: Concrete Classes

Concrete Class	Minimum Specified Compressive Strength at 28 days, f'c[1] (pounds per square inch)	Ratio of water to cementitious materials[2,3] (minimum - maximum)	Cementitious Materials Content[3] (pounds per cubic yard of concrete by weight)	Cement Type	Maximum Chloride Content (percent by weight of cement)	Maximum Coarse Aggregate Size[4]	Air Entrainment (percent) (N/R: not required)	Admixtures required[5]	Slump Range (inches)
A	4,500	0.40 to 0.45	535 to 575	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	0.15	57	6±1.5	AEA WRA	2 to 4
C	2,500	0.62 max.	423 min.	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	No limit	57	6±1.5	AEA WRA	3 to 6
CE	2,500	0.62 max.	423 min.	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	No limit	8	5±1.5	AEA WRA	3 to 6
PM	5,000	0.40	535 to 575	ASTM C150, Type II(MH) or ASTM C595, Type IL(<15)(MS) or IP(20)(MS)	0.15	57	5+1.5	AEA WRA	3 to 6

Notes:

(1) At locations where concrete will not be subjected to load from other elements of the structure or from Contractor’s placing operations, maximum time period for achievement of specified compressive strength may be extended to 56 days when accepted by the Contractor’s Engineer.
(2) W/C Ratio = Ratio of water to cementitious materials (Portland cement plus supplemental cementitious material) 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.
(3) Provide mix within the range of W/C ratio and cementitious materials content indicated.
(4) Size number in ASTM C33, Table 2.
(5) Admixtures are designated as follows:

Table B: Concrete Classes									
Concrete Class	Minimum Specified Compressive Strength at 28 days, f'c[1] (pounds per square inch)	Ratio of water to cementitious materials[2,3] (minimum - maximum)	Cementitious Materials Content[3] (pounds per cubic yard of concrete by weight)	Cement Type	Maximum Chloride Content (percent by weight of cement)	Maximum Coarse Aggregate Size[4]	Air Entrainment (percent) (N/R: not required)	Admixtures required[5]	Slump Range (inches)
AEA: Air entraining admixture. HRWR: High-range water reducing admixture. WRA: Water reducing admixture.									

2.06 CONCRETE BATCHING AND MIXING EQUIPMENT

A. Provide equipment and facilities for accurate measurement and control of materials.
   1. At all times, maintain proportions of concrete mix within specified limits.
   2. Control and adjust batch weights to secure maximum yield.

B. Measuring or weighing equipment:
   1. Furnish apparatus for weighing aggregates and cementitious materials that is suitably designed and constructed for this purpose.
   2. Devices shall bear the current and valid seal of the Sealer of Weights and Measures in the Authority having jurisdiction.
   3. Furnish devices capable of providing successive quantities of individual materials measured to within 2 percent of desired amount of that material.

C. Mixing equipment:
   1. Mixes shall be ready-mix or transit-mixed concrete in accordance with ASTM C94.
   2. Provide equipment capable of combining aggregates, cementitious materials, water, and admixtures into a thoroughly mixed and uniform mass during the time periods specified, and capable of discharging the resulting mixture without segregation.
   3. Maintain mixing equipment in good working order. Operate at loads and speeds, and for periods of time recommended by the manufacturer or specified in this Section.

2.07 CONCRETE FINISHING AND CURING MATERIALS

A. Evaporation retardant:
   1. Manufacturers: One of the following or equal:
      a. Euclid Chemical Co., Eucobar.
      b. Master Builders Solutions/Sika, MasterKure ER 50.

B. Plastic membrane for curing:
   1. White polyethylene film in accordance with ASTM C171:
      a. Nominal thickness not less than 0.0040 inches when measured in accordance with ASTM D2103, and thickness at any point not less than 0.0030 inches.
      b. Loss of moisture: Not to exceed 0.055 grams per square centimeter of surface when tested in accordance with ASTM C156.

C. Sprayed membrane curing compound:
   1. In accordance with ASTM C309, Type 1D. Clear with fugitive dye.

PART 3 EXECUTION

3.01 GENERAL

A. Preparation:
   1. Use construction methods and sequences that allow time for concrete to reach adequate strength to prevent damage to or overstress of the concrete structure or its elements during construction.
   2. Locations of construction and expansion joints are indicated on the Drawings.
      a. Make no other joints, except as accepted in advance by the Engineer.
      b. Schedule placing of concrete to complete any single placing operation between designated joints.
      c. Schedule and sequence placements to allow adequate time for concrete to achieve adequate strength before subsequent placements and loads are applied to the structure.

B. Verification of conditions:
   1. Do not place concrete until:
      a. Forms have been thoroughly cleaned of dirt and debris, and form release agents have been applied.
      b. Forms have been thoroughly checked for alignment, level, strength, and accurate location of reinforcement, joint accessories, and mechanical and electrical inserts or other embedded items.
      c. Reinforcement is secure and properly fastened in its correct position.
      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 are aligned and secured, and loose form ties at construction joints have been retightened.
   2. Notify the Engineer in writing of readiness, not just intention, to place concrete in any portion of the work:
      a. Provide this notification in advance of operations, allowing such time as the Engineer deems necessary to make final observation of preparations at location of the concrete placement.
      b. Have forms, reinforcement, screeds, anchors, ties, embeds, and inserts in place before notifying Engineer of readiness for final observations.
   3. Do not place concrete until Engineer has completed final observations of conditions at the placement and has given acceptance to proceed.

3.02 FORMING

A. General:
   1. Do not use earth cuts as forms for vertical or sloped surfaces unless specifically required by or indicated on the Contract Documents.
   2. Joints: Locate joints as indicated on the Drawings:
      a. Submit joint locations other than or differing from those indicated on the Drawings for Engineer's review before construction.
   3. Chamfers:
      a. Permanently exposed outside corners: Provide 3/4-inch chamfer.
      b. Re-entrant corners:
         1) Chamfer not required.
         2) Corner may be left square.
      c. Edges of formed joints: Chamfer not required except where indicated on the Drawings.
   4. Level strips: Install level strips at top of wall concrete placements to maintain true line at horizontal construction joints.

B. Constructing and erecting formwork:
   1. Brace and anchor formwork to ensure vertical and lateral stability and to maintain finish tolerances when subjected to uplift pressures and lateral pressures from plastic concrete.
      a. Ensure that formwork is positioned, braced, and firmly held against previously placed concrete to maintain flush surfaces and to prevent loss or leaking of mortar at construction joints.
         1) At joints with flush surfaces exposed to view, lap contact surface of form a maximum of 1 inch over the previously placed concrete.
      b. Design and construct forms with sufficient strength and stiffness that deflections resulting from loading by plastic concrete will not exceed the surface tolerance limits specified.
      c. Set forming materials in an orderly and symmetrical arrangement, keeping the number of seams to a practical minimum.
      d. Form ties: Tie forms together using cone snap ties placed at not more than 2-foot centers vertically and horizontally.
      e. Construct formwork to permit easy removal without damage to formed surfaces.
      f. Provide temporary openings at the base of column and wall formwork to allow cleaning and inspection immediately before concrete placement.
      g. 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.
   2. Where forms are reused, clean surfaces of mortar, grout, and foreign materials before coating with form release agent and setting.
   3. Cover formwork surfaces with form release agent to prevent bond with the concrete:
      a. Do not allow form release agent to puddle in the forms.
      b. Do not allow form release agent to contact reinforcement, embeds, or previously placed concrete.
   4. Provide runways supported directly on the formwork for moving equipment and supplies during preparations for concreting:
      a. Do not rest such runways on reinforcement.

C. Embeds, joints, and accessories:
   1. Position pipes, sleeves, conduits, inserts, anchors, castings, and other embedded items in the forms, and anchor to formwork to prevent displacement.
   2. Fill voids in sleeves, pipes, inserts and anchor slots with readily removable material, and seal if required to prevent entry of mortar.
   3. For pipe or conduit runs, position embeds to allow at least 3 inches of clear concrete separation between parallel runs of pipes, conduits or any combination of these items with each other or with reinforcement.

D. Removing formwork:
   1. Remove forms after the specified time for curing and protection has been provided and when operations will not damage concrete.
   2. Immediately after forms are removed, carefully examine concrete surfaces.
      a. Report any irregularities in surfaces and finishes to the Engineer.
      b. Where surface repairs are needed, contact Engineer with description of conditions and description of repair procedures before proceeding with work.
   3. Immediately follow form removal with installation of specified curing materials and procedures.
   4. After forms are removed from wall and curing is complete, fill tie holes as follows:
      a. Remove form ties and cones from surfaces.
      b. Roughen cone-shaped tie holes by heavy sandblasting before repair.
      c. Clean and dampen tie holes, maintaining a saturated surface for at least 2 hours before applying dry-pack mortar.
      d. Dry pack cone-shaped tie holes with dry-pack mortar as specified in this Section.

3.03 PLACING CONCRETE REINFORCEMENT, EMBEDS, AND ACCESSORIES

A. Preparation:
   1. Cut and bend deformed steel reinforcement in the shop and deliver completed bars to the site for installation.
      a. Do not field-bend deformed reinforcement.
   2. Surface preparation:
      a. Thoroughly clean reinforcing bars from rust scale, loose mill scale, rust coat, dirt, oil, and other coatings that adversely affect bonding capacity when placed in the work.
         1) Thin coating of red rust resulting from short exposures will not be considered objectionable.
      b. Remove concrete or other deleterious coatings on dowels and other reinforcement projecting from previous placements by wire brushing or sandblasting before the reinforcement is embedded in the subsequent placement.

B. Support of reinforcement and accessories:
   1. Provide supports for deformed bars and wire fabric to maintain reinforcement position indicated on the Drawings and to provide specified minimum clear concrete cover around the reinforcement.

2. Use number of supports required to prevent reinforcement from sagging and to support loads during construction, but in no fewer quantities and locations than recommended by ACI MNL-66 and CRSI Manual of Standard Practice.
3. Support wire fabric from reinforcing supports:
    a. Do not place wire fabric on grade or forms for subsequent lifting into plastic concrete during the concrete placement.
    b. Take care to maintain specified position of wire fabric in the concrete section and to prevent bending, draping, or kinking of the wires.
4. Do not:
    a. Use brick, broken concrete masonry units, concrete spalls, rocks, or other such material for supporting reinforcement.
    b. Support reinforcement on additional reinforcing bars installed with less cover than that required by the Contract Documents ("give away bars").
    c. Adjust location of reinforcement indicated on the Drawings to increase cover over support bars.
5. Furnish and use templates for placing column and wall dowels.

C. Placing reinforcement:
1. Locate reinforcement to provide minimum clear concrete cover specified:
    a. Where cover is not specified, provide cover in accordance with ACI CODE-318.
2. Accurately place reinforcement in accordance with the tolerances of ACI SPEC-117:
    a. Where reinforcement must be moved beyond the specified placing tolerances to avoid interference with other reinforcement, conduits, or embeds, submit the proposed arrangement for Engineer's review.
3. Fasten reinforcement securely in place with wire ties:
    a. After tying, bend ends of wire ties inward towards the center of the concrete to match clear concrete cover provided for reinforcement.
4. Do not weld reinforcing bars or wires.
5. Deformed reinforcing bars:
    a. Tie slab bars at every intersection around the perimeter of slabs.
    b. Tie wall bar and slab bar intersections, other than those around the perimeter, at every 4th intersection, but not more than 48 inches on center each way.
    c. Lap splices:
        1) Lap reinforcement at splices as indicated on the Drawings or specified.
        2) Unless indicated on the Drawings, install lap splices with bars in contact and fastened together with tie wire.
        3) If lap splice length is not indicated on the Drawings, provide lap splice equal to 40 times reinforcing bar diameter.
6. Welded wire fabric reinforcement:
    a. Bend fabric as indicated on the Drawings or required to fit work.
    b. Straighten fabric to make reinforcement in each face a flat, planar surface before placing in the Work.
    c. Extend welded wire fabric across concrete section to provide fabric to within 2 inches of vertical concrete edges.

d. Lap splice welded wire fabric as indicated on the Drawings:
    1) If no splice details are indicated, lap fabric at least 12 inches, fasten with wire ties spaced not more than 24 inches on center, and lace lap with wire of the same diameter of the fabric.

3.04 BATCHING, MIXING, TRANSPORTING, AND DELIVERING CONCRETE

A. General:
    1. Measure, batch, mix, transport, and deliver ready-mixed concrete in accordance with ASTM C94.

B. Measuring and batching:
    1. Measure materials by weighing, except as otherwise specified or where other methods are specifically authorized in writing by the Engineer.
        a. Weigh cementitious materials separately.
    2. Furnish satisfactory means for checking moisture content of aggregates before batching.
        a. Adjust mix water to compensate for free moisture content of aggregate.
    3. Mixing water:
        a. Measure by volume or by weight.
        b. Maximum water-to-cementitious materials ratio for each concrete class shall not exceed that specified in Table B of this Section.
    4. Admixtures:
        a. Provide admixtures as specified.
        b. Batch products by means of mechanical batcher capable of accurate measurement, and in accordance with the admixture manufacturer's instructions.

C. Mixing and transporting:
    1. Mixing:
        a. Equip each truck mixer with device capable of counting number of drum revolutions and interlocked to prevent discharge of concrete from drum before required number of revolutions is complete.
        b. Once drum revolutions commence, continuously revolve drum until it has completely discharged its batch.
        c. Do not add water until drum commences revolutions.
        d. Engineer may require an increase in the designated minimum number of revolutions, or a decrease in the designated maximum number of revolutions if necessary to obtain satisfactory mixing.
            1) Incorporate such changes without additional costs to Owner.
    2. Do not exceed the following time period for mixing and delivery:
        a. Total elapsed time from addition of water at batch plant through discharging of mix: Not to exceed the lesser of 90 minutes or 300 revolutions of the mixer drum.
        b. Total elapsed time for from arrival at the project site to completing discharge of mix: Not to exceed 30 minutes.
        c. Under conditions contributing to quick setting, the Engineer may reduce total elapsed time permitted.

D. On-site acceptance of concrete mixes:
   1. Concrete shall possess the properties specified in this Section at the point of placement.
   2. Do not place concrete:
      a. Having slump outside the limits indicated in Table B of this Section.
      b. That does not conform to specifications for entrained air content.
      c. For which the total elapsed time of mixing or elapsed time at the site exceeds the specified maximums.

3.05 CONVEYING, DEPOSITING, AND CONSOLIDATING CONCRETE

A. Preparation:
   1. General:
      a. Clean construction joints and forming surfaces of dirt, sawdust, chips, and other debris after forms are built and immediately before concrete or grout placement.
         1) Use vacuum cleaner if required to provide clean surfaces.
      b. Remove snow, ice, frost, and standing water from surfaces of formwork, reinforcement, and embeds in contact with concrete.
      c. Secure reinforcement, joint materials, anchors, embeds, and other items in place.
      d. During conveying, placement, consolidation, and finishing of concrete, protect surrounding construction, including concrete walls and slab surfaces, from concrete splatter.
      e. Thoroughly clean surrounding construction at the completion of each placement and before splatter sets up.
   2. Concrete construction on grade:
      a. Provide subgrade preparation, base materials, and compaction as required by the Contract Documents.
      b. Remove loose soils, debris, standing water, snow, or ice from subgrade.
      c. Provide moist subgrade with no standing or free water and no muddy or soft spots.
         1) When subgrade is not moist, sprinkle with water not less than 2 or more than 6 hours in advance of placing concrete.
         2) If subgrade becomes dry prior to actual placing of concrete, sprinkle again, without forming pools of water.
   3. Weather conditions:
      a. Hot weather: In hot weather conditions, make provisions in advance of placement for windbreaks, shading, fogging, sprinkling, ponding, or wet covering.
      b. Cold weather: In cold weather conditions, make provisions to maintain the required concrete temperatures without overheating or drying, and without exposing concrete to carbon dioxide from heater exhaust.
      c. Precipitation:
         1) Do not begin placements while rain, sleet, or snow is falling or anticipated, or unless adequate protection is provided.
         2) Do not allow precipitation to increase concrete water content or to damage the surface of the concrete.
      d. Wind:
         1) Do not begin placements during wind events that will blow dust or debris into the plastic concrete.

2) Do not allow wind-blown debris to become embedded in or to damage the surface of the concrete.
3) At all times, have sufficient coverings on hand to protect new concrete from excessive drying or blowing debris.

B. Conveying concrete:
1. Convey concrete from mixer to place of final deposit by methods that prevent segregation or loss of materials.
2. Use chutes, pumps, and conveyors of size and design that will ensure continuous flow of concrete at point of delivery without cold joints.
3. Design and use chutes and devices for conveying and depositing concrete that direct concrete vertically downward when discharged from the chute or conveying device.
4. Keep conveying equipment clean by thoroughly washing and scraping upon completion of any placement.

C. Depositing concrete:
1. Do not place concrete under the following conditions:
a. After initial set has occurred.
b. When re-tempering has occurred.
2. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing.
a. Do not use vibrators to move concrete from its point of deposit.
b. Use tremies for placing concrete where drop is over 5 feet.
3. Place concrete continuously in approximately horizontal layers not exceeding 24 inches in depth. Bring level up evenly in all parts of forms.
a. After placement begins, continue without significant interruption and as a continuous operation until the end of that placement is reached.
b. Do not allow “cold joints” to form between adjacent layers or areas of the placement, or initial set to form on “wet edge” of placements.
c. Take precautions to prevent delays between placement of adjacent layers or areas from exceeding 20 minutes.
1) If more than 20 minutes elapse after the initial surface was placed, spread a layer of neat cement grout, as specified for construction joints before depositing additional concrete.
4. Placing concrete on slopes: Commence placement at bottom of slope and work upward.
5. Placing horizontal concrete monolithically with structures below:
a. If concrete for slabs, beams, or walkways is to be cast monolithically with walls or columns below, do not place the horizontal concrete elements until the concrete in walls or columns below has been placed, consolidated, and allowed to achieve initial set.
b. Allow set time of not less than 1 hour.
c. Maintain a moist surface at the top of the walls or columns during the setting period.
6. Placing a second concrete lift over hardened concrete below:
a. Take special precautions in form work at top of old lift and bottom of new lift to prevent:
1) Spreading and vertical or horizontal displacement of forms.
2) Grout “bleeding” onto finished concrete surfaces.

D. Consolidating concrete:
   1. Thoroughly consolidate concrete into forms and around reinforcement, pipes, and other embeds using mechanical vibrators.
      a. Take special care to place concrete solidly against forms, leaving no voids.
      b. Make concrete solid, dense, compact, and smooth.
   2. Provide vibration energy sufficient to cause concrete to flow and readily settle into place, leaving no voids. Vibration should visibly affect concrete over a radius of at least 18 inches without segregation.
   3. Vibrators:
      a. At all times, have sufficient vibrators on hand to consolidate concrete as it is placed.
      b. In addition to vibrators in use while concrete is being placed, have on hand at least 1 spare vibrator in serviceable condition.
      c. Place no concrete until it has been ascertained that all vibrating equipment, including spares, are in serviceable condition.

3.06 FINISHING CONCRETE

A. Provide concrete finishes as specified in Section 03366 - Concrete Finishes.

B. Liquid evaporation retardant:
   1. Apply evaporation retardant when environmental conditions will result in rapid evaporation of moisture from the surface of the fresh concrete during finishing operations. Such conditions include low humidity, high heat, and wind occurring alone or in combination.
   2. Immediately after the concrete is screeded, coat the surface of the concrete with a liquid evaporation retardant.
   3. Apply the evaporation retardant again after each work operation as necessary to prevent drying shrinkage cracks and crazing at the surface.

3.07 CURING AND PROTECTING CONCRETE

A. Curing concrete:
   1. Cure concrete by methods specified in this Section.
   2. Keep concrete continuously moist and at a temperature of at least 50 degrees Fahrenheit for at least 7 days after placement unless the details of a particular method specify a longer period.
   3. Make provisions to maintain moisture or curing membrane integrity at edges of slabs, tops of walls, and joint surfaces, and to prevent loss of protection.
   4. Schedule of curing methods:
      a. Concrete surfaces that will receive additional materials that require bond to the initial placement (including concrete; concrete repairs, coatings, paints, sealers; grout; and other materials):
         1) Water curing or plastic membrane curing.
      b. Formed surfaces:
         1) If non-absorbent forms are left in place for 7 days after placement: No additional requirements.
         2) For absorbent forms or when forms are removed during the 7 days following placement: Cure by water curing, plastic membrane curing, or sprayed membrane curing.

c. Unformed concrete surfaces:
    1) Water curing, plastic membrane curing, or sprayed membrane curing.

5. Water curing:
    a. Keep surfaces of concrete constantly and visibly saturated by ponding, continuous fogging, or continuous sprinkling at all times during curing period.
        1) Cover surfaces if required to maintain saturated conditions.
        2) For horizontal surfaces, pond the surface with at least 2 inches of water or cover with saturated mats or fabric kept continuously wet.
    b. Formed surfaces:
        1) Each day forms remain in place may be counted as 1 day of water curing.
        2) Do not loosen form ties while concrete is being cured by forms left in place.
        3) No further credit for curing time will be allowed after contact between the concrete surface and the forms has been broken.
6. Plastic membrane curing:
    a. Cover concrete with plastic membrane, sealing joints and edges against displacement by wind or site operations and to prevent loss of moisture.
    b. Install plastic membrane as soon as concrete is finished and can be walked on without damage.
    c. Keep all surfaces of concrete under plastic membrane moist at all times during the curing period.
7. Sprayed membrane curing:
    a. Application of 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 between removal of forms and application of curing compound, provide water curing of affected surfaces for the full curing period.
        2) Contractor is cautioned that the method of applying curing compound specified in this Section may require more compound than normally suggested by manufacturer of compound, and also more than is customary in the trade.
        3) Apply curing compound by mechanical, power-operated sprayer with mechanical agitator that will uniformly mix all pigment and compound.
        4) Apply compound in at least 2 coats, with each subsequent coat in a direction turned 90 degrees from the preceding coat.
        5) Apply curing compound in sufficient quantity that concrete has uniform appearance and that the natural color of the concrete is effectively and completely concealed immediately after spraying.
        6) Continue to coat and recoat surfaces until specified coverage is achieved and until coating film remains on concrete surfaces.
        7) Apply compound to a film thickness that can be scraped from surfaces at any and all points after drying for at least 24 hours.
        8) Take care to apply curing compound to edges of placements and over full surface profile of construction joints.
    b. Removal of curing compound:
        1) Do not remove curing compound from concrete in less than 7 days after application.

2) Before placing fresh concrete against a surface previously coated with curing compound, remove the curing compound by heavy sandblasting, or alternate method acceptable to the Engineer.
3) Prior to final acceptance of the work, remove any curing compound on surfaces exposed to view by sandblasting or other acceptable method. After removal, only the natural color of finished concrete shall remain visible, and such color shall be uniform over the entire surface.

B. Protecting concrete:
1. Immediately after placement, protect concrete from hot or cold weather, and mechanical damage.
2. Temperature:
a. Hot weather: Protect concrete during the curing period so that the concrete temperature does not exceed 90 degrees Fahrenheit.
b. Remove protection against temperature gradually so that concrete surface temperature does not drop or rise by more than 40 degrees Fahrenheit during any 24-hour period.
3. Maintain forms, shoring, and bracing in place after concrete placement for a period after concrete placement as indicated in the following paragraphs. Forms may be removed after these periods if the concrete has developed sufficient strength and hardness to resist surface or other damage.
a. Vertical forms:
1) General: Minimum 24 hours after concrete placement.
2) Sides of footings: Minimum 24 hours after concrete placement.
3) Sides of beams, girders, and similar members: Minimum 48 hours after concrete placement.
b. Horizontal forms:
1) Slabs, beams, and girders: Until concrete reaches specified compressive strength, f'c, or until shoring is installed.
c. Shoring for slabs, beams, and girders:
1) Shore until concrete strength reaches specified compressive strength, f'c.
a) Temporary shoring may be required after the specified compressive strength is reached if construction loads will exceed the designated live load capacity of the structure.
d. Wall bracing:
1) Brace until strength of concrete beams and slabs laterally supporting the wall reaches specified compressive strength, f'c.

C. Loads against or on the concrete:
1. Loading of green concrete, by backfilling or by placing personnel and equipment on the surface, is not permitted.
2. Backfilling: Do not place backfill against concrete walls until the wall and all elements attached to it, including connecting slabs or beams, are fully braced by the structure, and have achieved their minimum specified compressive strength, f'c.

3.08 JOINTS AND JOINT PREPARATION

A. Joint locations and details:
1. Construct concrete work as monolith to the extent practical.

2. Construct joints as indicated on the Drawings and as specified.
3. Locations of construction, expansion, and other joints are indicated on the Drawings or specified in this Section.
    a. Do not relocate, add, or delete joints without prior approval from the Engineer.

B. Construction joints:
1. Where spacing is not indicated on the Drawings, provide construction joints in slabs and walls at intervals not greater than 35 feet.
2. Construct as indicated on the Drawings.
3. Before placing fresh concrete against the joint: Use heavy sandblast to thoroughly clean joint surfaces and reinforcement crossing the joint of laitance, grease, oil, mud, dirt, curing compounds, mortar droppings, or other objectionable matter.
4. Just before placing concrete against the joint, wash surface with water to saturate joint surface and concrete surfaces within 12 inches of the joint.
5. Horizontal joints:
    a. Immediately before placing concrete, thoroughly spread bed of neat cement grout over the joint surface. Grout shall be as follows:
        1) Use same sand-to-cementitious materials ratio that is used for concrete mix.
        2) Use same materials that are used for concrete.
        3) Use water-to-cementitious materials ratio that is no more than that specified for concrete.
    b. Grout thickness: Not less than 1/2 inch, or more than 1 inch.

C. Expansion joints:
1. Where width is not indicated on the Drawings, provide 3/4-inch wide joint.
2. Construct as indicated on the Drawings.
3. Do not extend reinforcement, conduits, or other items through expansion joints unless details for such crossings are indicated on the Drawings.
4. Preformed expansion joint material:
    a. Accurately position joint filler in the joint.
        1) Fasten to concrete or forms with adhesive.
        2) Fastening joint filler using nails, bolts, screws, or similar items is not permitted.
    b. Tape splices in joint filler to prevent intrusion of mortar.

3.09 TOLERANCES

A. Concrete:
1. Finished concrete: Conform to shapes, lines, grades, and dimensions indicated on the Drawings.
2. In accordance with ACI SPEC-117, except as modified in the following paragraphs:
    a. Where more restrictive tolerances to accommodate equipment are indicated on the Drawings.
    b. Slabs where slope is indicated:
        1) Uniformly slope to drain.
        2) Without depressions that puddle water.

c. Slabs indicated to be level:
    1) Maximum deviation of 1/8 inches in 10 feet without any apparent changes in grade.
    2) Without depressions that puddle water.

B. Embeds:
1. General:
    a. Sleeves and inserts: Plus or minus 1/8 inch.
    b. Projected ends of anchor bolts: Plus 1/4 inch; minus 0 inches.
    c. Anchor bolt position: Plus or minus 1/16 inch.
2. Equipment: Set inserts to tolerances required for proper installation and operation of equipment or systems to which insert pertains.

3.10 FIELD QUALITY CONTROL BY CONTRACTOR

A. Provide quality control over the Work of this Section as specified in 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. Requirements as specified in Section 01450 - Quality Control.
    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 firmly braced, insulated, heated, closed wooden curing boxes. Include cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication through receipt at Contractor'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 the requirements of ASTM C143. Test slump at the following intervals:
        1) Test slump 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 for mortar or moisture flow from slumped concrete.
            b) Reject concrete if mortar or moisture flows out of the 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 the beginning of each placement.
    2) As often as necessary to keep entrained air within the specified range, but not less than every 6th truck.
    3) When requested to do so by the Engineer.
f. Compressive strength, f'c, in accordance with ASTM C39. Required number of cylinders:
    1) Not less than 4 cylinder specimens, 4-inch diameter by 8-inches long, will be tested for each 150 cubic yards of each class of concrete; not less than 4 specimens for each half day of placement.
    2) One cylinder will be broken at 7 days and 3 cylinders will be broken at 28 days.

4. Furnish concrete for test specimens and provide manual assistance to testing lab in preparing said specimens.
5. Assume responsibility for providing care and on-site curing and protection for test specimens in accordance with ASTM C31.

3.11 FIELD QUALITY CONTROL BY OWNER

A. Provide on-site observation and field quality assurance for the Work of this Section as specified in Section 01450 - Quality Control.

B. 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.

C. 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 Specifications.
    a. If such additional testing shows that the materials 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, Engineer shall pay the cost of these tests.

3.12 NON-CONFORMING WORK

A. Enforcement of specification requirements:
1. Do not place concrete that does not conform to the requirements of these Specifications. Remove non-conforming materials from the site.
2. Strength requirements:
    a. Concrete is expected to reach higher compressive strength than the minimum specified compressive strength f'c as indicated in Table B of this Section.

b. Concrete strength will be considered acceptable if following conditions are satisfied:
    1) Averages of all sets of 3 consecutive strength test results are greater than or equal to specified compressive strength f'c.
    2) No individual strength test (average of 2 cylinders tested at 28 days) falls below specified compressive strength f'c by more than 500 pounds per square inch.
c. Whenever one or both of the conditions stated above is not satisfied, provide additional curing or testing of the affected portion as directed by the Engineer.
    1) Costs of such curing or testing shall be at the Contractor's expense.

3.13 ADJUSTING

A. Remove and replace or repair defective work as directed by the Engineer:
    1. Do not patch, repair, or cover defective work before observation by the Engineer.
    2. Make no repairs until Engineer has accepted proposed methods for preparation and repair.

END OF SECTION

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. 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.
   2. 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 03301 - Concrete Work, 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 03301 - Concrete Work.

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 03301 - Concrete Work.
   2. Provide curing after removal of forms as specified in Section 03301 - Concrete Work.
   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. 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 inch.
   3. Fill tie holes using dry-pack mortar.
   4. After removal of any curing compounds, fill depressions larger than 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 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 1/2 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.

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 03301 - Concrete Work 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	1a
			Below grade or water line:		
			- No coating	F1	
			- Bituminous coating	F2	
			- Waterproofing	F3	
		Dry structure:	Above grade line:		
			- Exposed to view	F4	
			- Covered	F2	1a
			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	1b
	Overhead slabs and beams	Wet structure:	Open basin	F3	1c, 1d
			Covered basin	F2	1d
		Dry structure:	Exposed	F3	1c, 1d
			Covered by ceiling	F1	1d

Notes:
(1a) Coverings include additional surfaces applied over the concrete, such as veneer, stucco, plaster, etc.
(1b) Coverings include additional surfaces applied over the concrete, such as veneer, stucco, plaster, furring strips with drywall, etc.
(1c) Applies to overhead surfaces visible from normal pedestrian travel routes.
(1d) 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	2a, 2b, 2g
			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	2g
	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 concrete fill	S1	2e
		Dry structure	Exposed		
			- Pipe galleries	S4	2c
			- Stairs & landings	S4	2d
			- Shops & garages	S4	
			- Equipment rooms	S4	
			Covered		
			- Tile on mortar bed	S2	
			- Resilient flooring	S3	
			- Carpet	S3	

Notes:
(2a) Includes slabs covering tanks, basins, channels and similar structures.
(2b) Includes tops of walls or beams that serve as walkways.
(2c) In galleries with slabs subject to wetting, provide broom finish (S5) where indicated on the Drawings.
(2e) Finish for concrete fill: See Floor slab, wet structure, exposed basins and channels.
(2g) Slabs include flat and sloping surfaces.

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 03301 - Concrete Work.
        b. Concrete sand: As specified in Section 03301 - Concrete Work.

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 03301 - Concrete Work.
    b. Concrete sand: As specified in Section 03301 - Concrete Work.

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 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. All thread rods.
      b. Forged steel structural hardware.
      c. 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 and stainless 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. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   7. A276 - Standard Specification for Stainless Steel Bars and Shapes.

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. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
13. A992 - Standard Specification for Structural Steel Shapes.
14. B695 – Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
15. F436 - Standard Specification for Hardened Steel Washers.
16. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
17. F594 - Standard Specification for Stainless Steel Nuts.
18. F959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
19. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
20. 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. Welding electrodes: Electrode manufacturer's data.
2. 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.
      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 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.
   3. Test reports:
   4. 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
Stainless steel		
Plate, sheet, and strip	A240	Type 304* or 316**
Bars and shapes	A276	Type 304* or 316**
* Use Type 304L (low-carbon stainless steel) if material will be welded.		
** 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.

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. Forged steel structural hardware - carbon steel:
   1. Clevises and turnbuckles: Forged steel in accordance with AISI C-1035.
   2. Eye nuts / Eye bolts: Forged steel in accordance with AISI C-1030.
      a. Having geometric and strength characteristics (including proof load, breaking strength, tensile strength, bend test, and impact strength) of eyebolts in accordance with ASTM A489, Type 1.
   3. Sleeve nuts: Forged steel in accordance with AISI C-1018 Grade 2.

E. High-strength bolts:
   1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators. Provide uncoated components unless galvanized coating is indicated on the Drawings.
   2. 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.
      d. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
         1) Compressible washer type direct tension indicators (“DTI”): In accordance with ASTM F959, Type 325-1.
         2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852.
   3. Carbon steel - Galvanized:
      a. Bolt and nut assemblies fabricated, galvanized, tested for rotational capacity, and shipped accordance with the provisions ASTM F3125, Grade A325and the RCSC Specification.
      b. Bolts, nuts, and washers: Hot-dip galvanized in accordance with ASTM F2329.
      c. Bolts: Plain heavy hex structural bolts in accordance with ASTM F3125, Grade A325, Type 1 and galvanized as specified.
      d. Nuts: Heavy hex nuts in accordance with ASTM A563, Grade DH, galvanized as specified, and lubricated in accordance with ASTM A563, Supplementary Requirement S1 to minimize galling.
      e. 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 and galvanized as specified. Flat circular washers unless otherwise indicated on the Drawings.
         2) Adjacent to long slotted holes: 5/16-inch thick plate washer fabricated from steel conforming to ASTM A36, and galvanized in accordance with ASTM A123.

f. Load indicator devices: At slip critical connections, provide one of the following devices at each bolt:
   1) Compressible washer type direct tension indicators (“DTI”): In accordance with ASTM F959, Type 325-1, with mechanically deposited zinc coating conforming to ASTM B695, Class 55.
   2) Twist-off type tension-control bolt assemblies: ASTM F3125, Grade F1852 with mechanically deposited zinc coating conforming to ASTM B695, Class 55.

F. Stainless steel bolts (for use in stainless steel structures):
   1. General:
      a. Bolts and nuts shall be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship bolts with properly fitting nuts attached.
      b. Units descaled, pickled and passivated as specified in “Fabrication."
   2. Alloy: Type 304 or Type 316 to match alloy of structural members being connected.
   3. Type 304:
      a. Bolts: ASTM F593, Group 1, Condition CW, coarse threads.
      b. Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
      c. Washers: Type 304 stainless steel.
   4. Type 316:
      a. Bolts: ASTM F593, Group 2, Condition CW, coarse threads.
      b. Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
      c. Washers: Type 316 stainless steel.

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 using laser-fused, full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as that of members indicated on the Drawings.
      b. Fabricate shapes from dual grade stainless steel.
      c. Fabricate beams and channels to ASTM A6 tolerances.
      d. Manufacturers: The following or equal:
         1) Stainless Structural, LLC.
   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:
    b. Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.

E. 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.

F. 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.

G. 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.
2. 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.

3. 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.

H. 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.

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.
   2. Post-installed steel anchors and fasteners:
      a. Concrete anchors.
      b. Sleeve anchors.
      c. Screw anchors.
   3. Appurtenances for anchoring and fastening:
      a. Anchor bolt sleeves.
      b. Isolating sleeves and washers.
      c. 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 Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.
   2. D1.6 - Structural Welding Code - Stainless Steel.

C. ASTM International (ASTM):
   1. A29 - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for.
   2. A36 - Standard Specification for Carbon Structural Steel.
   3. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   4. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold Finished.
   5. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   6. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   7. A240 - Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   8. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   9. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   10. A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plan and Deformed, for Concrete.

11. B633 - Standard Specification for *Electrodeposited* Coatings of Zinc on Iron and Steel.
12. B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
13. E488 - Standard Test Methods for Strength of Anchors in Concrete Elements.
14. F436 - Standard Specification for Hardened Steel Washers.
15. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
16. F594 - Standard Specification for Stainless Steel Nuts.
17. F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
18. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

D. 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.
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), or equivalent acceptable to the Engineer and the authority having jurisdiction, demonstrating:
a) Acceptance of that anchor for use under the building code specified in Section 01410 - Regulatory Requirements.

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.

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.

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. Type 304 stainless steel:
         1) Surfaces descaled, pickled, and passivated in accordance with ASTM A380.
         2) Bolts: ASTM F593, Group 1, Condition CW, coarse threads.
         3) Nuts: ASTM F594. Match alloy (group and UNS designation) and threads of bolts.
         4) Washers: Type 304 stainless steel.
      d. 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.

2.03 POST-INSTALLED ANCHORS AND FASTENERS - ADHESIVE

A. 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.

2.04 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. Reports prepared by other recognized evaluation agencies may be submitted for consideration if acceptable to the Engineer and to the authority having jurisdiction.
      a. 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 Florida.
   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.
            a) Type 304 stainless steel acceptable for use at wet and moist locations when accepted in writing by the Engineer.
         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.

D. Sleeve anchors:
   1. Description: Post-installed, torque-controlled anchor assembly consisting of an externally threaded stud with a spacer sleeve near the surface of the base material, and an expansion sleeve on the lower part of the stud. The expansion sleeve is forced outward by torquing of the center stud to transfer load.
      a. Do not use slug-in, lead cinch, and similar systems relying on deformation of lead alloy or similar materials in order to develop holding power.
   2. Sleeve anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Sleeve 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) Sleeve 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, HSL-3 Heavy Duty Expansion (sleeve) Anchor.
         2) DEWALT/Powers, Power Bolt+ Heavy Duty Sleeve Anchor.
      c. Materials:
         1) Stainless steel: Not available.
         2) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5).

E. Screw anchors:
   1. Description: Post-installed concrete anchor that develops tensile strength from mechanical interlock provided by creating a helical "key" that is larger than the diameter of the bolt itself along the length of the anchor shaft.
   2. Screw anchors for anchorage to concrete:
      a. Acceptance criteria:
         1) Screw 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 ICC ES AC193 (including all mandatory tests and optional tests for seismic tension and shear in cracked concrete).
         2) Screw anchor performance in the current ICC-ES Report shall be "Category 1" as defined in ACI 355.2.
      b. Manufacturers: Screw anchor: One of the following or equal:
         1) Hilti, Hex head, HUS-EZ Screw Anchor:
            a) With internally threaded head: HUS-EZ I Hanger Anchor.
         2) DEWALT/Powers, Screwbolt+ Screw Anchor:
            a) With internally threaded head: Vertigo+ Rod Hanging System.
         3) Simpson Strong-Tie, Titen® HD Screw Anchor:
            a) With internally threaded head: Titen® HD Rod Hanger.
      c. Materials:
         1) Stainless steel: Not available.

2) Galvanized steel: Carbon steel, zinc plated in accordance with ASTM B633, minimum 5 microns (Fe/Zn 5) or equal.

2.05 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.
   3. Fabricated steel sleeves:
      a. Fabricate to the following dimensions unless otherwise indicated on the Drawings:
         1) Inside diameter: At least 2 inches greater than bolt diameter.
         2) Inside length: Not less than 10 bolt diameters.
         3) Bottom plate:
            a) Square plate with dimensions equal to the outside diameter of the sleeve plus 1/2 inch each side.
            b) Thickness equal to or greater than one-half of the anchor bolt diameter.
      b. Carbon steel anchor bolts:
         1) Fabricated from ASTM A36 plate and ASTM A53, Grade B pipe.
         2) Welded connections: Conform to requirements of AWS D1.1.
         3) Hot dip galvanized in accordance with ASTM A153.
      c. Stainless steel anchor bolts:
         1) Fabricated from ASTM A240 plate and pipe. Type 304L or Type 316L to match Type of the anchor bolt.
         2) Welded connections: In accordance with AWS D1.6.

B. Forged steel hardware:
   1. See Section 05120 - Structural Steel Framing for forged steel hardware connectors, including clevises, turnbuckles, eye bolts, eye nuts, and sleeve nuts.

C. 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.

D. Coating for repair of galvanized surfaces:
1. Manufacturers: The following or equal:
a. Jelt, Galvinox.

E. 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. Fill sleeves with grout when a machine or other equipment is grouted in place.

3.04 INSTALLATION: POST-INSTALLED ADHESIVE ANCHORS

A. Epoxy and acrylic adhesive bonding of reinforcing bars, all thread rods, and internally threaded inserts in concrete: As specified in Section 03055 - Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete.

3.05 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.

F. Sleeve anchors:
   1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Sleeve Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
M8 (1/2 inch)	70 mm (2 3/4 inch)	Not accepted	100 mm (8 inch)
M10 (5/8 inch)	76 mm (3 inch)	Not accepted	250 mm (10 inch)
M12 (3/4 inch)	80 mm (3 1/4 inch)	Not accepted	300 mm (12 inch)

   2. Install with the sleeve fully engaged in the base material.

G. Screw anchors:
   1. Minimum effective embedment lengths unless otherwise indicated on the Drawings:

Screw Anchors			
Nominal Diameter	Minimum Effective Embedment Length		Minimum Member Thickness
	In Concrete	In Grouted Masonry	
3/8 inch	2 1/2 inch	3 1/4 inch	8 inch
1/2 inch	3 1/4 inch	4 1/2 inch	8 inch
5/8 inch	4 inch	5 inch	10 inch
3/4 inch	5 1/2 inch	6 1/4 inch	12 inch

   1. Install screw anchors using equipment and methods recommended by the manufacturer. Continue driving into hole until the washer head is flush against the item being fastened.

3.06 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.

3.07 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.
   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.
      b. Sleeve anchors.
      c. Screw 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.

3.08 NON-CONFORMING WORK

A. Remove misaligned or non-performing anchors.

B. Fill empty anchor holes and repair failed anchor locations as specified in Section 03600 - Grouting using high-strength, non-shrink, non-metallic grout.

C. If more than 10 percent of all tested anchors of a given diameter and type fail to achieve their specified torque or proof load, the Engineer will provide directions for required modifications. Make such modifications, up to and including replacement of all anchors, at no additional cost to the Owner.

3.09 SCHEDULES

A. Stainless steel. Provide and install stainless steel anchors at the following locations:
   1. “Corrosive locations” as defined in this Section: Type 316 stainless steel.
   2. “Wet and moist locations” as defined in this Section: Type 316 stainless steel.
   3. “Other locations:”
      a. For connecting steel or stainless steel members to concrete or masonry: Type 304 stainless steel.
      b. For connecting aluminum members to concrete or masonry.
      c. For connecting fiber-reinforced plastic (FRP) members to concrete or masonry.
   4. At locations indicated on the Drawings.

B. Galvanized: Provide and install galvanized carbon steel anchors at the following locations:
   1. Locations not requiring stainless steel.
   2. At locations indicated on the Drawings.

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Aluminum grating stair tread.
   2. Aluminum stair nosing.
   3. Concrete inserts.
   4. Handrails and guardrails.
   5. Ladders.
   6. Metal gratings.
   7. Metal tread plate.
   8. Preformed channel pipe supports.
   9. Stairs.
   10. Miscellaneous metals.
   11. 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. National Association of Architectural Metal Manufacturers (NAAMM):
   1. Metal Finishes Manual.

F. 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. Aluminum grating stair tread.
   2. Aluminum stair nosing.
   3. Handrails and guardrails.
   4. 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. Stairs.
6. 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	--

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
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
Stainless Steel		
Plate, sheet, and strip	A240	Type 304* or 316**
Bars and shapes	A276	Type 304* or 316**
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
* Use Type 304L if material will be welded. ** 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. Aluminum stair nosing:
   1. Manufacturers: One of the following or equal:
      a. Wooster Products, Inc., Type 101 Nosing.
      b. American Safety Tread Co., Inc., Style 801 Nosing.
   2. Material: Cast aluminum abrasive nosings with aluminum oxide granules integrally cast into metal, forming permanent, nonslip, long-wearing surface.
   3. For installation in cast-in-place stairs.
   4. Configuration: 4 inches wide, fabricated with integrally cast stainless steel anchors at approximately 12-inch centers. Length to extend within 3 inches of stair edge on each side.

C. Concrete inserts:
   1. Concrete inserts for supporting pipe and other applications are specified in Section 15061 - Pipe Supports.

D. 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. Aluminum handrails and guardrails (nonwelded pipe):
      a. Rails, posts, and fitting-assembly spacers:
         1) In accordance with ASTM B429, 6005, 6063 or 6105, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
      b. Kick plates: 6061 or 6105 aluminum alloy.
      c. Fastenings and fasteners: As recommended or furnished by the manufacturer.

d. Other parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
    1) Fabrications: In accordance with ASTM B209 or ASTM B221 extruded bars:
        a) Bases: 6061 or 6063 extruded aluminum alloy.
    2) Plug screws or blind rivets: Type 305 stainless steel.
        a) Other parts: Type 300 series stainless steel.
e. Finish of aluminum components:
    1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
    2) Pretreat aluminum for cleaning and removing markings before anodizing.
f. Fabrication and assembly:
    1) Fabricate posts in single, unspliced pipe length.
    2) Perform without welding.
    3) Do not epoxy bond the parts.
    4) Maximum clear opening between assembled railing components as indicated on the Drawings.
g. Manufacturers: One of the following or equal:
    1) Moultrie Manufacturing Co., Wesrail.
    2) Golden Railings, Riveted System.
    3) Craneveyor Corp. Enerco Metals, C-V Rail.

3. Guardrail gates:
    a. Supplied by guardrail manufacturer:
        1) Of same material, quality, and workmanship as specified for guardrail system in which they will be installed.
        2) Of design similar to that of handrail or railing system in which they will be installed.
    b. Components: Gate frame, stainless steel self-closing device, hinges, gate stops, and durable self-locking type latch. Fabricate components in conformance with OSHA minimum strength requirements.
4. Fastenings and fasteners: As recommended or furnished by guardrail manufacturer for use with this system.

E. Ladders:
1. General:
    a. Type: Safety type conforming to local, State, and OSHA standards as minimum. 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. Finish of aluminum components:
    1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
    2) Pretreat aluminum for cleaning and removing markings before anodizing.
e. Fabrication:
    1) Welded construction, of size, shape, location, and details indicated on the Drawings.
    2) For ladders over 20 feet high, furnish standard ladder cages or fall prevention system designed in accordance with State and OSHA requirements.
f. Fall prevention system: Include but not limit to railing, brackets, clamps, 2 sleeves, and 2 belts, satisfying OSHA safe climbing requirements:
    1) Manufacturers: One of the following or equal:
        a) North Consumer Products, Saf-T-Climb.
        b) Swager Communications, Climbers Buddy System.

F. 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 50 pounds each.
        9) Fabricate aluminum grating sections in units of weighing not more than 50 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.

G. Metal tread plate:
1. Plate having a raised figured pattern on 1 surface to provide improved traction.

H. Stairs:
1. Aluminum stairs:
    a. Stringers: 6061-T6 aluminum alloy.
    b. Stair treads:
        1) Aluminum of same type specified under Aluminum Grating.
        2) Of sizes indicated on the Drawings, and 1-3/4 inch minimum depth with cast abrasive type safety nosings.
    c. Provide a vertical close piece between each riser. Fabricate, install, and fasten close pieces as indicated on the Drawings.
    d. Handrails and guardrails: Aluminum pipe specified under Aluminum Handrails and Guardrails (Nonwelded Pipe).
    e. Fasteners: Type 304 or Type 316 stainless steel.

I. 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.

J. 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.

K. 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.

L. 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.

M. 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 as specified in Section 09960 - High Performance Coatings.
      c. Aluminum in contact with concrete or masonry.

B. Aluminum stair nosing:
   1. Install stair nosings on treads of concrete stairs, including top tread on upper concrete slab.
   2. Omit stair nosings where concrete is submerged.
   3. Cast stair nosings in fresh concrete, flush with tread and riser faces. Install nosing in center of step.

C. 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. Guardrail gates:
    a. Install gate to be a vertical plane with the guardrail when in the closed position.
    b. Install hinges so that each gate can swing 180 degrees from the closed position to the fully open position.
    c. Install so that the gates swing to the walkway side of the guardrail only.
        1) Install gate stops on the stationary railing posts to prohibit gates from swinging in the wrong direction.
    d. Install gate frames, hinges, stops, and latches in conformance with OSHA minimum strength requirements.

D. Ladders:
1. Secure to supporting surface with bent plate clips providing minimum 8 inches between supporting surface and center of rungs.
2. 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.
3. Where exit from ladder is to side, extend ladder 5 feet 6 inches minimum above landing and rigidly secure at top.
4. Erect rail straight, level, plumb, and true to position indicated on the Drawings:
    a. Correct deviations from true line or grade which are visible to the eye.

E. 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.
   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.

F. Stairs:
   1. General:
      a. Install guard railings around stair wells as indicated on the Drawings or specified.

G. 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 06608

FIBERGLASS REINFORCED PLASTIC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: General fabrication and design requirements for fiberglass reinforced plastic fabrications.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment.

B. ASTM International (ASTM):
   1. C582 - Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
   2. D883 - Standard Terminology Relating to Plastics.
   3. D2563 - Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts.
   4. D2583 - Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.
   5. D2584 - Standard Test Method for Ignition Loss of Cured Reinforced Resins.
   6. D3299 - Standard Specification for Filament-Wound Glass Fiber Reinforced Thermoset Resin Corrosion-Resistant Tanks.
   7. D4097 - Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.

1.03 DEFINITIONS

A. Chopped Glass: Fibrous material consisting of randomly oriented chopped filaments applied directly to a mold surface or laminated under construction by a chopper gun.

B. Equipment: The fiberglass reinforced plastic equipment, including ancillary equipment, work, and materials as described in this specification.

C. Fabrication Drawings: Those drawings produced by the Fabricator or Contractor, with the intention of providing the necessary information to construct or install the equipment.

D. Fiber Prominence (Jackstraw): The distinct visibility of individual glass strands causing a loss of translucency of the laminate.

E. Fiberglass Reinforced Plastic: Fiberglass Reinforced Plastic or glass fiber and resin fabrication consisting of approximately 35 to 55 percent glass fiber reinforcement by weight for hand lay-up structural laminates and 55 to 70 percent glass for filament wound structural laminates, unless otherwise specified.

F. Mat: Fibrous material consisting of randomly oriented chopped or swirled filaments loosely held together with a binder.

G. The terminology of this specification is in accordance with ASTM D883. Fabricators using this specification are responsible for correct interpretation.

1.04 SUBMITTALS

A. Shop drawings and calculations:
   1. Submit general arrangement and fabrication drawings, calculations, and elements of the design.
   2. Include submittal information which describes specifically how the equipment is to be built and details necessary to ascertain that products meet specified requirements. Provide in the form of drawings, standards, specifications, or other shop instructions, but may also be partially contained in quality control records. The submittal shall include, but not be limited to:
      a. Fabrication drawings.
      b. General arrangement drawings signed by an Engineer registered in the state where the project is located, showing complete structural, fasteners, and erection procedures for a complete assembly.
      c. Quality control programs.
      d. Verification that the manufacturer has been engaged in fabrication of similar fiberglass reinforced plastic equipment for a minimum of 5 years.
      e. Statement of compliance with contract design requirements, codes, and standards.
      f. Recommendation for each resin selection from resin manufacturer.
      g. Type and amounts of fillers.
      h. Nominal corrosion liner description.
      i. Reinforcement types and glass content range for hand lay-up laminates.
      j. For filament wound laminates:
         1) Helix angle.
         2) Glass content range.
         3) Strand yield.
         4) Strand per inch in the winding band.
         5) Ply thickness.
         6) Amount of chop or unidirectional roving interspersed with winding, if any, and location within laminate.
      k. For other components:
         1) Construction type.
         2) Laminate thicknesses.
         3) Ply sequences.
         4) Glass content range.
      l. For secondary overlays (both interior and exterior):
         1) Laminate thicknesses.
         2) Ply sequences and widths.
      m. Construction details: Construction details for assembly and other special configurations, including:
         1) Tank bottom/top attachments with knuckle configuration and overlays and thicknesses.
         2) Tank support and anchor lugs, including attachment details.

3) Tank nozzles and installation, including cutout reinforcement, gusseting, and similar items.
4) Tank lateral or other support fabrication details, including platform attachment clips and/or shoulders.
5) Scrubber configuration and fabrication details of internal support system and other specialty items.
6) Cover panel joints, anchorage detail, and details of doors and inspection ports and their attachment or incorporation within the cover.

n. Miscellaneous equipment required.
o. Test reports and certification of compliance with physical property requirements.
p. Color samples.
q. Manufacturer's installation instructions.
r. ASME RTP-1 certification.

B. Operation and Maintenance Data.

C. Warranty.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications: Fiberglass reinforced plastic manufacturer with experienced personnel, physical facilities, and management capacity sufficient to produce custom-made glass fiber and resin products of quality and size specified for minimum 5 years with satisfactory performance record.

B. Quality assurance plan: Fabricator shall be responsible for implementation of a comprehensive quality assurance plan. The quality assurance plan describes procedures with the following minimum requirements:
1. Fabricator shall designate personnel to inspect equipment while in process and after completion to ensure compliance to every aspect of the section and fabrication drawings.
a. Inspection shall include, as a minimum, checks for visual defects, laminate thickness and sequence, glass content, Barcol hardness, dimensional tolerances, adherence to construction details, surface preparation, and environmental conditions.
b. Fabricator's inspector shall complete a report of the findings including method of measurement for each separate assembly.
2. Prior to use of resins in fabrication, fabricator shall extract samples of resins and retain them for use by the Engineer. Sample size shall be 100 cubic centimeters minimum:
a. Take 1 sample for each manufacturer's batch number if resin is received in the form it will be used.
b. If the fabricator alters the resin after receipt, such as through the addition of styrene, promoters, or other additives, take samples from each drum or portion thereof mixed with additives.
c. Fabricator shall provide documentation for each sample including resin type, manufacturer, batch and lot number, drum number, complete listing of additives with amounts added, and description and manufacturer of each additive.

3. Fabricator shall inspect glass reinforcement prior to use in fabrication.
    a. Do not use glass that does not meet the manufacturer's acceptance standards.
    b. Do not use glass material that is wet or has been wet.
    c. For each type of glass and lot number used, fabricator shall record the manufacturer, product description, binder type, product code, production date, and lot number.
    d. For mat, woven roving, unidirectional roving, and cloth, also include in records actual measured weight per square yard of material.
4. Fabricator shall retain nozzle cutouts and other excess laminate, clearly marking each piece to identify its original location. These laminate samples become the property of the Owner.
5. For areas where valid laminate samples are not available, take sample plugs at the Engineer's request.
    a. Repair subsequent holes in a manner acceptable to the Engineer.
6. Fabricator shall verify glass content on available samples in accordance with ASTM D2584. Complete this test and submit the results complete for each major component where samples are available.
7. Prior to final shipment of the equipment, fabricator shall submit to the Engineer a complete quality control report, consisting of copies of records maintained for compliance with this Section.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design fiberglass reinforced plastic tanks, scrubbers, and other vessels following the procedures and methods, utilizing the equations and formulas, and incorporating safety factors and allowable design stresses and strains set forth in ASME RTP-1. Base the design of duct and other fiberglass reinforced plastic equipment not covered by ASME RTP-1 on the engineering rationale, applicable formulas, and safety factors set forth in ASME RTP-1.

B. Perform calculations necessary to ensure long-term, low risk service of the fiberglass reinforced plastic equipment with minimum reasonable maintenance requirements.
    1. Long-term, low risk service is defined as a service life of 20 years without major structural failure or leakage.
    2. The design shall ensure proper functioning of the equipment at the stated operating conditions.
    3. The design shall include as a minimum, engineering calculations, materials selection and documented physical and mechanical properties, and detailed drawings required for fabrication and assembly of the equipment.

C. Design in accordance with applicable national, regional, and local design and building codes.
    1. Wind forces shall be determined in accordance with the building code as specified in Section 01410 - Regulatory Requirements.

D. Resistance to overturning shall not include the weight of the liquid contained in the equipment.

E. Consider the interaction of the installed system including but not limited to thermal expansion of duct, tanks, and vessels and the effects of external loading from piping, fans, pumps, platforms, and other attached items.

F. Allow for the most severe combination of conditions which may include, but not be limited to, the following:
   1. Internal or external pressure.
   2. Static head of contents (working and test conditions).
   3. Mass of structure and contents.
   4. Design temperature including upset conditions.
   5. Superimposed loads, such as wind forces.
   6. Bending moments due to eccentric loads.
   7. Localized loads acting at supports, lugs, and other attachments.
   8. Shock loads.
   9. Loads due to heating or cooling and thermal gradients.
   10. Loads applied during transport or erection.
   11. Loads imposed by personnel during erection and operations.
   12. Fatigue.

G. Use safety factors and allowable strains specified in ASME RTP-1 unless otherwise specified. Do not use safety factors and allowable strains less than the following:
   1. Allowable hoop and axial strain shall be 0.001 inch per inch for filament wound tanks.
   2. A safety factor of 10 for hand lay-up components in tension, flexure, or other loading conditions where elastic stability is not in question.
   3. A safety factor of 5 for external loading (vacuum) or local buckling due to wind loading.

H. Safety factors for upset conditions or infrequent loading situations may be less than the above values for the specific condition if acceptable to the Engineer.

I. There will typically be other aspects which should be considered. Identify and consider their effects, identify design limitations, and submit this information.

J. Provide test reports or other documentation for laminate properties used in the design. Laminates shall be similar in construction, layer sequence, resin type, and cure to those used to determine tested properties. Properties shall be adjusted to reflect reductions at operating temperatures. Test reports shall be provided for:
   1. Grating: Indicate grating strength and deflection.
   2. Physical properties of test cover panels.
   3. Tanks showing conformance with specified strength requirements.

K. The corrosion liner shall be a minimum of 100 mils in thickness, unless otherwise specified, and documentation shall be provided verifying veil type, liner thickness, and resin cure.
   1. Consider 50 mils of the corrosion liner as sacrificial and do not include it in determining structural wall thickness.

2. Use structural wall thickness not less than 0.625 inches for tanks and vessels and 0.1875 inches for ductwork.
3. Submit minimum structural thicknesses of other types of fiberglass reinforced plastic fabrications.

L. Laminate types may include hand layup, helical winding, and hoop/chop construction methods.
1. In laminates with helix angles greater than 80 degrees and in hoop/chop laminates, orientate approximately 10 percent of the structural wall thickness at 0 degrees (longitudinal direction).
2. Apply this reinforcement in at least 2 layers of weft unidirectional fabric and equally spaced within the structural wall.

M. For tanks and scrubbers; nozzles, determine manways and shell reinforcements according to the tables and formulas in ASME RTP-1.

N. Anchor tanks and vessels using lugs and a continuous filament wound band or an integral filament wound load ledge with external stainless steel anchor clips.
1. The anchor clips shall be bolted to the concrete foundation; use non-shrink grout to level anchor clips.
2. The design shall resolve the sum of the moments and the sum of the force equal to 0.

O. Design internal beams and support attachments using a maximum of 200 pounds per square inch shear stress for secondary bonds. Also apply this to design of external lugs required for ladders, platforms, and other attached items.

2.02 RESIN AND REINFORCEMENT MATERIALS

A. General physical properties: In accordance with ASTM C582, ASTM D3299, ASTM D4097, and ASME RTP-1 with verification of properties. Physical properties may include tensile, flexural, and compression modulus of elasticity and ultimate strengths, limiting strains, Poisson ratios, coefficients of expansion, and other directional properties as required for the design of the equipment.

B. Resin:
1. Fabricate equipment using the corrosion-resistant resin(s) specified in the fiberglass reinforced plastic equipment specifications. The fabricator is required to obtain independent endorsement of each resin selection from the resin manufacturer. Unless otherwise specified, use the resin throughout laminates.
2. The type of catalyst recommended varies between resin manufacturers. Submit resin/catalyst before fabrication begins to verify compliance to the resin manufacturer's recommended procedures.
3. Employ no fillers, additives, or pigments in the resin.
a. A thixotropic agent for viscosity control may be used in the proportion and type recommended by the resin manufacturer.
b. Use no thixotropic agent in the corrosion liner or on surfaces to be in contact with the corrosive environment.

4. Make resin putty using the same resin as was used in the original fabrication and shall contain milled glass fibers.
    a. The use of silica flour, grinding dust, or other fillers is not allowed.
5. When specified, add antimony trioxide or antimony pentoxide to the resin in the amount necessary to achieve the required fire retardancy rating in the structural wall only. Follow resin manufacturer's recommendations.
    a. Unless otherwise specified, the corrosion liner shall not contain this additive.

C. Reinforcement:
1. Show the type and sequence of reinforcements to be used on the fabrication drawings.
2. Use as commercial grade corrosion-resistant borosilicate glass fiber reinforcement, unless otherwise specified.
3. Use glass fiber reinforcing having a surface finish and binder that is specifically recommended by the glass manufacturer for the particular resin system to be used.
4. Use Type C (chemical grade) glass, 10 mils (0.01 inches) thickness, or polyester surfacing veil, such as Nexus surfacing veils.
5. Use Type E (electrical grade) glass, 1-1/2 ounces or 3/4-ounce per square foot, with nominal fiber length of 1.25, within 0.75 inches mat.
6. Continuous glass roving used in chopper guns for spray up shall be Type E chopper roving.
7. Woven roving shall be 24 ounces per square yard Type E glass and have a 5-by-4 plain weave.
8. Continuous roving used in filament wound structures shall be Type E glass winder roving with a yield of 200 yards or more per pound.
9. Use Type E glass unidirectional fabric. Weft unidirectional fabric shall be 15.7 ounces per square yard.
10. When specified, use Type ECR glass reinforcements supplied in similar fabric styles to those specified above.

2.03 FABRICATION

A. Molds:
1. Construct molds of a suitable material to produce a smooth and glossy corrosion liner surface on the fiberglass reinforced plastic equipment.
2. Covering of mandrels with cardboard must be accepted by the Engineer prior to start of fabrication.

B. Laminates:
1. Determine specified glass content in accordance with ASTM D2584.
2. Consider laminate thicknesses shown on the fabrication drawings as construction minimums. Verify that minimum thicknesses are obtained using the laminate sequences specified. When only total laminate thicknesses are specified or indicated on the Drawings, the minimum allowable structural laminate thickness shall be the total laminate thickness less the specified corrosion liner thickness.
3. Interruptions in laminating sequence shall follow the application of a ply of mat and be succeeded by a ply of mat.

4. The interruption shall not exceed 24 hours, and the in-process surface must retain acetone sensitivity until laminating is resumed. Lack of compliance with these aspects or indication that contamination of the surface has occurred shall require that surface preparation be accomplished before resuming.
5. Chopped strand glass applied by chopper gun is allowed in lieu of mat layers in the structural laminates only.
    a. Chopper gun application of the corrosion liner is not allowed.
6. Coat non-mold surfaces with resin containing wax additive in the amount necessary to allow full cure of the surface. In the case of exterior surfaces, this wax coat shall also contain an ultraviolet stabilizer in the type and amount recommended by the resin manufacturer.
7. The exterior surface of equipment shall be resin-rich and reinforced with 1 layer C glass surfacing veil, unless otherwise specified.
8. When specified, the exterior coat shall be an opaque pigmented surface coat, applied only after Engineer's inspection. Color shall be selected by the Engineer.

C. Corrosion liner laminates:
1. The inner surface of laminates shall be resin-rich and reinforced with surfacing veil of the type and number of layers as shown on the fabrication drawings.
2. The interior layer of the corrosion liner shall consist of 1-1/2 ounces per square foot mat in the number of layers specified on the fabrication drawings. An exotherm interruption is specifically prohibited within the corrosion liner.
3. Chopped glass applied by chopper gun is not allowed in the corrosion liner.
4. Plies of the inner surface and interior layer are to gel completely before proceeding with the structural laminates.
5. Completed corrosion liner as described above shall contain not less than 20 percent nor more than 30 percent glass by weight.
    a. Use no thixotropic material in the resin for the liner, nor in the fabrication of fiberglass reinforced plastic components intended for internal service.
    b. The completed liner shall be the minimum thickness specified or indicated on the Drawings.
6. Do not use a separately cured unreinforced gel coat.

D. Hand lay-up structural laminates:
1. The corrosion liner laminate shall be followed by hand lay-up structural laminates of varying reinforcement sequences as indicated on the fabrication drawings.
2. For hand lay-up structural laminates, reinforcement shall consist of mat and woven roving in the sequence specified on the fabrication drawings.
3. Woven roving shall have a ply of mat on each side. Two adjacent plies of woven roving are not permitted.
4. Laminates containing primarily 1-1/2 ounces per square foot mat layers in conjunction with woven roving shall contain not less than 35 percent or more than 45 percent glass (by weight).
5. Laminates containing primarily 3/4-ounce per square foot mat layers in conjunction with woven roving are considered to be high strength laminates and shall contain not less than 45 percent or more than 55 percent glass by weight.

E. Filament wound structural laminates:
   1. The corrosion liner laminate shall be followed by filament wound structural laminates as indicated on the fabrication drawings.
   2. For filament wound structural laminates, reinforcement shall consist of continuous strand fiberglass roving applied with a minimum of interruptions until the specified minimum thickness is attained.
      a. This laminate shall contain 55 to 70 percent glass by weight as indicated on the fabrication drawings.
   3. Each complete cycle of filament winding shall form a closed pattern of winding bands which completely covers the surface with 2 bi-directional layers.
      a. Each layer shall be a maximum of 1 roving in thickness.
      b. Uniformly space the filaments across the winding band without bunching or gaping.
   4. Specify the helix angle of winding on the approved fabrication drawings, as measured from the centerline of revolution of the equipment shell.
   5. Tolerance on helix angle is plus or minus 2 degrees, unless otherwise specified.
   6. The fabrication drawings may require that layers of unidirectional roving be interspersed within the continuous filament winding.
   7. Apply the unidirectional roving with the glass strand aligned in the axial direction, to within plus or minus 5 degrees.
   8. If layers of mat or chopped glass are needed to ensure proper bonding of unidirectional roving, or within the filament winding to accommodate the Fabricator's manufacturing methods, consider the layers' extra material that will result in a thickness greater than specified. The amount of filament winding and unidirectional roving specified must still be applied.

F. Joining laminates:
   1. Fiberglass reinforced plastic joining laminates are subject to applicable requirements specified in other sections for laminates.
   2. Reinforce fiberglass reinforced plastic joints with an overlay of glass reinforcement and resin which extends equally within plus or minus 1/2 inch on each side of the joint. Use minimum thickness, ply sequence, and ply widths of fiberglass reinforced plastic joints as indicated on fabrication drawings.
   3. Restrain parts to be joined to prevent movement until completion and cure of the joint overlay.
   4. Fit-up parts and verify that tolerances and assembly requirements are satisfied. Completely fill the void between component parts with resin putty, taking care not to extrude an excessive amount of putty into the interior.

G. Environment:
   1. The fabrication process and materials at the point of fabrication are to be maintained within a range of 60 to 95 degrees Fahrenheit. This temperature must also be at least 5 degrees greater than wet bulb temperature, as measured with a sling psychrometer.
   2. Store materials in a dry area and within the temperature and humidity limits recommended by the manufacturers.

H. Flanges:
   1. Make flanges by hand lay-up construction with nozzle neck and flange made integrally in 1 piece and fabricated in accordance with the dimensions indicated on the fabrication drawings. Extend layers of reinforcement in the nozzle neck and hub uninterrupted into the flange.
   2. Build-up additional hub thickness using alternating layers of 1-1/2 ounces per square foot mat and 24 ounces per square yard woven roving.
   3. Build-up additional thickness in the flange using "ring" cutouts of mat, evenly distributed throughout the flange thickness.
   4. Press molded or filament wound flanges are not allowed.
   5. Overall machine facing of the back of flanges is not permitted.
      a. To obtain proper seating, spotface bolt holes for SAE size washers.
      b. Resin coat bolt holes and other cut surfaces so that no fibers are exposed.
      c. Spotfacing shall not produce a flange thickness less than indicated in the fabrication drawings.
   6. Bolt holes in flanges shall straddle principal centerlines of the Equipment. Tolerance in bolt hole locations and in diameter of bolt circle shall be plus 1/16 inch.
   7. Depressions or projections in flange face shall be no greater than 1/32 inch.

I. Allowable visual defects:
   1. Visual defects in areas of the equipment shall not exceed level 2 as specified in ASME TRP-1 Table 6-1, unless acceptable to Engineer.
   2. Visual defects in accordance with ASTM D2563 and RTP-1 Table 6-1.
   3. Presence of visual defects in excess of the allowable level 2 of RTP-1 Table 6-1 shall be grounds for rejection of the equipment. Listed quantities apply to small, localized areas and shall not be averaged over larger areas.

2.04 SOURCE QUALITY CONTROL

A. Inspection:
   1. Owner's inspection: Permit the Engineer access to the equipment during fabrication and upon completion for the purpose of verifying compliance to the Contract Documents. The inspection is not intended to replace the Fabricator's own quality control procedures.
   2. In no respect does inspection of equipment by Engineer relieve the Fabricator of compliance with the Contract Documents.
      a. A final inspection will be performed by the Engineer.
   3. The Fabricator shall notify the Engineer at the completion of particular milestones during fabrication. The milestones are as follows:
      a. View tooling prior to fabrication.
      b. Beginning application of corrosion liner for each part, extraction of each part prior to beginning assembly.
      c. Upon completion of each separate assembly, Engineer reserves the right to include additional milestones.
   4. Allow Engineer to photograph the equipment while in process and/or upon completion.
   5. Engineer may use magnification or other special viewing or measurement devices during inspection.

6. Evidence of poor workmanship or lack of compliance with aspects of the Contract Documents will be grounds for rejection of the equipment.
7. Subsequent repair of rejected equipment may, at the Engineer's option, be undertaken in an attempt to bring the equipment to an acceptable state.
    a. Repair procedures must be accepted by the Engineer prior to implementation.

2.05 TESTING

A. The Engineer may employ destructive testing, such as ultimate tensile or flexure strength tests or glass content ignition tests, on available samples or use other non-destructive test methods, such as acoustic emission or ultrasonic polygauge thickness measurement, on the completed equipment for verification of compliance to the contract documents.

B. Testing performed by the Engineer will be accomplished through use of applicable ASTM test methods when appropriate.

C. Hardness tests will be made for acceptance by the Engineer on the liner surface using the Barcol impressor, Model GYZJ 934 1, calibrated at 2 points in accordance with ASTM D2583.
    1. Ten readings will be taken in a localized area, deleting the 2 highest and 2 lowest, and averaging the remaining 6.
    2. Minimum acceptable Barcol hardness will be a reading of 30 unless otherwise specified.

D. An acetone sensitivity test will also be performed by the Engineer as an acceptance criteria. Evidence of a sticky or tacky surface following rubbing with an acetone-saturated cloth will be grounds for rejection of the equipment.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 07900

JOINT SEALANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Acrylic-Latex sealant.
   2. Silicone sealant.
   3. Synthetic rubber sealing compound.
   4. Synthetic sponge rubber filler.
   5. Related materials.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C920 - Standard Specification for Elastomeric Joint Sealants.
   2. C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants.
   3. C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
   4. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   5. 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 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.

2.04 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.

2.05 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.

2.06 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. Chemical containment areas: 1 test per every 1,000 LF of joint sealed.
      c. Building expansion joints: 1 test per every 500 LF of joint sealed.
      d. All other type of joints except butt glazing joints: 1 test per every 3,000 LF of joint sealed.
      e. Manufacturer's authorized factory representative provide written recommendations for remedial measures on failing tests.

END OF SECTION

SECTION 09960

HIGH-PERFORMANCE COATINGS

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 touch 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. Pre-installation conference: Conduct as specified.
   1. Coordinate Hold Point schedule.

E. 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.

F. 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.

G. 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.

H. 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.

I. 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.

4. Hold Points shall be as follows:
    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 01600 - 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.

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 01600 - Product Requirements.

2.03 COATING SYSTEMS IDENTIFICATION

A. Naming conventions: Coating Systems Identifications contain the elements defined in Table 1.

Table 1. Coating System Identification Elements

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.

2.04 PRODUCTS FOR COATING SYSTEMS

A. Products: As specified in Attachment B - Coating Detail Sheets.

B. 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.

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.
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. 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.

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 Attachment B.

C. Engineer to ensure Work is in accordance with Contract Documents requirements.

D. 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

A. The following schedule is incomplete. Coat unlisted surfaces with same coating system as similar listed surfaces. Contact Engineer for clarification.

ACR-PVC-1	PVC

Notes:

1: Non-immersed ferrous metal surfaces include:
- a. Doors, doorframes, ventilators, louvers, grilles, exposed sheet metal, and flashing.
- b. Pipe, valves, pipe hangers, supports and saddles, conduit, cable tray hangers, and supports.
- c. Motors and motor accessory equipment.
- d. Drive gear, drive housing, coupling housings, and miscellaneous gear drive equipment.
- e. Valve and gate operators and stands.
- f. Structural steel.
- g. Crane and hoist rails.
- h. Exterior of tanks and other containment vessels.
- i. Mechanical equipment supports, drive units, and accessories.
- j. Bare electrical equipment: boxes, exposed conduit, and accessories.
- k. Pumps not submerged.
- l. Other miscellaneous metals.

2: Immersed ferrous metal surfaces include:
- a. Interior surfaces of ferrous metal tanks.
- b. Field priming of ferrous metal surfaces with defective shop-prime coat; including non-submerged service.
- c. Bell rings, underside of manhole covers and frames.
- d. Sump pumps, including underside of base plates and submerged suction and discharge piping.
- e. Exterior of submerged piping and valves other than stainless steel or PVC piping.
- f. Submerged pipe supports and hangers.
- g. Stem guides.
- h. Other submerged iron and steel metal unless specified otherwise.

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 10400

SIGNAGE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic and metal signs for building and site use.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.

B. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. Product data.

B. Shop drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.

C. Samples: Include actual materials.

D. Manufacturer's installation instructions.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.

C. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.

PART 2 PRODUCTS

2.01 METAL SAFETY SIGNS

A. Manufacturer: Meeting OSHA Requirements; 40-mil thick aluminum with baked enamel finish. One of the following or equal:
   1. Seton Name Plate Co., Special Wording.
   2. Emedco.

B. Danger sign colors:
   1. Background: White.
   2. Heading: White lettering on red oval with white border in black rectangular panel.
   3. Message: Black lettering on white.
   4. Size: As scheduled.

C. Caution sign colors:
   1. Background: Yellow.
   2. Heading: Yellow lettering on black rectangular panel.
   3. Message: Black lettering on yellow.
   4. Size: As scheduled.

D. Safety instruction signs:
   1. Background: White.
   2. Heading: White lettering on green rectangular panel.
   3. Message: Black lettering.
   4. Size: As scheduled.

E. Warning sign colors:
   1. Background: Orange.
   2. Heading: Black lettering on orange diamond in black rectangular panel.
   3. Message: Flack lettering on orange.
   4. Size: As scheduled.

F. Notice information signs:
   1. Background: White.
   2. Heading: White lettering on blue rectangular panel.
   3. Message: Black lettering.
   4. Size: As scheduled.

G. Fasteners: Round head stainless steel bolts or screws.

H. See Attachment B - Metal Safety Sign Schedule for specific sign size, location, text, and quantity.

2.02 HAZARD MATERIAL SIGNALS

A. Manufacturer: One of the following or equal:
   1. Seton Name Plate Co.
   2. Emedco.

B. Hazard material signals: In accordance with NFPA 704; vinyl panels, letters, and symbols with pressure sensitive adhesive, sizes as required for viewing distances, letters and symbols in accordance with Attachment C - Hazard Material Signals.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect adjacent surfaces which may be damaged by installation of signs.

B. Prepare substrates in accordance with sign manufacturer's instructions.

C. Remove scale, dirt, grease, and other contaminates from substrates.

3.02 INSTALLATION

A. Install signs in accordance with sign manufacturer's instructions.

B. Fasten signs securely in level, plumb, and true to plane positions.

C. Install signs where indicated on the Drawings or as indicated in the following Attachments.

END OF SECTION

ATTACHMENT A - METAL SAFETY SIGN SCHEDULE

METAL SAFETY SIGN SCHEDULE

A. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:
   1. Location: On front and back of equipment that starts automatically by remote control.
   2. Height: Five feet above floor elevation.
   3. Size: 6 inches square.
   4. Heading: DANGER
   5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY BY REMOTE CONTROL

ATTACHMENT B - HAZARD MATERIAL SIGNALS

HAZARD MATERIAL SIGNALS

B. HAZARD SIGNAL FOR ALUMINUM SULFATE (ALUM) 48 PERCENT:
   1. Location: At entrances to locations where stored and on storage tanks.
   2. Height: Five feet above floor elevation.
   3. View Distance: 25 feet.
   4. Health: 2
   5. Flammability: 0
   6. Reactivity: 1
   7. Special: COR

C. HAZARD SIGNAL FOR AMMONIUM SULFATE 40 PERCENT:
   1. Location: At entrances to locations where stored and on storage tanks.
   2. Height: Five feet above floor elevation.
   3. View Distance: 25 feet.
   4. Health: 2
   5. Flammability: 0
   6. Reactivity: 1
   7. Special: IRR

SECTION 11242

LIQUID CHEMICAL MOTOR DRIVEN DIAPHRAGM-TYPE METERING PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Positive displacement, diaphragm metering pumps; accessories, drives, and control panel requirements for pumping chemical solutions.

B. Tag numbers:
   1. As specified in Pump Schedule.

1.02 REFERENCES

A. Instrumentation Controls Specialty Contractor (ICSC).

B. International Society of Automation (ISA):
   1. ISA5.4 - Instrument Loop Diagrams.

C. National Electrical Code (NEC).

D. National Electrical Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

F. Underwriters Laboratories, Inc. (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.
   3. 698A – Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
   4. 1283 - Standard for Electromagnetic Interference Filters.
   5. 1449 - Surge Protective Devices.

1.03 DELEGATED DESIGN

A. As specified.

B. Anchoring and bracing.

1.04 SUBMITTALS

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

B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
   1. Design data, test reports, certificates, manufacturer's instructions, manufacturer's field reports:
      a. Chemical feed pumps:
         1) For each pump type, submit calibration charts and tables relating flow rate to stroke length and stroke rate.
         2) Submit hydraulic modeling results for each pumping system.
            a) Confirm scheduled values or recommend new pressure setpoints for the backpressure valves and pressure relief valves listed in the Pump Schedule.
         3) Submit calculations for each metering pump showing the suitability of each pump for the suction and discharge conditions of each application point.
            a) Pump manufacturer shall recommend and size an accumulator to be piped to the suction side of each metering pump, when required based on calculations.
         4) Submit calculations recommending dimensions of pulsation dampener indicated on the Drawings.
   2. Vendor control panel components.

C. Shop drawings: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
   1. Provide a list of parameters, ratings, or other characteristics where the proposed chemical feed systems deviate from the requirements.
   2. Dimensions, including anchor bolt layout, materials of construction, size, weight, and performance data.
   3. Drawings: Provide electrical and instrumentation drawings showing coordination with electrical control devices operating in conjunction with the associated feed system.
   4. Dimensioned inlet and outlet connections.
   5. Current NSF 61 Certification for components to be in contact with associated chemical or potable water.
   6. Provide data showing chemical compatibility and history of service with the associated chemical for materials in the system.
   7. Manufacturer's certificate stating that the materials of construction are compatible with the pumped fluid.
   8. Calibration curves for each pump relating stroke length to flow rate shall be supplied.
   9. Capacity control shall be 0 to 100 percent with delivery repeatable within plus or minus 1 percent accuracy over at least a 10 to 1 range.
   10. Motor and VFD supplier shall carefully review the intended application of the VFD and certify in writing that sizes provided are adequate for continuous or intermittent operations (whichever is the most severe operating condition.
   11. Vendor control panel:
      a. Wiring schematics and control panel layouts:
         1) Scaled exterior front and side elevations with dimensional information.
         2) Scaled interior panel layout showing all components coordinated with the bill of materials.
         3) Bill of materials with detailed description of components.

4) Wiring schematics including wire numbers and terminal numbers.
5) Single-line diagram of power distribution.
6) Control wiring, control logic, and instrumentation.

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. For vendor control panels installed outdoors.

E. Calculations: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

F. Vendor operation and maintenance manuals: As specified in Section 01782 - Operation and Maintenance Manuals.
1. Provide information on each piece of equipment, including instrumentation.
2. Provide all safety considerations relating to operations and handling of the associated chemical.
3. Maintenance data shall include all information and instructions required by plant personnel to keep equipment properly cleaned, lubricated, and adjusted so that it functions economically throughout its full design life.
4. Lubrication charts and tables of alternate lubricants.
5. Name, address, and phone number of manufacturer and manufacturer's local service representative.

G. Commissioning submittals:
1. As specified, 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.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

1.06 DELIVERY, STORAGE AND HANDLING

A. Packing, shipping, handling and unloading:
1. Pack for shipping and outdoor storage at the project site for up to 6 months.
a. Apply temporary corrosion protective coatings to unpainted components and pack components to protect from the elements.
2. Ship pump and drive completely assembled.
a. VFD shall be shipped unwired to the motor for field wiring.

PART 2 PRODUCTS

2.01 GENERAL

A. A single pump manufacturer shall furnish and coordinate all drives and pump components specified in this Section, including motors, gears, couplings, supports, and other specified accessories and appurtenances to ensure compatibility and integrity of the individual components.

B. The manufacturer of the pumps shall have sole-source responsibility for furnishing the complete assemblies and meeting the specified performance requirements.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General: Provide mechanically actuated, positive displacement, diaphragm type chemical metering pumps, accessories, and other items required for a complete and operational system. Each chemical metering pump system shall include, but not be limited to, the following items, which shall be supplied by the chemical metering pump manufacturer.
   1. Pumps.
   2. Motors.
   3. Variable frequency drive (VFD).
   4. Vendor control panels.
   5. Calibration columns.
   6. Pulsation dampeners.
   7. External pressure relief valves.
   8. Diaphragm back pressure valves.

B. Fluid characteristics:
   1. Aluminum sulfate (water solution):
      a. Dry chemical formula: $Al_2(SO_4)_3$.
      b. Solution concentration: 48-49 percent by weight.
      c. Solution pH: Less than 2.5.
      d. Solution specific gravity: 1.32 to 1.34.

C. Design requirements:
   1. Pump:
      a. Dry self-priming, capable of being run dry without damaging effects to pump.
   2. Motor characteristics:
      a. As specified in this Section and in Section 16405 - Electric Motors up to 500 Horsepower.
      b. Minimum acceptable motor size is 1/2 horsepower.
   3. VFD characteristics: As specified in this Section.
   4. Shafting and couplings: Design shafting and couplings to withstand a minimum of 1.5 times the maximum operating torque or other imposed loads.
   5. Supports:
      a. Provide pump and driver supported on a common base.
      b. Design anchor bolts to withstand a minimum of 1.5 times the maximum imposed operating loads.

D. Performance requirements:
   1. Systems shall deliver the pressures and volumes listed for their respective services in the Pump Schedule.

E. Product requirements as specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 PUMPS

A. Existing products:
   1. Existing facility has Prominent brand pumps.
   2. New pumps must match style, material, finish, operation, and dimensions.

B. Equipment:
   1. Pump:
      a. Manufacturers: One of the following or equal:
         1) Prominent Fluid Controls, Inc.
   2. Type: Simplex chemical proportioning pumps of the positive displacement diaphragm type.
   3. Materials:
      a. The metering pumps and their components and accessories shall be suitable for the following chemical concentrations, as scheduled in this Section:
         1) Aluminum sulfate:
            a) Wetted parts shall be suitable for use with 40 to 50 percent aluminum sulfate solution.
            b) Other non-specified materials are to be manufacturer's standard for continuous service with 40 to 50 percent aluminum sulfate solution.
            c)
      b. Diaphragm materials:
         1) Flat, composite, mechanically actuated diaphragms shall be Viton™, EPDM or PTFE faced as pump manufacturer deems suitable for the pumped liquid, fiber reinforced and bonded to an elastomeric support with a Type 316 stainless steel backing plate.
      c. Other parts in contact with pumped liquid: PTFE, PVC, or other suitable thermoplastic.
   4. Characteristics:
      a. Diaphragm simplex chemical proportioning pumps of the positive displacement, lost-motion, flat disc diaphragm type.
      b. The diaphragm shall be mechanically actuated.
      c. Liquid end:
         1) Liquid end shall be sealed by means of an o-ring of material compatible with the pumped liquid.
         2) Pumps for sodium hypochlorite service shall be equipped with an off-gassing valve.
         3) Liquid end of each metering pump shall be fitted with a system to detect early stage diaphragm failure. Upon actuation, the leak detector shall stop the pump, light a locally visible LED and sound a remote alarm.

5. Components:
    a. Manually controlled external stroke controllers.
    b. Suction and discharge single check valves.
    c. Built-in internal or external, adjustable pressure relief valve to relieve pressure in the event of discharge line stoppage, which shall be factory set to relieve at 100 pounds per square inch gauge.
    d. Hydraulic make-up and air bleed valves.
6. Accessories: As indicated on the Drawings, pumps shall be equipped with:
    a. Calibration column in suction piping.
    b. Diaphragm backpressure, pulsation dampener, and pressure relief valve in discharge piping.
7. Tests and inspections:
    a. As scheduled in this Section.
8. Verification of performance.

2.04 PUMP GEARBOX DRIVE

A. Pump gearbox shall be constructed of PPE and be water resistant and suitable for outdoor installation.
    1. Pump and gearbox housing shall be coated in high-solids epoxy.

B. Gearbox shall be oil bath lubricated.

C. All fasteners shall be Type 316 stainless steel.

2.05 MOTOR

A. Type:
    1. Each chemical metering pump shall be motor-driven through a flexible coupling, or direct-connected to the pump when manufacturer's standard.
    2. Pumps and motors shall be skid mounted.
        a. Coupler:
            1) Manufacturers: One of the following or equal:
                a) ProMinent Fluid Controls, Inc.

B. Characteristics:
    1. Provide motors as specified in Section 16405 - Electric Motors and the Pump Schedule.
    2. AC Motors and drives shall be furnished by the pump manufacturer and shall be coordinated with the requirements of the pumps.
    3. DC motors:
        a. The motor shall be a permanent magnet type, having a [90][250][500] volt direct current armature rating, and horsepower not less than the minimum specified rating.
        b. Motor shall have a thermostat for high temperature shutdown.
        c. The motor brushes shall have tinned leads.

2.06 VENDOR CONTROL PANELS

A. General:
   1. Construction and components as specified in Section 17320 - Package Control Systems.
   2. Vendor control panels shall be UL listed and labeled.
   3. VCP shall be wired and factory tested for proper operation prior to shipment.
      a. Factory-assemble and wire the control panel such that field wiring only requires connections to terminals.
      b. Additional testing requirements as specified in Section 17300 - Instrumentation Control and Monitoring System General Provisions.
   4. Provide necessary control hardware, software, and components as required for a fully functional and operational installation.

B. Enclosures and panel components:
   1. NEMA enclosure type: NEMA Type 4X, Type 316 stainless steel.
   2. Main circuit breaker:
      a. As specified in Section 17320 - Package Control Systems.
      b. Rated for the available fault current at the installed location.
      c. Flange-mounted operator:
         1) Pad-lockable in the off position.
      d. Disconnects all power to the panel.
      e. Interlock with the panel door:
         1) Defeat mechanism.
   3. Control power transformer:
      a. Primary voltage: match the power supply voltage to the VCP.
      b. Sized for all panel components plus 10 percent spare capacity.
      c. Primary and secondary fuses.
   4. Input voltage: 120 volts, 1-phase, 60 hertz.
   5. Control requirements:
      a. Provide and install Allen Bradley Compact Logix Remote I/O with necessary I/O cards to accommodate all I/O signals from the chemical metering pumps. All hardwire signals from pumps, instruments, and other skid provided equipment shall be wired to the Remote I/O Panel.
      b. Refer to P&ID drawings for signal interface requirements and any additional signals that shall be part of the package provided Remote I/O that is not part of chemical skid scope and provide number of I/O cards accordingly.
      c. Programming of the Plant PLC and configuring this Remote I/O to the Plant PLC network is part of the Instrumentation Integrator scope. Provide all necessary panel components including but not limited to Remote IO communication card (Ethernet IP), I/O cards, Ethernet Switch, etc. for fully functional system in place.
      d. Coordinate with the Instrumentation System Integrator responsible for programming of the Plant PLC and SCADA to fully integrate this Remote I/O panel in overall Plant PLC system. The participation is required in system testing, calibration, startup services, control and instrument loop checks to verify and ensure proper loop operation from all HMI and SCADA screens to the physical instrument or control device.

6. Pilot devices (per pump):
    a. Controls:
        1) LOCAL-OFF-REMOTE selector switch.
        2) Speed potentiometer.
    b. Lights:
        1) Run Status:
            a) Leak Alarm.
            b) Fault Alarm.
7. Control Panel Schedule:
    a. Alum Control Panel RIO.

C. Monitoring and control:
1. Provide the following information available at the Remote I/O for communication connections to the plant control system for each pump:
    a. Speed setpoint.
    b. Speed feedback.
    c. REMOTE status.
    d. RUNNING status.
    e. LEAK alarm status.
    f. FAILURE alarm status.
    g. Pump RUN COMMAND.
2. Refer to P&ID drawings for all other monitoring and control requirements for additional signals that shall be part of the package provided Remote I/O.

2.07 ACCESSORIES

A. Pulsation dampeners:
1. Manufacturers: One of the following or equal:
    a. ProMinent Fluid Controls, Inc.
2. Pulsation dampeners shall be furnished and installed on each chemical metering pump's discharge lines as indicated on the drawings.
3. Materials:
    a. Pulsation dampeners shall have Hypalon or PTFE diaphragms and PVC chamber.
        1) Materials shall be compatible with the pumped liquid at the specified concentration, and suitable for outdoor use and exposure.
4. Characteristics:
    a. Pulsation dampeners shall be gas or air charged, single diaphragm type complete with valved gas/air charge valve connection and pressure gage graduated from 0 to 200 pounds per square inch.
    b. Pulsation dampeners shall be sized appropriately for each pump to remove a minimum of 95% of the pulsations. Supplier shall provide calculations to verify sizing..
5. Dampeners shall be provided with a true-union ball valve for shutoff.

B. Calibration columns:
1. Materials:
    a. Materials shall be compatible with the pumped liquid and concentration specified in this Section, and suitable for outdoor use and exposure.

2. Characteristics:
    a. Furnish and install calibration columns, 1 for each chemical metering pump, on each chemical pump's inlet line as indicated on the Drawings and specified in this Section.
        1) Columns shall be translucent.
    b. Chamber shall be sized to give adequate capacity for a minimum 30-second draw down test at maximum pump capacity.
    c. Provide top cap threaded connection with vent piped to floor to prevent entry of foreign materials and to direct spillage or overflow.
    d. End connections shall be threaded.
    e. Capacities and graduations shall be as indicated in the schedule in this Section.

C. Diaphragm backpressure and pressure relief valves:
1. As specified in Section 15118 - Pressure Reducing and Pressure Relief Valves.
2. Manufacturers: One of the following or equal:
    a. ProMinent Fluid Controls, Inc.
3. Materials:
    a. Valves shall be of suitable materials for the pumped liquid.
4. Characteristics:
    a. Ported to serve as either a backpressure valve or a pressure relief valve.
    b. Relief valve shall be plumbed to the nearest chemical drain, or back to the pump suction on the non-pump side of the pump suction isolation valve, to avoid spillage, as indicated on the Drawings.
    c. Valves shall be furnished and installed on each chemical metering pump's discharge lines as indicated on the Drawings and scheduled in this Section.
    d. Valves shall have an adjustable spring range of 0-150 pounds per square inch. Valves shall be factory adjusted for the backpressure recommended by the pump manufacturer.
    e. Valves shall produce a back pressure no greater than 10 pounds per square inch above valve set pressure when metering pumps are operating at full capacity, pulsating flow.

D. Pressure relief valves:
1. Furnish and install pressure relief valves on each chemical metering pump's discharge line as indicated on the Drawings.
2. Materials:
    a. Wetted materials shall be compatible with the pumped liquid.
3. Characteristics:
    a. Valves shall have an adjustable spring range of 0-150 pounds per square inch. Valves shall be factory adjusted for the relief pressure recommended by the pump manufacturer.

E. Additional accessories:
1. Additional accessories required for the system but not required to be supplied by the pump manufacturer include:
    a. Diaphragm seals as specified in Section 17304 - Instrumentation, except as modified in this Section:

1) Materials shall be compatible with the pumped liquid at the specified concentration and suitable for outdoor use and exposure.

b. Pressure switches as specified in Section 17304 - Instrumentation.
c. Pressure gauges as specified in Section 17304 - Instrumentation.
d. Isolation valves as specified in Section 15111 - Ball Valves for suction and discharge piping as indicated on the Drawings.

F. Each chemical metering pump shall be provided with an automatically controlled, manual external stroke controller graduated in 0.25 percent increments to adjust the capacity from 0 to 100 percent while the pump is operating.
1. Electronic external stroke controller shall operate on a power source of 120 volts supplied from the VCP, and shall automatically control stroke of the pump based on a 4-20 mA signal.
2. Electronic external stroke controller shall allow pump to be controlled remotely by a signal originating from the PLC or by a manually controlled external stroke adjustment wheel located on controller.
3. Stroke controller shall include a digital stroke length indicator, calibrated from 0 to 100 percent.
4. Stroke control panel shall be rated in accordance with NEMA Type 4X enclosure.

G. The skid-mounting of the metering pumps and accessories shall conform to the following requirements:
1. Components to be mounted on the skid are as indicated on the Drawings and shall include the metering pump, calibration column, piping, valves, piping accessories (e.g., pulsation dampeners, back pressure valves, pressure relief valves, etc.), and wiring integral to the skid. The supplier shall be responsible for providing all equipment, valves, and piping within the skid boundary.
2. The skids shall be constructed of fusion welded polypropylene sheets with adequate supports for all equipment and piping and a 1/2-inch drip lip. Forklift truck cut outs shall also be provided.
3. All new components of the skid-mounted system (pumps, piping, and controls) shall be tested at the shop prior to shipping.

2.08 NAMEPLATES

A. Each pump, gearbox, and motor shall have, securely affixed in a conspicuous location, a stainless steel nameplate with raised letters providing the manufacturer's model, serial number, rating, range, speed and other pertinent data.

2.09 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts: Furnish the following spare parts packed and labeled for warehouse storage:
1. Complete set of inlet and outlet ball check valves (balls, seats and gaskets) and a diaphragm for each pump.
2. 1 complete spare parts kit for each pump provided.
3. 1 spare parts kit for each size and type of backpressure and pressure relief valve.

4. An initial supply of all oils, greases, and lubricants required to start operations. Supply an amount of these materials equivalent to 1 year of continuous operation for each system.

B. Vendor to provide spare parts that are required to provide uninterrupted operation for a minimum of 2 years.

C. Additional spare part requirements as specified in the Contract Documents.

D. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

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 vendor control panel in accordance with the accepted installation instructions and anchorage details.

3.03 COMMISSIONING

A. As specified.

B. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.

C. Installation Verification:
   1. Furnish Manufacturer’s Certificate of Installation Verification.

D. Functional Testing:
   1. Equipment testing:
      a. As scheduled.
   2. System testing:
      a. As specified in this Section.
   3. Furnish Manufacturer’s Certificate of Functional Compliance.

E. Owner Training:
   1. Perform Owner training as specified.
   1. Number of sessions:
      a. Operations 2.
      a. Maintenance 2.

3.04 SCHEDULES

A. Pumps:

Tag Number	**66-CMP-11; 66-CMP-12**
Feed Point	Rapid Mix Basin
Service	Aluminum Sulfate
Pump Type	Single Diaphragm
Number of Pumps	2
Named Manufacturer	ProMinent Fluid Controls, Inc.
Rotodynamic Analysis	Not Required
Pump Characteristics	
Design Conditions:	
Maximum Flow, (gallons per hour)	134
Minimum Flow, (gallons per hour)	7
Normal Flow, (gallons per hour)	57
Pump Stroke Range (strokes per hour)	0.01 - 120
Maximum Discharge Pressure (psig)	18
Minimum Suction Lift (feet)	0
Pump Materials	
Pump Housing/Enclosure	Fiberglass-reinforced PPE
First Diaphragm	PTFE faced
Second Diaphragm	N/A
Pump Liquid End	PVDF
Driver Characteristics	
Driver Type	Motor with VFD
Drive Coupling	Close-coupled, Horizontal
Minimum Driver Horsepower	0.5
Maximum Driver Speed (rpm)	1,700
Source Testing	
Performance Test Level	1
Vibration Test Level	None
Noise Test Level	None
Functional Testing	
Performance Test Level	1
Vibration Test Level	1
Noise Test Level	1

1. Provide pumps that deliver the maximum capacity, listed in the above table, when at full speed and maximum stroke length.

END OF SECTION

SECTION 11243

LIQUID CHEMICAL SOLENOID DRIVEN DIAPHRAGM-TYPE METERING PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Positive displacement, solenoid metering pumps for pumping chemical solutions, complete with drives, controls, and features specified and scheduled in this Section.

B. Tag numbers: As specified in Pump Schedule.

1.02 REFERENCES

A. Instrumentation Controls Specialty Contractor (ICSC).

B. International Society of Automation (ISA):
   1. ISA-5.4 - Instrument Loop Diagrams.

C. National Electrical Code (NEC).

D. National Electrical Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

F. Underwriters Laboratories, Inc. (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.
   3. 698A – Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
   4. 1283 - Standard for Electromagnetic Interference Filters.
   5. 1449 - Surge Protective Devices.

1.01 DELEGATED DESIGN

G. As specified.

H. Anchoring and bracing.

1.03 SUBMITTALS

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

B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
   1. Provide all safety considerations relating to operations and handling of the associated chemical.
   2. Maintenance data shall include all information and instructions required by plant personnel to keep equipment properly cleaned and adjusted so that it functions economically throughout its full design life.
   3. Name, address, and phone number of manufacturer and manufacturer's local service representative.
   4. Vendor control panel components.

C. Shop drawings:
   1. Provide a list of parameters, ratings, or other characteristics where the proposed chemical feed systems deviate from the requirements.
   2. Dimensions, materials of construction, size, weight, and performance data.
   3. Drawings: Provide electrical and instrumentation drawings showing coordination with electrical control devices operating in conjunction with the associated feed system.
   4. Dimensioned inlet and outlet connections.
   5. Current NSF 61 Certification for components to be in contact with associated chemical or potable water.
   6. Provide data showing chemical compatibility and history of service with the associated chemical for materials in the system.
   7. Vendor control panel:
      a. Wiring schematics and control panel layouts:
         1) Scaled exterior front and side elevations with dimensional information.
         2) Scaled interior panel layout showing all components coordinated with the bill of materials.
         3) Bill of materials with detailed description of components.
         4) Wiring schematics including wire numbers and terminal numbers.
         5) Single-line diagram of power distribution.
         6) Control wiring, control logic, and instrumentation.

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. For vendor control panels installed outdoors.

E. Calculations: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
   1. For each pump type, submit calibration charts and tables relating flow rate to stroke length and stroke rate.
   2. Confirm scheduled values or recommend new pressure setpoints for the backpressure valves and pressure relief valves listed in the Pump Schedule.
   3. Submit calculations recommending dimensions of pulsation dampener indicated on the Drawings.

4. Calibration curves for each pump relating stroke length to flow rate shall be supplied.
    a. Capacity control shall be 0 to 100 percent with delivery repeatable within plus or minus 1 percent accuracy over at least a 10 to 1 range.
    b. Motor and VFD supplier shall carefully review the intended application of the VFD and certify in writing that sizes provided are adequate for continuous or intermittent operations (whichever is the most severe operating condition.

F. Vendor operation and maintenance manuals: As specified in Section 01782 - Operation and Maintenance Manuals.

G. Commissioning submittals:
    1. As specified, 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.

1.04 DELIVERY, STORAGE AND HANDLING

A. Packing, shipping, handling and unloading:
    1. Pack for shipping and outdoor storage at the project site for up to 6 months.
    2. Ship all pumps and drives completely assembled.
    3. Deliver spare parts at same time as equipment. Deliver to Owner after completion of the work.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. A single pump manufacturer shall furnish and coordinate all drives and pump components specified in this Section, calibration columns and other specified accessories and appurtenances to ensure compatibility and integrity of the individual components.

B. The manufacturer of the pumps shall have sole-source responsibility for furnishing the complete assemblies and meeting the specified performance requirements.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General: Provide solenoid actuated, positive displacement, diaphragm type chemical metering pumps, accessories, and other items required for a complete and operational system. Each chemical metering pump system shall include, but not be limited to, the following items, which shall be supplied by the chemical metering pump manufacturer except as noted.
   1. Pumps.
   2. Pulsation dampeners.
   3. Calibration columns.
   4. Diaphragm back pressure valves.
   5. External pressure relief valves.

B. Fluid characteristics:
   1. Liquid ammonium sulfate:
      a. Dry chemical formula: $(NH_4)_2SO_4$.
      b. Solution concentration: 38-40 percent by weight.
      c. Solution pH: 4.0-7.0.
      d. Solution specific gravity: 1.21-1.23.

C. Design requirements:
   1. Pump performance characteristics:
      a. As specified in Pump Schedule in this Section.
      b. Dry self-priming, capable of being run dry without damaging effects to pump.
   2. Positive flow shall be ensured by a minimum of 2 ball-type check valves and valve functions for pressure relief, backpressure, anti-siphon, air bleed and discharge drain.
   3. The pumps shall be suitable for operation with the chemicals specified below under performance requirements.
   4. All solenoid metering pumps shall be especially designed, adapted, and fully guaranteed for the respective, intended use.

D. Performance requirements:
   1. Systems shall deliver the pressures and volumes listed for their respective services in the Pump Schedule in this Section.

E. Product requirements as specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 PUMPS

A. Existing products:
   1. Existing facility has ProMinent Fluid Controls, Inc. brand pumps. New pumps must match style, material, finish, operation, and dimensions.

B. Equipment:
   1. Manufacturers: All solenoid metering pumps shall all be of the same manufacturer. One of the following or equal:
      a. ProMinent Fluid Controls, Inc., Gamma XL Series

2. Type: Simplex chemical proportioning pumps of the positive displacement diaphragm type.
3. Materials:
    a. Flat, composite, mechanically actuated diaphragms shall be Hypalon, Viton™, EPDM or PTFE faced as pump manufacturer deems suitable for the pumped liquid, fiber reinforced and bonded to an elastomeric support with a Type 316 stainless steel backing plate.
    b. All other wetted parts shall be Teflon™, PVC or other suitable thermoplastic material.
    c. All other non-specified materials are to be manufacturer's standard, for continuous service with the specified pumped liquids.
    d. Manufacturer shall submit the materials for each component to be used for each chemical service with record of service with same chemical.
4. Characteristics: Chemical proportioning pumps of the positive displacement, non-hydraulic, solenoid driven, diaphragm type. Pump shall be water resistant for outdoor installation, and internally dampened for noise reduction.
    a. Pumps for sodium hypochlorite service shall be equipped with an off-gassing valve.
    b. Liquid end of each metering pump shall be fitted with a system to detect early stage diaphragm failure. Upon actuation, the leak detector shall STOP the pump, light a locally visible LED and sound a remote alarm.
5. Components:
    a. Electronically controlled stroke controllers.
    b. Suction and discharge double check valves.
    c. Built-in internal or external, adjustable pressure relief valve to relieve pressure in the event of discharge line stoppage, which shall be factory set to relieve at manufacturer’s recommended pressure limit.
6. Accessories: As indicated on the Drawings, pumps shall be equipped with:
    a. Calibration column in suction piping.
    b. Diaphragm backpressure valve, pulsation dampener, and pressure relief valve in discharge piping.
7. Tests and inspections:
    a. As scheduled in this Section.

2.04 MOTOR

A. Characteristics:
    1. Provide motors as specified in Section 16405 - Electric Motors and the Pump Schedule.
    2. Motors shall be furnished by the pump manufacturer and shall be coordinated with the requirements of the pumps

2.05 CONTROL REQUIREMENTS

A. Hardwired control functions:
    1. Pump shall automatically stop pulsing when the discharge pressure exceeds pump pressure rating by not more than 35 percent with the pump at maximum stroke rate.

B. Each chemical metering pump shall be provided with an automatically controlled, electronic external stroke controller graduated in 0.25 percent increments to adjust the capacity from 0 to 100 percent while the pump is operating.
   1. Electronic external stroke controller shall operate on a power source of 120 volts supplied from the VCP, and shall automatically control stroke of the pump based on a 4-20 mA signal.

2.06 VENDOR CONTROL PANELS

A. General:
   1. Construction and components as specified in Section 17320 - Package Control Systems.
   2. Vendor control panels shall be UL listed and labeled.
   3. VCP shall be wired and factory tested for proper operation prior to shipment.
      a. Factory-assemble and wire the control panel such that field wiring only requires connections to terminals.
      b. Additional testing requirements as specified in Section 17300 - Instrumentation and Control Monitoring System General Provisions.
   4. Provide necessary control hardware, software, and components as required for a fully functional and operational installation.

B. Enclosures and panel components:
   1. NEMA enclosure type: NEMA Type 4X, Type 316 stainless steel.
   2. Main circuit breaker:
      a. As specified in Section 17320 - Package Control Systems.
      b. Rated for the available fault current at the installed location.
      c. Flange-mounted operator:
         1) Pad-lockable in the off position.
      d. Disconnects all power to the panel.
      e. Interlock with the panel door:
         1) Defeat mechanism.
   3. Control power transformer:
      a. Primary voltage: match the power supply voltage to the VCP.
      b. Sized for all panel components plus 10 percent spare capacity.
      c. Primary and secondary fuses.
      d. Input voltage: 120 volts, 1-phase, 60 hertz.
   4. Control requirements:
      a. Provide and install Allen Bradley Compact Logix Remote I/O with necessary I/O cards to accommodate all I/O signals from the chemical metering pumps. All hardwire signals from pumps, instruments, and other skid provided equipment shall be wired to the Remote I/O Panel.
      b. Refer to P&ID drawings for signal interface requirements and any additional signals that shall be part of the package provided Remote I/O that is not part of chemical skid scope and provide number of I/O cards accordingly.
      c. Programming of the Plant PLC and configuring this Remote I/O to the Plant PLC network is part of the Instrumentation Integrator scope. Provide all necessary panel components including but not limited to Remote IO communication card (Ethernet IP), I/O cards, Ethernet Switch, etc. for fully functional system in place.

d. Coordinate with the Instrumentation System Integrator responsible for programming of the Plant PLC and SCADA to fully integrate this Remote I/O panel in overall Plant PLC system. The participation is required in system testing, calibration, startup services, control and instrument loop checks to verify and ensure proper loop operation from all HMI and SCADA screens to the physical instrument or control device.

5. Pilot devices (per pump):
   a. Controls:
      1) LOCAL-OFF-REMOTE selector switch.
      2) Speed potentiometer.
   b. Lights:
      1) Run Status:
         a) Leak Alarm.
         b) Fault Alarm.
6. Control Panel Schedule:
   a. Ammonia Control Panel RIO.

C. Monitoring and control:
   1. Provide the following information available at the Remote I/O for the communication connections to the plant control system for each pump:
      a. Speed setpoint.
      b. Speed feedback.
      c. REMOTE status.
      d. RUNNING status.
      e. LEAK alarm status.
      f. FAILURE alarm status.
      g. Pump RUN COMMAND.
   2. Refer to P&ID drawings for all other monitoring and control requirements for additional signals that shall be part of the package provided Remote I/O.

2.07 ACCESSORIES

A. Pulsation dampeners:
   1. Manufacturers: One of the following or equal:
      a. ProMinent Fluid Controls, Inc.
   2. Pulsation dampeners shall be furnished and installed on each chemical metering pump's discharge lines as indicated on the Drawings.
   3. Materials:
      a. Diaphragms shall be Hypalon or PTFE.
      b. Chamber shall be PVC.
      c. Materials shall be compatible with the pumped liquid at the specified concentration, and suitable for outdoor use and exposure.
   4. Pulsation dampener shall be provided/designed by the pump manufacturer.
   5. Pulsation dampeners shall be sized appropriately for each pump to remove a minimum of 95% of the pulsations. Supplier shall provide calculations to verify sizing. Pulsation Dampeners shall be mounted within 6 feet of the pump discharge port and upstream of associated flow meters. No other equipment shall be installed between the discharge pulsation dampener and pump.
   6. Dampener shall be provided with a true-union ball valve for shutoff.

B. Calibration columns:
   1. Materials:
      a. Materials shall be compatible with the pumped liquid and concentration specified in this Section, and suitable for outdoor use and exposure.
   2. Characteristics:
      a. Furnish and install calibration columns, 1 for each chemical metering pump, on each chemical pump's inlet line as indicated on the Drawings and specified in this Section. Columns shall be translucent.
      b. Chamber shall be sized to give adequate capacity for a minimum 30-second draw down test at maximum pump capacity.
      c. Provide top cap threaded connection with vent piped to floor to prevent entry of foreign materials and to direct spillage or overflow.
      d. End connections shall be threaded.
      e. Capacities and graduations shall be as shown in the schedule in this Section.

C. Diaphragm backpressure valves and pressure relief valves:
   1. As specified in Section 15118 - Pressure Reducing and Pressure Relief Valves.
   2. Manufacturers: One of the following or equal:
   3. ProMinent Fluid Controls, Inc.Materials:
      a. Valves shall be of suitable materials for the pumped liquid.
      b. The valves shall have a Hypalon or PTFE diaphragm, PVC body and seat, and PVC bonnet.
   4. Characteristics:
      a. Ported to serve as either a backpressure valve or a pressure relief valve.
      b. Valves shall have an adjustable spring range of0-150 pounds per square inch. Valves shall be factory adjusted for the backpressure recommended by the pump manufacturer.
      c. Valves shall produce a back pressure no greater than 10 pounds per square inch above valve set pressure when metering pumps are operating at full capacity, pulsating flow.
   5. Relief valves shall be plumbed to the nearest chemical drain, or back to the pump suction on the non-pump side of the pump suction isolation valve, to avoid spillage, as indicated on the Drawings.
   6. Valves shall be furnished and installed on each chemical metering pump's discharge lines as indicated on the Drawings and scheduled in this Section.
   7. As an alternative to separate backpressure and pressure relief valves, each metering pump may be supplied with a multi-function valve. The valve shall perform the following functions: Pressure relief, back pressure, anti-siphon, pump head air bleed and discharge drain. Multi-function valve shall be from the pump manufacturer with the proper materials of construction selected and design features made specifically for its intended chemical service.

D. Pressure relief valves:
   1. Furnish and install pressure relief valves on each chemical metering pump's discharge line as indicated on the Drawings.
   2. Materials:
      a. Wetted materials shall be compatible with the pumped liquid.

3. Characteristics:
    a. Valves shall have an adjustable spring range of 0-150 pounds per square inch. Valves shall be factory adjusted for the relief pressure recommended by the pump manufacturer.

E. Additional accessories:
    1. Additional accessories required for the system but not required to be supplied by the pump manufacturer include:
        a. Diaphragm seals as specified in Section 17304 - Instrumentation, except as modified in this Section:
            1) Materials shall be compatible with the pumped liquid at the specified concentration and suitable for outdoor use and exposure.
        b. Pressure switches as specified in Section 17304 - Instrumentation.
        c. Pressure gauges as specified in Section 17304 - Instrumentation.
        d. Isolation valves as specified in Section 15111 - Ball Valves for suction and discharge piping as indicated on the Drawings.

F. The skid-mounting of the metering pumps and accessories shall conform to the following requirements:
    1. Components to be mounted on the skid are as indicated on the Drawings and shall include the metering pump, calibration column, piping, valves, piping accessories (e.g., pulsation dampeners, back pressure valves, pressure relief valves, etc.), and wiring integral to the skid. The supplier shall be responsible for providing all equipment, valves, and piping within the skid boundary.
    2. The skids shall be constructed of fusion welded polypropylene sheets with adequate supports for all equipment and piping and a 1/2-inch drip lip. Forklift truck cut outs shall also be provided.
    3. All new components of the skid-mounted system (pumps, piping, and controls) shall be tested at the shop prior to shipping.

2.08 NAMEPLATES

A. Each pump, gearbox, and motor shall have, securely affixed in a conspicuous location, a stainless steel nameplate with raised letters providing the manufacturer’s model, serial number, rating, range, speed and other pertinent data.

2.09 SPARE PARTS AND SPECIAL TOOLS

A. Furnish the following spare parts packed and labeled for warehouse storage:
    1. 1 complete spare parts kit as recommended by the manufacturer for each pump provided.
    2. 1 spare parts kit for each size and type of backpressure and pressure relief valve.

B. Vendor to provide spare parts that are required to provide uninterrupted operation for a minimum of 2 years.

C. Additional spare part requirements as specified in the Contract Documents.

D. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

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 vendor control panel in accordance with the accepted installation instructions and anchorage details.

3.03 IDENTIFICATION

A. Identification of the health, flammability, and reactivity of hazardous materials shall be affixed to each chemical storage drum and day tank, as specified in Section 10400 - Signage.

3.04 COMMISSIONING

A. As specified.

B. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.

C. Installation Verification:
   1. Furnish Manufacturer’s Certificate of Installation Verification.

D. Functional Testing:
   1. Equipment testing:
      a. As scheduled.
   2. System testing:
      a. As specified in this Section.
   3. Furnish Manufacturer’s Certificate of Functional Compliance.

E. Owner Training:
   1. Perform Owner training as specified.
   2. Number of sessions:
      a. Operations 2.
      b. Maintenance 2.

3.05 SCHEDULES

A. Pumps:

Tag Number	**67-CMP-11** **67-CMP-12**	**67-CMP-13** **67-CMP-14**
Feed Point	Surface Water Plant, Pre-Filters	RO Permeate Clearwell
Service	Liquid Ammonium Sulfate	Liquid Ammonium Sulfate
Pump Type	Solenoid Actuated	Solenoid Actuated
Number of Pumps	2	2
Named Manufacturer	ProMinent Fluid Controls, Inc.	ProMinent Fluid Controls, Inc.
Pump Characteristics		
Design conditions:		
Maximum Flow, (gallons per hour)	9.7	10.0
Minimum Flow, (gallons per hour)	0.9	0.06
Normal Flow, (gallons per hour)	3.6	1.9
Pump Stroke Range (spm)	0.02 – 200	–0.02 – 200
Maximum Discharge Pressure (psig)	32	28
Minimum Suction Lift (feet)	0	0
Pump Materials		
Pump Housing/Enclosure	Fiberglass-reinforced PPE	Fiberglass-reinforced PPE
Diaphragm	PTFE	PTFE
Pump liquid End	PVDF	PVDF
Driver Characteristics		
Driver Type	Solenoid	Solenoid
Maximum Driver Speed (spm)	200	200
Service Factor	1.0	1.0
Voltage/Phases/Hertz	120/1/60	120/1/60
NEMA Enclosure Type	4X	4X

Tag Number	**67-CMP-11** **67-CMP-12**	**67-CMP-13** **67-CMP-14**
Source Testing		
Test Witnessing	Not Witnessed	Not Witnessed
Performance Test Level	None	None
Vibration Test Level	None	None
Noise Test Level	None	None
Functional Testing		
Performance Test Level	1	1

1. Provide pumps that deliver the maximum capacity, listed in the above table, when at full speed and maximum stroke length.

END OF SECTION

SECTION 11312S

HORIZONTAL MAGNETIC DRIVE CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Centrifugal, close coupled, magnetic drive, end-suction, sealless pumps with drivers and features as scheduled.
   2. Tag numbers: As specified in the Pump Schedule.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.
   3. B73.1 - Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process.

B. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
   5. A395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
   6. A494 - Standard Specification for Castings, Nickel and Nickel Alloy.
   7. A743 - Standard Specification for Casting, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   8. B367 - Standard Specification for Titanium and Titanium Alloy Castings.
   9. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   10. F594 - Standard Specification for Stainless Steel Nuts.

C. Hydraulic Institute (HI):
   1. 9.1-9.5 - Pumps - General Guidelines.
   2. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
   3. 14.3 - Rotodynamic Pumps for Design and Application.
   4. 14.4 - Rotodynamic Pumps for Installation Operation and Maintenance.

D. National Electrical Code (NEC).

E. Occupational Safety and Health Administration (OSHA).

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, 14.1-14.2, 14.3, 14.4, and as modified in this Section.
   4. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.
   5. Tolerances: In accordance with HI 9.1-9.5, 14.1-14.2, 14.3, and 14.4, unless specified more restrictively.

1.04 DELEGATED DESIGN

A. As specified.

B. Anchoring and bracing.

C. 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. For equipment installed outdoors.
      b. For wall mounted equipment weighing 125 pounds or more.

C. Commissioning Submittals:
   1. As specified, 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. As specified in Section 01600 - Product Requirements.
   1. Product data.
   2. Shop Drawings.
   3. Manufacturer's instructions.
   4. Calculations:
      a. Torsional analysis.
   5. 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 01600 - 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. Pump:
   1. The following or equal:
      a. Flowserve Polychem, M Series.
      b. Goulds Pump, Model 3298.
      c. Iwaki America, MDM Series.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Supply horizontal, centrifugal, ASME B73.1 end suction, magnetic-drive pump. non-metallic, lined magnetic drive pumps shall utilize ductile cast iron outer shell with injection molded liner and encapsulated inner rotating assembly, including a set of inner magnets within a containment shell or rear casing.
   1. Inner magnets are magnetically coupled or driven by outer magnet ring or drive magnet coupled to a conventional drive motor.
   2. Liquid end is hermetically sealed by static O-ring or gasket(s).
   3. Provide components as specified and other items as required for a complete and operational system.
   4. Pumps shall comply with the latest additions of the following codes and standards:
      a. ASME B73.1.
      b. HI.
      c. NEC.
      d. OSHA Rules and Regulations.

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.
         1) Vibration analysis expert: Provide when scheduled.
      c. All required conditions (flow/head) shall be within the pump manufacturer's Allowable Operating Region (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 the Pump Schedule.

C. Product requirements as specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 MATERIALS

A. General: Materials in the Pump Schedule shall be the type and grade as specified in this Section.

B. Cast iron: ASTM A48, Class 30 minimum.

C. Ductile iron: ASTM A395.

D. Steel: ASTM A108, Grade as scheduled.

E. Stainless steel: ASTM A276, type as scheduled.

F. Iron-chromium alloy: ASTM A743, Grade CA40.

G. Structural steel: ASTM A283, Grade D.

H. Hastelloy C: ASTM A494, Grade CW-12M-2.

I. Titanium: ASTM B367, Grade C-3.

2.04 GENERAL PUMP CONSTRUCTION

A. Type: Centrifugal, close coupled, magnetic drive, end-suction, sealless pumps manufactured in accordance with ASME standards.

B. Discharge flange: ASME B16.1 or B16.5 drilled; rated for 1.2 times the pump shutoff head at 150 degrees Fahrenheit.

C. Suction flange: ASME B16.1 or B16.5 drilled.

D. Fasteners: Provide Type 316 stainless steel fasteners in accordance with ASTM F593 or ASTM F594.

E. Vibration: As specified in Section 15958 - Mechanical Equipment Testing.

F. Permanent alignment of the pump to motor shall be provided.

2.05 PUMP CASINGS

A. Type: 2-piece volute type with a minimum 1/8-inch thick liner, integral suction, and discharge nozzles.

B. Material: As scheduled.

C. Design working pressure: Minimum 1.10 times maximum shutoff total dynamic head with maximum installable impeller diameter at maximum operating speed plus maximum suction static head.

D. Hydrostatic test: 10-minute hydrostatic test at minimum 1.5 times design working pressure.

E. Pump lining shall be applied to the casing and not rely on a mechanical locking method.

2.06 IMPELLERS

A. Type: As scheduled.

B. Material: As scheduled.

C. Radial bearings and spacers shall be supplied and manufactured of silicon carbide with carbon coating for run dry protection.

D. Thrust bearings and rear wear ring shall be supplied and manufactured of silicon carbide with carbon coating for run dry protection.

E. Bearings shall be lubricated by a pumpage recirculation circuit.

F. Balance: As specified in Section 15050 - Common Work Results for Mechanical Equipment and vibration criteria as specified in Section 15958 - Mechanical Equipment Testing.

2.07 PUMP SHAFTS

A. Material: As scheduled.

B. Strength: Able to withstand minimum 1.5 times maximum operating torque and/or other loads as applicable.

C. Pump shaft shall be a solid shaft design.

2.08 MAGNETS

A. Provide drive magnets suitable for the entire pump curve performance range to ensure that the pump will not de-couple.

B. Impeller magnets to be encased in the same material as the impeller.

2.09 PUMP FRAME

A. Material: As scheduled.

B. Provide a 1-piece rigid construction frame with a machined face for a “C” face mounted motor at the driver end and gasketed at pump end.

C. Frame shall have drain and vent connections.

2.10 EQUIPMENT GUARDS

A. Provide equipment safety guards as specified in Section 15050 - Common Work Results for Mechanical Equipment.

2.11 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: Provide motors as specified in Section 16405 - Electric Motors and as specified in this Section:
   1. Revolutions per minute: As scheduled.
   2. Enclosure: As scheduled.
   3. Electrical characteristics: As scheduled.
   4. Efficiency, service factor, insulation, and other motor characteristics: As specified in Section 16405 - Electric Motors.
   5. Motor accessories: As specified in Section 16405 - Electric Motors and in this Section.
   6. Coordinate motors with the variable frequency drive manufacturer to ensure compatibility between the motor and variable frequency drive.

C. Drivers: As scheduled and as specified in sections listed in the Schedule.

2.12 ANCHOR BOLTS

A. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.13 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts:
   1. Pump thrust bearing set.
   2. Pump radial bearing set.
   3. 1 set of gaskets, seals, and O-rings.

B. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

PART 3 EXECUTION

3.01 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.

3.03 COMMISSIONING

A. As specified.

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.
   2. Number of sessions:
      a. Operations 2.
      b. Maintenance 2.

3.04 PUMP SCHEDULE

Tag Numbers	**66-PMP-01 66-PMP-02**	**67-PMP-01 67-PMP-02**
General Characteristics:		
Service	Aluminum Sulfate 48%	Liquid Ammonium Sulfate 40%
Quantity	2	2
First Named Manufacturer's Model		
Maximum Noise, dBA at 3 feet	78	78
Minimum Pumped Fluid, degrees Fahrenheit	60	60
Normal Pumped Fluid, degrees Fahrenheit	75	75
Maximum Pumped Fluid, degrees Fahrenheit	90	90
Rotordynamic Analysis Level	None	None
Vibration Analysis Expert	Not Required	Not Required
Pump Characteristics:		
Impeller Type	Enclosed	Enclosed
Bearing Lubrication	Pumpage	Pumpage
Drive Type	Magnetic	Magnetic
Speed Control	Fixed	Fixed
Maximum Pump Revolutions per Minute	1,800	1,800
Minimum Pump Revolutions per Minute	1,700	1,700
Suction Flange Size, minimum (in.)	1.5	1.5
Discharge Flange Size, minimum (in.)	1.0	1.0

Tag Numbers	66-PMP-01 66-PMP-02	67-PMP-01 67-PMP-02
Rated Design Point (at Maximum Revolutions per Minute):		
Flow, Gallons per Minute	50	6
Head, Feet	45	16
Minimum Efficiency, Percent	50	50
Other Conditions:		
Maximum Shut Off Head, Feet	60	35
Maximum NPSHr at Specified Flow, Feet	8	8
Minimum NPSHa at Specified Flow, Feet	31	32
Minimum Suction Static Head, Feet	1.0	0.5
Maximum Suction Static Head, Feet	13	10
Pump Materials:		
Pump Casing	Ductile Iron	Ductile Iron
Impeller	Teflon™ Based Fluoropolymer	Teflon™ Based Fluoropolymer
Pump Frame	Cast Iron	Cast Iron
Radial and Thrust Bearings	Silicon Carbide	Silicon Carbide
Shaft	Silicon Carbide	Silicon Carbide
Liner and Containment Shell	Teflon™ Based Fluoropolymer	Teflon™ Based Fluoropolymer
Driver Characteristics:		
Driver Type	Motor	Motor
Drive Arrangement	Horizontal, C Face Mounted, Solid Shaft	Horizontal, C Face Mounted, Solid Shaft
Non-reverse Ratchets	None	None
Minimum Driver Horsepower	2	1
Maximum Driver Speed, Revolutions per Minute	1,800	1,800
Motor Characteristics (when motor is driver type):		
Inverter Duty Rated	No	No
Motor Voltage/Phases/Hertz	460/3/60	460/3/60
Enclosure Type	TEFC	TEFC
Source Testing:		
Performance Test Level	2	2
Vibration Test Level	1	1
Noise Test Level	None	None

Tag Numbers	66-PMP-01 66-PMP-02	67-PMP-01 67-PMP-02
Functional Testing:		
Performance Test Level	1	1
Vibration Test Level	1	1
Noise Test Level	1	1
Hydrostatic Pressure Test	As specified in this Section	As specified in this Section

END OF SECTION

SECTION 13206A

FIBERGLASS REINFORCED PLASTIC ABOVEGROUND STORAGE TANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fiberglass reinforced plastic aboveground storage tanks.

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.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.
   3. RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment.

B. ASTM International (ASTM):
   1. D2240 - Standard Test Method for Rubber Property-Durometer Hardness
   2. D3299 - Standard Specification for Filament-Wound Glass Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.
   3. D4097 - Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.

1.03 SUBMITTALS

A. Submit as specified in Section 06608 - Fiberglass Reinforced Plastic.

B. Calculations
   1. Calculations for anchoring equipment to structures.
      a. Indicate anchor type, layout, number, size, and embedment requirements to resist dead, live, and other applicable loads specified in Section 01850 - Design Criteria.
      b. Calculations shall be prepared and sealed by a Structural or Mechanical Engineer licensed in Florida.
      c. Design anchors in accordance with the structural design criteria specified in Section 01850 - Design Criteria, and the requirements of this Section.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed corrosion-resistant fiberglass reinforced plastic structures for a minimum of 5 years with satisfactory performance record as specified in Section 06608 - Fiberglass Reinforced Plastic.

B. The manufacturer-approved installer shall have installed products of similar fiberglass reinforced plastic equipment on a minimum of 5 projects with a satisfactory performance record.

C. Manufacturer shall be ASME RTP-1 certified.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. NOV Fiberglass Systems
   2. Perry Fiberglass Products, Inc.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design tanks in accordance with ASTM D3299, follow the procedures and methods, utilize the equations and formulas, and incorporate safety factors and allowable design stresses and strains set forth in ASME RTP-1 and other design requirements as specified in Section 06608 - Fiberglass Reinforced Plastic.

B. 12-foot diameter by 25-foot straight shell, minimum capacity 21,000 gallons.

C. Roof live load:
   1. Personnel access/maintenance: Load of 250 pounds distributed over a 12-inch by 12-inch area.

D. Static head of contents.

E. Chemical environment: Product shall be resistant to corrosion by chemicals used in the water field as specified:
   1. Chemical: Aluminum Sulfate.
   2. Concentrations: 48 to 49 percent by weight.
   3. pH levels: Less than 2.5.
   4. Abrasion: NA.

F. Specific gravity: 1.32 to 1.34.

G. Agitation: None.

H. Fire retardancy: not required.

I. Design tank(s) and anchoring to withstand the following loads:
   1. Tank self-weight (dead load).
   2. Roof live loads specified in this Section.
   3. Weight of tank contents.
   4. Loads specified in Section 01850 – Design Criteria:
      a. Wind load.

J. Tank wall structural design shall not include corrosion barrier thickness in design calculations for the structural wall thickness required to meet design loads as specified in this Section. Minimum structural wall not to be less than 0.625” thickness.

K. Support conditions as indicated on the Drawings.

L. Tank Schedule:

Chemical	No. of Tanks	Storage Volume	Orientation	Diameter	Straight Shell Height
Aluminum Sulfate	2	21,000	Horizontal	12 ft	25 ft

A. Tank Components:
   1. Head: Domed.
   2. Tank connections:
      a. Top shell connections (locations as shown on the Drawings):
         1) Vent: One 6-inch with chemically compatible vent screen, No. 24 mesh secured in place with bolted retainer ring.
         2) Fill nozzle: One 2-inch with downcomer to 6 inches above tank bottom.
         3) Level sensing element: 4” nozzle.
         4) Manway: 24-inch manway
      b. Side shell connections (locations as shown on the Drawings):
         1) Outlet: One 2-inch nozzle 6 inches up from bottom of the tank side shell.
         2) Overflow: One 2-1/2-inch nozzle 6 inches from top of tank side shell.
      c. Bottom shell connections (locations as shown on the Drawings):
         1) Drain: One 2-inch nozzle

2.03 MATERIALS

A. Materials as specified in Section 06608 - Fiberglass Reinforced Plastic.
   1. Submit manufacturer's data sheets for each resin used to verify compatibility of the resin with the product the tank will be storing.

B. Resin:
   1. For non-fire-retardant applications: Premium grade vinyl ester resin as recommended by the resin manufacturer for the specific operating environment.
      a. Manufacturers: One of the following or equal:
         1) Derakane, 411-350.
         2) Reichhold Dion, VER 9100.
         b. Interplastic, VE 8300.
   2. For fire-retardant applications:
      a. Premium grade vinyl ester resin as recommended by the resin manufacturer for the specific operating environment.
      b. Add antimony trioxide or pentoxide for Class I fire rating to the structural laminate only.
      c. Manufacturers: One of the following or equal:
         1) Derakane, 510C-350.
         2) Ashland, Hetron 992FR.
         3) Interplastic, VE 8440.
         4) Reichhold Dion, VER 9300FR.

C. Minimum corrosion liner:
   1. 1 10 mil ”C” veil and 1 10 mil nexus

2. In addition to 1 10 mil ”C” veil and 1 10 mil nexus, include 1-1/2 ounces per square foot mat to a total minimum thickness of 0.096 inches on surfaces exposed to the service environment.
3. 2 nexus veils for tanks intended for sodium hypochlorite storage.
4. 10 mil OD “C” veil on tank exterior.

D. Ultraviolet stabilizer: Add to the resin used in the wax coat for exterior surfaces in the type and amount recommended by the resin manufacturer.

2.04 FABRICATION

A. Fabrication method: Hand lay-up or filament wound at construction with integral molded bottom knuckle in accordance with applicable portions of Section 06608 - Fiberglass Reinforced Plastic:
1. Follow manufacturer's recommendations for MEKP and post cures.

B. Structural section with internal veil: Prohibited.

C. Color: White with UV inhibitors.

D. Legs and tie-down lugs: Components laminated onto tank wall shall be Type 316 stainless steel.

E. Anchor bolts: Type 316 stainless steel, of size and length recommended by tank manufacturer.

F. Flanges:
1. All flange dimensions, except thickness, and bolting shall conform to the following standards:
   a. 2 inches through 24 inches: ASME B16.5 Class 150.
   b. 30 inches through 42 inches: ASME B16.1 Class 125.
2. Flange faces shall be perpendicular to the centerline of the duct within 1 degree and shall be flat to plus or minus 1/32-inch up to and including 18-inch equivalent diameter and plus or minus 1/16-inch for equivalent diameters greater than 18 inches.
   a. The minimum flange shear thickness shall be 4 times the flange thickness.
   b. The flange thickness shall be 25 pounds per square inch pressure-rated flanges.
3. Flanges shall be made by hand lay-up construction with nozzle neck and flange made integrally in 1 piece as specified in Section 06608 - Fiberglass Reinforced Plastic.
4. Press molded or filament-wound flanges not allowed.
5. Use 1/8-inch thick full-faced elastomeric gaskets having a Shore A Durometer hardness of 60, within plus or minus 5, in accordance with ASTM D2240 for flanged joints.
6. Elastomer specified by Fabricator to be resistant to chemical environment.

G. Gussets:
1. Reinforce nozzles, except manways, with plate or conical gussets to match piping.

2. Conical gussets having comparable strength may be substituted for plate gussets.

H. Reinforcement of nozzle and manhole openings in vessel walls:
   1. In accordance with ASTM D3299 for filament wound vessels or ASTM D4097 for contact-molded, hand lay-up vessels as specified in Section 06608 - Fiberglass Reinforced Plastic.
   2. When reinforcing materials are cut to facilitate placement around an installed nozzle or opening, stagger joints in successive reinforcing layers to avoid overlapping and do not place so that the joints are parallel to the axis of the tank.
      a. The principal fiber direction of the woven roving reinforcement (0 degree/90 degree) shall be parallel to the tank axis.

I. Cover: Bolted lid.
   1. Platforms and ladders: T5051 Aluminum platform and ladder system supplied by tank manufacturer.

J. Fall protection:
   1. Provide safety harness tie-off points: As indicated on the Drawings.

K. Saddles:
   1. Concrete.
   2. Saddles will be furnished and installed by the contractor.

2.05 VESSEL ASSEMBLY

A. All cutouts from the equipment shall be marked, indicating their original location, and retained. All cutouts shall become the property of the Owner.

B. Do not remove centerlines marked on the equipment for use in assembly until after inspection by the Engineer.

C. Install flanged nozzles with boltholes straddling principal centerlines of the vessel.
   1. For tank tops, nozzle boltholes straddle radial centerlines.

D. When requested, Fabricator shall supply to the Owner, at the earliest possible time, a template which locates anchor boltholes within plus or minus 1/8 inch for each vessel.

E. Where specified, a non-skid surface shall be provided on the exterior surface of the cover.
   1. Silica grit may be applied in conjunction with the final resin coat.
   2. Other methods may be submitted.

F. Furnish and overlay on the outside of the equipment a plastic nameplate showing the following information:
   1. Name of manufacturer.
   2. Date of manufacture.
   3. Owner's purchase order number.
   4. Equipment name/number.

5. Resin number and manufacturer.
6. Design pressure and temperature.
7. Vessel diameter, height, and weight.

G. Butt joints or shell joints shall be in the number and location(s) as indicated on the fabrication drawings.
   1. Additional joints are not allowed.
   2. Slip joints, "mod joints," or other methods not conforming to the fabrication drawings are not allowed.
   3. If joint locations are not indicated on the fabrication drawings, Fabricator shall submit number and location.

H. Allowable tolerances shall be in accordance with ASTM D3299 or ASTM D4097, except as modified in this Section or on the fabrication drawings.

I. When joining components, gaps at mating edges shall be limited to 1/4-inch maximum, and misalignment of inside surfaces shall not exceed 1/3-inch of the lesser wall thickness.

PART 3 EXECUTION

3.01 TANK INSTALLATION

A. For flat bottom vessels without legs, the foundation must provide full non-elastic support to the flat bottom, preferably through the use of grout, which will allow continuous support even though surfaces may not be flat.

B. All anchor lugs or leg pads shall be set on a 1-inch thick layer of non-shrink grout.
   1. Do not use hard shim to fill void between the lugs and foundation.

C. Unless otherwise agreed, independently support all piping so as not to apply loads to the vessel nozzles.

D. Isolate potential load due to thermal expansion of piping from the vessel.

E. During installation, do not force piping into alignment, which can create excessive stresses in the tank.

F. Do not mate raised-face flanges or ring gaskets to full-faced fiberglass reinforced plastic nozzles.

G. Vertically support ladders at the tank foundation or platform.
   1. Ladder lugs attached to the vessels shall provide lateral support only.

H. Where tank foundations are cut out to accommodate full bottom drains, fill the cutout area after tank installation with grout or other material that will provide localized support.

END OF SECTION

SECTION 13208

POLYETHYLENE TANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Type 1 and Type 2 polyethylene storage tanks. Type 1 tank shall be made from crosslinked polyethylene resin and Type 2 shall be made from linear (non-crosslinked) polyethylene resin.

1.02 REFERENCES

A. American Society for Mechanical Engineers (ASME):
   1. B16.4 - Gray Iron Threaded Fittings.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. ASTM International (ASTM):
   1. D638 - Standard Test Method for Tensile Properties of Plastics.
   2. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   3. D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
   4. D1525 - Standard Test Method for Vicat Softening Temperature of Plastics.
   5. D1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
   6. D1998 - Standard Specification for Polyethylene Upright Storage Tanks.
   7. D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.

C. National Fire Protection Association (NFPA):
   1. 30 - Flammable and Combustible Liquid Code.

D. National Electrical Manufacturer's Association (NEMA).

E. Occupational Safety and Health Administration (OSHA):
   1. 29 CRF Part 1910 - Occupational Safety and Health Standards.

1.03 SUBMITTALS

A. Fabrication drawings for each tank including:
   1. Dimensions.
   2. Tank wall thickness.
   3. Materials of construction.
   4. Tank fittings.
   5. Tank appurtenances.
   6. Tank restraint system.

7. Tank resin and hoop stress data.

B. Chemical compatibility sheet to include:
   1. Chemical to be stored.
   2. Percentage of chemical.
   3. Temperature of chemical.

C. Engineering design calculations of restraint and anchoring system signed by a civil or structural engineer registered in the state where the project is located.

D. Installation instructions.

E. Warranty.

F. Certification to certify that each tank is suitable for the specified chemical service, no degradation within warranty period, including tank fittings and gasket material.

G. Proof of qualification: Provide lists of installation and contact information with same type of application and chemical used.

H. Color charts for proposed coating systems.

1.04 WARRANTY

A. Manufacturer warranty against defects:
   1. Tank: 5 years full warranty. Prorated warranties are not acceptable.
   2. Heat tracing system if scheduled: 10 years.

1.05 QUALITY ASSURANCE

A. Qualification of manufacturer: Manufacturer with experienced personnel, physical facilities, and management capacity sufficient to produce custom-made rotationally molded polyethylene tanks of the size, exposure, and chemical services specified for minimum 5 years with satisfactory performance record.

PART 2 PRODUCTS

2.01 SCOPE OF SUPPLIES

A. Provide all materials, labor, equipment, and hardware to provide all polyethylene storage tanks with specified fittings and accessories, wind load restraint systems, anchor bolts, and flange flexible connectors for complete installation in the positions and orientations indicated on the Drawings.

2.02 MANUFACTURERS

A. One of the following or equal:
   1. Poly Processing Co.
   2. Snyder Industries, Inc.
   3. Assman Corporation of America

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Tanks: As scheduled.

B. Tank wall thickness: Calculated in accordance with ASTM D1998 using design specific gravity as scheduled. Note that design specific gravity may be higher than specific gravity of tank contents.

C. Design requirements:
   1. The minimum required wall thickness of the cylindrical shell at any fluid level shall be determined by the following equation, but shall not be less than 0.187 inches thick:

      T = P x O.D./2 SD = 0.433 x S.G. x H x O.D./2 SD
      T = wall thickness, in.
      SD = hydrostatic design stress, psi
      P = pressure (.433 x S.G. x H), psi
      H = fluid head, ft.
      S.G. = specific gravity, g/cm^3
      O.D. = outside diameter, in.

D. The hydrostatic design stress shall be determined by multiplying the hydrostatic design basis, determined by ASTM D2837 using rotationally molded samples, with a service factor selected for the application.
   1. The hydrostatic design stress is 600 pounds per square inch at 73 degrees Fahrenheit for Type I and Type II materials.
   2. The tank shall have a stratiform (tapered wall thickness) wall.

E. The hydrostatic design stress shall be derated for service above 100 degrees Fahrenheit and for mechanical loading of the tank.

F. The minimum design specific gravity shall be 1.5.

G. The minimum required wall thickness for the cylinder straight shell must be sufficient to support its own weight in an upright position without any external support.
   1. Flat areas shall be provided to allow locating large fittings on the cylinder straight shell.

H. The top head must be integrally molded with the cylinder shell.
   1. The minimum thickness of the top head shall be equal to the top of the straight wall.
   2. The top head of tanks with 2,000 or more gallons of capacity shall be designed to provide a minimum of 1,300 square inches of flat area for fitting locations.

I. Tanks with 2,000 or more gallons of capacity shall have a minimum of 3 lifting lugs integrally molded into the top head.
   1. The lifting lugs shall be designed to allow erection of an empty tank.

J. The tank shall be designed to provide a minimum of 4 tie-down lugs integrally molded into the top head.
    1. The tie-down lugs shall be designed to allow tank retention in wind loading situations without tank damage.

K. Tank shell thickness:
    1. In accordance with ASTM D1998, Section 6.1.
    2. Design tank wall thickness for liquid with specific gravity as specified.
    3. Provide adequate thickness at all fittings and connection points for mounting of fittings to the tank without damage to the tank or causing excessive deflection.
    4. Maximum allowable hoop stress used in tank wall thickness calculations per ASTM D1998 shall be based on test data in accordance with ASTM D2837.

L. Wind load restraint system:
    1. Wind design criteria: Design tank restraint system of outdoor or exposed tanks to meet the wind design criteria as specified in Section 01850 -Design Criteria.
    2. Consist of Type 316 stainless steel angles or brackets equally spaced around the tank perimeter anchored into the concrete tie down cable.
    3. If the restraint system includes the use of tensioning and adjustment devices, such as turnbuckles, provide easy adjustment of the cables at the time of construction and as required in the future.
        a. Hardware shall be provided to attach cables to anchored brackets at the base of the tank.
    4. The tank shall be designed to provide a minimum of 4 tie-down lugs integrally molded into the top head.
        a. The tie-down lugs shall be designed to allow tank retention in wind loading situations without tank damage.
        b. Anchor bolts shall be provided by the Contractor per the instructions and the base plates for the system.

2.04 TANK MATERIALS

A. Type 1 high-density crosslinked polyethylene (XLPE) or Type 2 high-density linear polyethylene (HDLPE).

B. Resin:
    1. Manufacturers: One of the following or equal:
        a. PAXON, grade 7204 resin for crosslinkable polyethylene.
        b. Exxon, 8660-8661 for linear polyethylene.

C. The material used shall be virgin polyethylene resin as compounded and certified by the manufacturer.
    1. Type 1 tanks shall be made from crosslinked polyethylene resin as manufactured by ExxonMobil Chemical, or resin of equal physical and chemical properties.
    2. Type II tanks shall be made from high-density linear polyethylene resin as manufactured by ExxonMobil Chemical, or resin of equal physical and chemical properties.
    3. Resin choice would be based on the specific application, chemical to be stored and concentration.

D. Ultraviolet stabilizer:
   1. The polyethylene resin material shall contain a minimum of a UV 8 stabilizer as compounded by the resin manufacturer.
   2. Pigments may be added but shall not exceed 0.25 percent (dry blended) of the total weight.

E. Free of holes, blisters, crazing, cracking, delamination, undispersed raw materials, and any sign of contamination from foreign matter.
   1. The finished tank wall shall be free of visual defects such as foreign inclusions, air bubbles, pinholes, pimples, crazing, cracking, and delaminations.
   2. All cut edges where openings are cut into the tanks shall be trimmed smooth.

F. Resin shall meet or exceed the following properties:
   1. Mechanical Properties of Type 1 of Tank Material: Current XLPE Resin:

Property	ASTM	Value
Density (Resin)	D1505	0.938-0.946 g/cc
Tensile (Yield Stress 2"/min)	D638	3,000 psi
Elongation at Break (2"/min.}	D638	>300%
ESCR (100% Igepal, Cond. A, F50)	D1693	>1000 hours
ESCR (10% Igepal, Cond. A, F50)	D1693	>1000 hours
Vicat Softening Temperature,	D1525	250
Flexural Modulus	D790	100,000 psi

   2. Mechanical Properties of Type II tank material: Current HDLPE Resin:

Property	ASTM	Value
Density (Resin)	D1505	0.942-0.948 g/cc
Tensile (Yield Stress 2"/min)	D638	2,950 psi
Elongation at Break (2"/min.)	D638	>1,000%
ESCR (100% Igepal, Cond. A, F50)	D1693	550 hours
ESCR (10% Igepal, Cond. A, F50)	D1693	48 hours
Vicat Softening Temperature	D1525	235
Flexural Modulus	D790	129,000 psi

G. Gel test: This test does not apply to Type II linear resins.
   1. Inner portion of tank wall:
      a. Not less than 65 percent.
      b. ASTM D1998 requirements.

2. Entire wall thickness: Not less than 80 percent.

H. Restraint system:
   1. Metal components, including anchor bolts:
      a. Type 304 stainless steel.
      b. The Anchor bolts shall be supplied by the tank manufacturer.
   2. Concrete anchors or flush shells shall not be used.

2.05 FITTINGS

A. Terminate in socket, threaded, or flanged connections:
   1. Flanges: 150 pound ASME B 16.5.
   2. Double flanged CPVC bolted fittings with encapsulated stainless steel or Hastelloy bolts.
   3. Threaded connections: ASME B 16.4.

B. Fittings at upper tank sidewall or top:
   1. Compression threaded type, long shank, polyvinyl chloride flanged fittings with deep cut threads (not injection molded thread) and with dual wide nuts.
   2. The bulkhead fittings shall be constructed of PVC, PP, or other specified material.
   3. Gaskets shall be a minimum of 1/4 inch thickness and constructed of 40-50 durometer EPDM, 60-70 durometer Viton™ or other specified material.

C. Fittings on tank top:
   1. Bosses molded into the tank.
   2. Fittings shall be vertical.
   3. The top head shall be integrally molded with the cylinder shell.
   4. The minimum thickness of the top head shall be equal to the top of the straight wall.
   5. The top head of tanks with 2,000 or more gallons of capacity shall be designed to provide a minimum of 1,300 square inches of flat area for fitting locations.

D. Flanged outlet drain fitting in the lower tank sidewall: Integrally molded into the bottom knuckle of the tank to allow full drainage of tank contents.

E. Fittings and appurtenances for each tank:
   1. As scheduled.

2.06 ACCESSORIES

A. Finish coating:
   a. Waterproof and ultraviolet light resistant.
   b. Acrylic enamel or latex mastic.
   c. 2 coats.
   d. Minimum dry film thickness: 5 mil.
   e. Color: Selected by Owner.

B. Level gauge:
   1. Provide each tank with:
      a. Level gauge shall be a magnetic flap type or "reverse float type" made of 2 inch polyvinyl chloride or PVDF stilling well tube.
      b. Float.
      c. Polypropylene rope.
      d. Clear polyvinyl chloride sight tube.
   2. Materials: Suitable for the specified chemical service for the individual tanks.
   3. Tank level staff gauge:
      a. Resistant to abrasion and corrosion.
      b. Mounted on the tank adjacent to the indicator.
      c. Calibrated in nominal 500 gallon increments.

C. Tank vents:
   1. Each tank shall be properly vented for the type of material and flow rates expected.
   2. Vents must comply with OSHA Part 1910 normal venting for atmospheric tanks or other accepted standard, or shall be as large as the filling or withdrawal connection, whichever is larger but in no case less than 2 inches nominal inside diameter with screening.

2.07 TANK FABRICATION

A. Rotationally molded construction in accordance with ASTM D1998.

B. Provide for each tank the following shop finishing:
   1. Shipping label identifying:
      a. Tank tag number.
      b. Chemical service.
   2. Coating:
      a. Coat each tank and appurtenances after installation as specified in Section 09960 - High-Performance Coatings.
      b. Color: Selected by the Engineer.
   3. Permanent labels:
      a. Identification label.
      b. NFPA label specifically coded for the tank contents in accordance with NFPA 30.
      c. Paint or affix label onto the tank wall to be clearly visible from outside the tank enclosure.

2.08 TESTING

A. Each tank shall be leak tested by the manufacturer prior to shipment by filling with clean water for a period of at least 4 hours with all fittings installed and blinded.
   1. There shall be no measurable drop in liquid surface.
   2. Any leaks shall be noted and repaired and the tank shall be re-tested for an additional 4 hours minimum.
      a. Reason for leak and method of repair shall be recorded and submitted to the Engineer.
   3. Any defects or leaks that have not been adequately repaired will be cause for rejection of the tank.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Transportation, handling, storage of the tanks, and installation shall be in accordance with the manufacturer's printed instructions.
   2. Repair any damage to tank components or the insulation due to transportation or installation.
   3. Install piping to tank with sufficient flexibility to allow tank movement of 1 inch in any direction without damage to piping.

B. All tank fitting attachments shall be equipped with flexible couplers or other movement provisions provided by the tank customer.
   1. The tank will deflect based upon tank loading, chemical temperature and storage time duration.
   2. Tank piping flexible couplers shall be designed to allow 4 percent design movement.
   3. Movement shall be considered to occur both outward in tank radius and downward in fitting elevation from the neutral tank fitting placement.

3.02 FIELD QUALITY CONTROL

A. Manufacturer's field service:
   1. Inspect the installed tanks for proper installation.
   2. Instruct Owner's personnel on operations and maintenance of the tanks.

3.03 SCHEDULE

A. As specified in Attachment A - Tank Schedule.

END OF SECTION

ATTACHMENT A - TANK SCHEDULE

TANK SCHEDULE

Tag Number	[XXX]	[XXX]	[XXX]
Service	Aluminum Sulfate – Day Tank	Liquid Ammonium Sulfate – Bulk Storage Tanks	Liquid Ammonium Sulfate – Day Tank
Chemical pH	3.5	3.0 - 7.0	3.0 - 7.0
Chemical Specific Gravity	1.33	1.22	1.22
Tank Design Specific Gravity	1.9	1.4	1.4
Number of Tanks	1	2	1
Usable Capacity, each	1,550 gal	2,550 gal	165 gal
Type of Tank	Crosslink PE	Crosslink PE	Crosslink PE
General Design	Flat bottom, dished top	Flat bottom, dished top	Flat bottom, dished top
Installation	Vertical	Vertical	Vertical
Diameter (feet)	6	8	3
Height (feet	12 (max)	12 (max)	12 (max)
Inlet Nozzle Size (inches)	2-1/2	2	1
Outlet Nozzle Size (inches)	1/2	1	1/2
Drain Nozzle Size (inches)	2-1/2	2	1
Overflow Nozzle Size (inches)	2-1/2	2	1
Vent Nozzle Size (inches)	5	4	2
Roof Nozzle Size (inches)	4-inch nozzle for mounting ultrasonic level sensor	2-inch nozzle for mounting ultrasonic level sensor	2-inch nozzle for mounting ultrasonic level sensor
Top Manway (inches)	24	16	7
Ladder	Not Required	Not Required	Not Required
Lifting Lugs	Required	Required	Required
Level indicator	Required	Required	Required
Pipe and Conduit Supports	Required	Required	Required

SECTION 13447

ELECTRIC ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electric motor-driven actuators for valves and gates.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C504 - Standard for Rubber-Seated Butterfly Valves.
   2. C542 - Standard for Electric Motor Actuators for Valves and Slide Gates.

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 01600 - Product Requirements.

B. Provide a complete list/schedule of actuators being provided with their associated tag names, as indicated on the Drawings and/or Specifications, service process area and the size of the valve they are actuating.

C. Product data:
   1. Electrical ratings:
      a. Voltage and number of phases.
      b. Starting and running current.
      c. Voltage levels and source for control and status.
   2. Description of integral control interface.
   3. Remote control station components (If applicable).
   4. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
   5. Gear ratios for both manual and motorized actuation.
   6. Opening and closing directions.
   7. Allowable starts per hour.
   8. List of included options and accessories.
   9. Full travel times.
   10. Gearbox data including gear ratio, and gearbox efficiency.

D. Shop Drawings:
   1. Wiring diagrams:
      a. Include options and expansion cards furnished with each actuator.
   2. Dimensioned drawings of each valve and actuator combination.

3. Dimensioned drawings of each valve gearbox.
4. Electric motor data.

E. Calculations:
1. Operating torque.
2. Maximum torque calculations for seating and unseating.
3. Maximum operating torque at starting and normal operation.

F. Provide draft vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals:
1. Include a list of configurable parameters and the final values for each.
2. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

G. Commissioning Submittals:
1. Provide Manufacturer's Certificate of Source Testing as specified in Section 15958 - Mechanical Equipment Testing .
a. Affidavit in accordance with AWWA C542.
2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 15958 - Mechanical Equipment Testing.

H. Project closeout documents:
1. Provide final vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for lines 3 inches and smaller:
1. The following or equal:
a. Rotork Controls Inc.:
1) Hayward Flow Control.
2) ROMpak (Quarter-turn).
3) CMA Range:
a) CMR - Multi-turn.
b) CMQ - Quarter-turn.

2.02 CHARACTERISTICS FOR ACTUATORS ON LINES 3 INCHES AND SMALLER

A. Actuators for valves 3 inches and smaller:
1. Complete and operable with all components and accessories required for operation.
2. Power supply:
a. Valve motion independent of power supply phase rotation.

b. 120 VAC single phase.

3. Size actuator to move valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
   a. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
4. For outdoor or vault installations, provide an integral anti-condensation heater when available as an option.
5. Control inputs:
   a. Capable of using discrete 120 VAC.
   b. Controls the valve when local-stop-remote is in REMOTE.
   c. Material: Type 316 stainless steel.
   d. Provide the following inputs at the actuator:
      1) OPEN.
      2) CLOSE.
6. Status outputs:
   a. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
      1) FULLY CLOSED.
      2) FULLY OPEN.
      3) REMOTE.
   b. Output contacts rated for 5 amps, 120 VAC.
7. Analog input:
   a. Provide a 4 to 20 mA analog input for analog modulating valves when indicated on the Drawings.
   b. Modulate valve to maintain position based on analog input value.
   c. Maximum input impedance 250 ohms.
8. Analog output:
   a. Provide an isolated 4 to 20 mA analog output when indicated on the Drawings.
9. Materials:
   a. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.
   b. Enclosure ratings:
      1) As scheduled with the following requirements.
         a) Actuators will be double sealed for corrosion protection rated at ip68.
      2) NEMA 4X for actuators located outside of Class I areas.
      3) All others shall be rated FM - Class I Groups B, C, and D, and Class II E, F, and G.
10. Components:
    a. Motors:
       1) Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
       2) Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
          a) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
          b) 60 starts per hour minimum for open/close service.

b. Enclosures:
    1) Actuator housing ratings as indicated in the Motorized Actuator Schedule.
    2) Stainless steel external fasteners.
c. Manual actuation:
    1) Hand wheel for manual operation.
d. Gearing: Self-locking, high-alloy steel gears.

11. Communication options:
    a. Ethernet Modbus TCP.
    b. Profibus DP.
    c. Modbus RTU.
    d. Foundation Fieldbus.
    e. Pakscan.

2.03 ACCESSORIES

A. Software:
    1. Furnish PC-based diagnostic and configuration software to display diagnostic data and configure actuators.
    2. Provide software communications to the valve actuator and handheld setting tool using Bluetooth wireless or IrDA infrared communications.
        a. Provide accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.
        b. Where infrared communications are used, furnish an IrDA to USB adapter with a mounting device to secure the infrared element to the valve actuator IrDA port:
            1) Provide with a minimum cable length of 3 feet, capable of being extended with a standard USB extension cable.

B. Termination module cover:
    1. For actuators on a valve network, provide a means to keep the valve network in service, in the event where the actuator must be removed.
    2. Provide sunshades for outdoor installations of remote control stations that use an LCD or similar screen. Regular pushbutton, sector switches, and pilot light control stations will not require a sunshade.

2.04 SPARE PARTS AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements.

B. Spare parts:
    1. Provide the following (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
        a. Stem nut.
        b. Worm shaft subassembly.
        c. Drive sleeve subassembly.
        d. Complete actuator seal kit.
        e. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
        f. Encoder.
        g. Control module.

C. Setting tool:
    1. If required for setting or configuring the actuator, provide a handheld setting tool. Furnish 1 setting tool for every 10 actuators.
        a. Capable of communicating with PC-based configuration software and transferring the following in either direction between the computer and programmer and setting tool, and between the setting tool and actuator.
        b. Actuator configurations:
            1) Capable of storing up to 10 different configurations.
        c. Diagnostic data:
            1) Capable of storing 4 complete sets of diagnostic data.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

B. Position visual indicators so that they are most easily visible.

3.02 COMMISSIONING

A. As specified in Section 15958 - Mechanical Equipment Testing, and this Section.

B. Manufacturer services:
    1. Provide certificates:
        a. Manufacturer's Certificate of Source Testing:
            1) Proof-of-Design and Performance Test Reports in accordance with AWWA C542.
        b. Manufacturer's Certificate of Installation and Functionality Compliance.
    2. Manufacturer's representative on-site requirements:
        a. Installation: 2 trips, 2-day minimum each.
        b. Functional Testing: 2 trips, 2-day minimum each.
    3. Training:
        a. Maintenance: 4 hours per session, 2 sessions.
        b. Operation: 2 hours per session, 2 sessions.

C. Source Testing:
    1. Design and Performance Test Reports in accordance with AWWA C542.
    2. Test each actuator with a simulated load.
        a. Simulate a typical valve load.
    3. Electrical Instrumentation and Controls:
        a. Test witnessing: Not witnessed.
        b. Conduct testing as specified in 15958 - Mechanical Equipment Testing, 16950 – Electrical Testing, and this Section.

D. Functional Testing:
    1. Installed actuator:
        a. Test witnessing: Witnessed.
        b. Conduct Level 2 General Equipment Performance Tests.

c. Conduct Level 2 Vibration Test s.
d. Conduct Level 2 Noise Test s.

2. Electrical Instrumentation and Controls:
   a. Test witnessing: Witnessed.
   b. Conduct testing specified in Section 15958 - Mechanical Equipment Testing, Section 16950 - Electrical Testing, and this Section.

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 Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. American Gear Manufacturers Association (AGMA) 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 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. 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 when specified in the equipment Technical Sections.
      1) Must be a 3rd party, unaffiliated with the equipment vendor or Contractor.
   b. Vibration analysis expert and analysis shall be provided by one of the following or equal:
      1) Engineering Dynamics Inc. (EDI, Texas).
      2) Mechanical Solutions, Inc. (MSI, New Jersey).
   c. 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) 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) 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) 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) 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) 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) 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 specified 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. Insulation Type 3 and cover Type 5 as specified.

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 SAFETY SIGNS

A. Material, sign size, and text: As specified in Section 10400 - Signage.

2.17 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. 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. 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 NPS 24, Metric/Inch Standard.
   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. C151 - Ductile-Iron Pipe, Centrifugally Cast.
   3. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.

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. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health. Effects.

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. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.
   2. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.
   3. Pipes adjacent to a wet wall: Pipe centerline within 10 inches of the wet wall.
   4. Underground pipes: Buried pipes - see A. above.
   5. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.
   6. Wet wall: A wall with water on at least one side.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

B. Coatings and linings requirements stated in the Pipe Schedule, as modified in the individual pipe Technical Sections, and as specified in 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.

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. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer.
         1) Manufacturer's factory trained representative:
            a) Provide on-site training for Contractor's field personnel.
            b) Periodically visit the jobsite to verify Contractor is following best recommended practices.
         2) Distributor's representative is not considered qualified to conduct the training or jobsite visits.
      e. Flanged joints: Where one 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 the 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 and Section 15063 - Non-Metallic Pipe Support System:
   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.
4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion as specified in Section 09960 - High-Performance Coatings.

F. Restraining buried piping:
1. 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. 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.

3.03 PIPE SCHEDULE

A. As indicated on the Drawings.

END OF SECTION

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 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. Manufacturers Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

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 01600 - Product Requirements.

2.02 MATERIALS

A. General:
   1. Hot dip galvanized:
      a. Fabricate as specified in Section 05500 - Metal Fabrications.
      b. Hot dip after fabrication of support in accordance with ASTM A123.
      c. Repair galvanized surface as specified in Section 05500 - Metal Fabrications.
   2. Stainless steel:
      a. Fabricate as specified in Section 05500 - Metal Fabrications.
      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 ASTM A967.
      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. Type 316 Stainless Steel

C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
   1. Type 316 Stainless Steel.

D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
   1. Type 316 Stainless Steel.

E. Stainless steel piping system:
   1. Type 316 Stainless Steel.

F. Chemical containment areas and chemical piping:
   1. Type 316 Stainless Steel.

G. Fasteners:
   1. As specified in Section 05500 - Metal Fabrications.

2.03 PIPE SUPPORTS

A. Hanger rods: 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 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) FM Stainless Fasteners.
         2) Nibco-Tolco, Figure 101.
      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) Bergen-Power, Figure 100SS.
         2) Nibco-Tolco, Figure 1C.I.
      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) Cooper B-Line Systems, Inc., Figure B3110.
2) FM Fasteners, Figure 81.
3) Nibco-Tolco, Figure 324.
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) Cooper B-Line Systems, Inc., Figure B3066.
2) FM Stainless Fasteners, Figure 98.
3) Nibco-Tolco, Figure 30M.
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) Cooper B-Line Systems, Inc., Figure B3188.
2) FM Stainless Fasteners, Figure 37.
3) Nibco-Tolco, Figure 110.
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) Cooper B-Line Systems, Inc., Figure 3140.
2) Nibco-Tolco, Figure 4.
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) Cooper B-Line Systems, Inc., Figure B3149.
2) FM Stainless Fasteners, Figure 63.
3) Nibco-Tolco, Figure 4.
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) Cooper B-Line Systems, Inc., Figure 3148.
2) Nibco-Tolco, Figure 8.
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) FM Stainless Fasteners, Figure 59.
2) Nibco-Tolco, Figure 318.
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) Cooper B-Line Systems, Inc., Figure 3083.
         2) Nibco-Tolco, Figure 304.
      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 otherwise indicated 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 thermal pipe shield in accordance with MSS SP-58, Type 40 on pipe supports for insulated pipes.

W. Install riser clamps at floor penetrations and where indicated on the Drawings.

X. Coat support system components as specified in Section 09960 - High-Performance Coatings.

END OF SECTION

SECTION 15063

NON-METALLIC PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Non-metallic pipe support system including the following:
   1. Channel framing and components.
   2. Pipe clamps.
   3. Fittings.
   4. Fasteners.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

1.03 SUBMITTALS

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

B. Shop drawings.

C. Calculations.

1.04 QUALITY ASSURANCE

A. Supply materials from a single manufacturer with sole responsibility for the pipe support system.

B. The supplied system, including pipe clamps, shall be interchangeable with industry standard 1-5/8-inch steel and fiberglass channel framing systems.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Transportation, handling, storage, and installation shall be in accordance with the manufacturers printed instructions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. StrutTech.
   2. Unistrut.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design responsibility:
   1. The manufacturer of the non-metallic pipe support system shall be considered the designer of the support system.
   2. Prepare design calculations utilizing the design criteria included in these Specifications.
   3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.

B. Design requirements:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   2. Maximum allowable deflection: 1/240 of span.
   3. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
   4. Future loads:
      a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
      b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
      c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
   5. Seismic design criteria: As specified in Section 01850 - Design Criteria as specified for mechanical equipment.
   6. Spacing of supports: As required to comply with design requirements but not more than 5 feet.

2.03 MATERIALS

A. Fiberglass resin: Corrosion-resistant premium grade vinylester.

B. Injection molded components: Polyurethane thermoplastics.

C. Flame spread of fiberglass:
   1. Vinylester fiberglass (Series VF): Class 1, ASTM E84.
   2. Polyurethane: V-O UL 94V.

D. Physical properties of fiberglass:

Physical Property	Longitudinal	Transverse
Tensile Strength	37,500 pounds per square inch (psi)	10,000 psi
Tensile Modules	3.0 X 10^6 psi	1.0 X 10^6 psi
Flexural Strength	37,500 psi	14,000 psi
Flexural Modules	2.0 X 10^6 psi	1.0 X 10^6 psi

Physical Property	Longitudinal	Transverse
Compressive Strength	37,500 psi	20,000 psi
Shear Strength	6,000 psi	5,500 psi
Izod Impact	30 foot-pounds per square inch	5 foot-pounds per square inch

E. Surface veil: Fiberglass channel shall have polyester surface veil over 100 percent of the surface to provide protection against degradation from ultraviolet light.

F. Touch-up resin:
   1. Manufacturers: The following or equal:
      a. Krylon, 7006-Satin Polyurethane Clear Finish.

2.04 COMPONENTS

A. Channel framing:
   1. All channel framing shall be supplied with integral notches 1 inch on center.
   2. Locate notches on interior flange to prevent slippage of pipe clamps and fittings after installation.

B. Pipe clamps:
   1. Adjustable type: Non-metallic and non-conductive.
   2. Fixed type:
      a. Pipe clamps for pipe less than 6 inches in diameter shall be non-metallic and non-conductive.
      b. Pipe clamps for pipe equal to and greater than 6 inches in diameter shall be fiberglass.

C. Channel fittings:
   1. Make fittings and post bases from glass-filled polyurethane or polyester.

D. Fasteners:
   1. Make fasteners from one of the following materials:
      a. Glass-filled polyurethane.
      b. Vinylester fiberglass.

E. Cushion strip:
   1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to 275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets this criteria.
      a. Manufacturers: One of the following or equal:
         1) Anvil, AS 3795.
         2) Unistrut, P2600 Unicushion.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install in accordance with manufacturer's instructions, shop drawings, and as indicated on the Drawings.
   2. Seal machined edges and holes with touch-up resin.

END OF SECTION

SECTION 15076

PIPE IDENTIFICATION

PART 1 GENERAL

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
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: PVC.
   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 APWA 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.

C. Witness markers:
1. Manufacturers: One of the following or equal:
   a. Carsonite Composites, Utility Marker.
2. Materials:
   a. Glass fiber and resin reinforced thermosetting composite material.
   b. UV resistant.
3. Constructed as a single piece.
4. Pointed at the bottom end.
5. Information to be included on the marker:
   a. “Caution” (type of service) “Pipeline”.
   b. Phone number for Sunshine 811.
   c. Phone number for Owner in case of emergency.
   d. Station number.
   e. Offset:
      1) Only provide offset if marker is not directly over the pipe.
   f. Name of appurtenance or fitting (e.g. 45, BO, ARV, etc.)

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 01600 - 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.
   2. Detectable warning tape:
      a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe or a greater height if necessary to limit the tape bury depth to 36 inches. Do not bury detectable warning tape deeper than 36 inches.

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.

C. Witness markers:
   1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
   2. Place markers at appurtenances located in unpaved areas.
   3. Embed markers at least 18 inches into the soil.

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. Power valve actuators:
         1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
         2) Complete wiring diagrams and control system schematics.
      d. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.

f. Certifications of reference standard compliance:
    1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
h. 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.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified.

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.
            1) Plastic butterfly valves shall be flanged.
        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-PWS as specified in Section 09960 - High-Performance Coatings.
      1) Certified in accordance with NSF 61 for drinking water use.
      2) 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-PWS 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.
      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 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 15111

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ball valves.

B. As specified in Section 15110 - Common Work Results for 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.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA):
   1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.

C. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   3. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

1.03 SUBMITTALS

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

B. Product data: As specified in Section 15110 - Common Work Results for Valves:
   1. Metal body ball valves: 6 inches and larger only: Submit affidavit of compliance in accordance with AWWA C507.
   2. Operation and maintenance manual.

C. Commissioning submittals:
   1. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Unless otherwise indicated on the Drawings use:
   1. Metal body ball valves on metallic pipelines.
   2. Plastic body ball valves on plastic pipelines.

B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

2.02 PLASTIC BODY BALL VALVES – FULL PORT (BAV40)

A. Manufacturers: One of the following or equal:
   1. Asahi America.
   2. Chemtrol Division, NIBCO, Inc.
   3. Georg Fischer Piping Systems.
   4. Hayward Flow Control.
      a. For sodium hypochlorite service, provide model TB-Z. Model TBH-Z shall not be used.
   5. Plast-O-Matic Valves, Inc.

B. General:
   1. Type: Non-lubricated and capable of sealing in either flow direction.
   2. End connections:
      a. 4 inches and smaller size: Socket end true unions for solvent welded connection to adjacent piping.
      b. 6-inch size: Socket end true unions with attached flanges for flanged connection to adjacent piping.
   3. All valves shall have integral ISO 5211 mounting pad for actuator installation.
   4. All valves shall have integral plate for lock-out/tag-out.
   5. Stem: Double o-ring seal with shear point above seal.
   6. Pressure rating: Suitable for the test pressure and maximum temperature of the corresponding piping system listed in the Piping Schedule.

C. Materials:
   1. Body and ball:
      a. PVC piping systems: PVC.
   2. Seats: PTFE (Teflon™).
   3. O-rings: Match gasket material of corresponding piping system listed in the Piping Schedule.
      a. Chlorine solution: FKM (Viton™).
      b. Aluminum sulfate: EPDM.
      c. Liquid ammonium sulfate: EPDM.

D. Limit switches, when indicated on the Drawings:
   1. Mechanical cam type with watertight enclosure and suited for remote indication of valve open-close status.
   2. Mount on valve actuator.
   3. Contacts: 120-volt alternating current, 20 amperes at 75 to 100 percent power factor and 24-volt direct current, 5 amperes minimum.

E. Valve actuator:
   1. Valves shall be quarter turn operated with valve seat adjustability.
   2. Manually operated valves: Lever.
      Electric motor operated valves, when indicated on the Drawings: Provide electric motor operator as specified in Section 13447 - Electric Actuators.

F. Venting requirements:
   1. PVC ball valves for hypochlorite service:
      a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
      b. Provide an engraved plastic tag permanently attached to the valve stem stating, "One side of ball drilled for hypochlorite service".
      c. Provide an arrow inscribed on the valve body to indicate direction of flow.

2.03 PLASTIC BODY THREE-WAY BALL VALVES

A. Manufacturers: One of the following or equal:
   1. Asahi America.
   2. Chemtrol Division, NIBCO, Inc.
   3. Georg Fischer Piping Systems.
   4. Hayward Flow Control.
   5. Plast-O-Matic Valves, Inc.

B. General:
   1. Type: Non-lubricated and capable of sealing in either flow direction.
   2. End connections:
      a. 4 inches and smaller size: Socket end true unions for solvent welded connection to adjacent piping.
      b. 6-inch size: Socket end true unions with attached flanges for flanged connection to adjacent piping.
   3. All valves shall have integral ISO 5211 mounting pad for actuator installation.
   4. All valves shall have integral plate for lock-out/tag-out.
   5. Stem: Double o-ring seal with shear point above seal.
   6. Pressure rating: Suitable for the test pressure and maximum temperature of the corresponding piping system listed in the Piping Schedule.

C. Materials:
   1. Body and ball:
      a. PVC piping systems: PVC.
   2. Seats: PTFE (Teflon™).
   3. O-rings: Match gasket material of corresponding piping system listed in the Piping Schedule.
      a. Chlorine solution: FKM (Viton™).
      b. Aluminum sulfate: EPDM.
      c. Liquid ammonium sulfate: EPDM.

D. Limit switches, when indicated on the Drawings:
   1. Mechanical cam type with watertight enclosure and suited for remote indication of valve open-close status.
   2. Mount on valve actuator.

3. Contacts: 120-volt alternating current, 20 amperes at 75 to 100 percent power factor and 24-volt direct current, 5 amperes minimum.

E. Valve actuator:
   1. Valves shall be quarter turn operated with valve seat adjustability.
   2. Manually operated valves: Lever.
      Electric motor operated valves, when indicated on the Drawings: Provide electric motor operator as specified in Section 13447 - Electric Actuators.

F. Venting requirements:
   1. PVC ball valves for hypochlorite service:
      a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
      b. Provide an engraved plastic tag permanently attached to the valve stem stating, "One side of ball drilled for hypochlorite service".
      c. Provide an arrow inscribed on the valve body to indicate direction of flow.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

3.02 COMMISSIONING

A. As specified in 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 15956 - Piping Systems Testing.

END OF SECTION

SECTION 15114

CHECK VALVES

GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ball Check Valves:
      a. Plastic Ball 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. A213 - Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A313 - Standard Specification for Stainless Steel Spring Wire.
   5. A536 - Standard Specification for Ductile Iron Castings.
   6. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
   7. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   8. B16 - Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines.
   9. B61 - Standard Specification for Steam or Valve Bronze Casting.
   10. B62 - Standard Specification for Composition Bronze or Q=Ounce Metal Castings.
   11. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

D. National Electrical Manufacturers Association (NEMA).

E. NSF International (NSF):
   1. 61 - Drinking Water Components Health Effects.
   2. 372 - Drinking Water System Components - Lead Content.

F. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. As specified in Section 01600 - Product Requirements.

C. Commissioning Submittals:
   1. Provide Manufacturer's Certificate of Installation Compliance as specified.

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements and Section 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 in accordance with ASTM A126 Grade B.
   2. Ductile iron in accordance with ASTM A536 Grade 65-45-12.
   3. T-303 stainless steel in accordance with ASTM A582 (UNS S30300).
   4. Type 316 stainless steel in accordance with ASTM A313.

D. Flanges: Drilled in accordance with ASME B16.1 Class 125/150 unless otherwise specified or indicated on the Drawings.

2.02 PLASTIC BALL CHECK VALVES (CKV65)

A. Manufacturers: One of the following or equal:
   1. Georg Fischer Piping Systems.
   2. Hayward Flow Control.
   3. Nibco, Chemtrol Series.
   4. Plast-O-Matic.

B. Valve design:
   1. Ball type design.
   2. Materials: As specified in the Check Valve Schedule.
   3. Inlet pressure rating:
      a. PVC, CPVC, or PVDF: 150 pounds per square inch at 77 degrees Fahrenheit.
      b. PP: 100 pounds per square inch at 77 degrees Fahrenheit.

2.03 INTERIOR PROTECTIVE LININGS

A. As shown in the valve schedules and as specified in Section 15110 - Common Work Results for Valves.

PART 3 EXECUTION

3.01 COMMISSIONING

A. As specified in 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 15118

PRESSURE CONTROL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure reducing and pressure relief valves for water, air, sludge and chemical service.

B. As specified in Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

B. ASTM International (ASTM):
   1. A536 - Standard Specification for Ductile Iron Castings.

C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

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

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 PLASTIC BODY PRESSURE REDUCING VALVES - CHEMICAL OR WATER SERVICE (PRV40)

A. Manufacturers: One of the following or equal:
   1. Plast-O-Matic: Series PRHM.

B. Materials:
   1. Valve body:
      a. PVC piping systems: PVC.

2. U-cups:
    a. Match gasket/elastomer material of corresponding piping system, as indicated on the Piping Schedule.
3. Non-wetted metallic components: Stainless steel.

C. Design:
1. Diaphragm type.
2. Pressure rating: Not less than 150 pounds per square inch.
3. In-line or angle pattern design, size as indicated on the Drawings.
4. End connections: Threaded.
5. Downstream pressure set point:
    a. Externally adjustable without removing valve from piping system.
    b. Adjustable from 5 to 125 psig.

2.02 PLASTIC BODY PRESSURE RELIEF VALVES FOR CHEMICAL OR WATER SERVICE (PRV24)

A. Manufacturers: One of the following or equal:
1. Plast-O-Matic, Series RVT, RVDT or TRVDT.
2. Asahi/America.
3. Georg Fischer Piping Systems.

B. Materials:
1. Valve body:
    a. PVC piping systems: PVC.
    b.
2. U-cup seals:
    a. Match gasket/elastomer material of corresponding piping system, as specified in the Piping Schedule.
        1) Chlorine solution: FKM (Viton™).
        2) Aluminum sulfate: EPDM.
        3) Liquid ammonium sulfate: EPDM.
3. Adjusting bolt, locknut, control spring and fasteners: Stainless steel.

C. Design:
1. Pressure rating: Not less than 150 pounds per square inch.
2. In-line or angle pattern design, size as indicated on the Drawings.
3. End connections:
    a. 1 inch and smaller: Threaded.
    b. Larger than 1 inch: Flanged.
4. Relief set point:
    a. Externally adjustable without removing valve from piping system.
    b. Adjustment range:
        1) Valve sizes 2 inches and smaller: 5 to 125 psig.
        2) Valve sizes 3 inches and larger: 5 to 100 psig.
    c. For chemical pump discharge applications, set valve to open at 10 pounds per square inch more than pump discharge pressure at maximum operating point, or as indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 - Common Work Results for Valves.

3.02 COMMISSIONING

A. As specified in 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. Flexible rubber connections.
      b. Pipe saddles.
      c. Tapping sleeves.
      d. Sight gauges.
      e. Chemical Injector/Diffuser.

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 01600 - 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:
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 01600 - Product Requirements.

B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

2.02 FLEXIBLE RUBBER CONNECTIONS

A. Manufacturers: One of the following or equal:
1. Mercer Rubber Co., Type 150 Vibraflex.
2. Red Valve Co., Inc., Part Number P-5.

B. Provide flexible rubber connections with 3/8-inch thick EPDM rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.

C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

2.03 VIBRATION CONTROL JOINTS

A. Manufacturers:
1. Braided bronze flexible vibration joints 2 inches and less in size: One of the following or equal:
a. Flex-Weld, Inc., Keflex, Type KFCB.
b. Senior Flexonics Canada, Inc., Type BRC bronze connectors.
2. Flexible vibration joints larger than 2 inches: One of the following or equal:
a. Flex-Weld, Inc., Keflex, Series 151-TR-1215.

b. Senior Flexonics Canada, Inc., Type TCS.

3. Corrugated stainless steel with stainless steel braid flexible vibration joints: One of the following or equal:
   a. Flex-Weld, Inc., Keflex, Type USFNSS-31.
   b. Senior Flexonics Canada, Inc., Type BSFS stainless steel connectors.

B. Design:
1. Flexible vibration joints 2 inches and smaller: Braided bronze, suitable for pressures of not less than 250 pounds per square inch gauge.
2. Flexible vibration joints larger than 2 inches: Flexible bellows type, suitable for pressures of not less than 150 pounds per square inch gauge, at 70 degrees Fahrenheit, except as follows:
   a. Provide vibration joints in piping subject to test pressures higher than 150 pounds per square inch gauge, suitable for such higher pressures.
   b. Bellows: Stainless steel, equipped with a stainless steel liner.
   c. Ends: ASME Class 150 flanges.
3. Vibration joints in high-pressure air piping and in digester gas piping: Corrugated Type 316 stainless steel with stainless steel braid, suitable for pressures of not less than 150 pounds per square inch gauge.
   a. Ends: ASME Class 150 flanges.

C. Protection: Protect vibration absorbers against end loading and torsional stresses by anchoring attached piping.

2.04 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: EPDM.

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: EPDM.

2.05 TAPPING SLEEVES

A. Manufacturers: One of the following or equal:
1. Romac Industries, Inc., Style FTS 420.
2. Smith-Blair, Inc., Style 622.

B. Materials:
   1. Tapping sleeves: Steel construction.
   2. Bolts and nuts: Type 304 stainless steel.
   3. Nuts: Teflon™ coated.
   4. Gaskets: EPDM.
   5. Size of tapped boss: As indicated on the Drawings.

2.06 SIGHT GLASSES

A. Assembly: Body casting with ASME standard adapter flanges, borosilicate glass section, cleaning assembly with scalloped neoprene wipers, operating rod and handle, packing gland with packing and suitable adapter, and cock with solvent hand pump.

B. Suitable for a minimum pressure of 30 pounds per square inch gauge.

C. Manufacturers: One of the following or equal:
   1. EIMCO Process Machinery Division of Envirotech Corp.
   2. John C Ernst.

2.07 CHEMICAL INJECTOR/DIFFUSER

A. Design:
   1. Chemical injector/diffuser:
      a. Injector configuration: Single feed point into center of water main, as shown on the drawings.
   2. Heavy duty brass corporation stop or stainless steel ball valve:
      a. Thread connection shall be NPT or AWWA inlet.
      b. Corporation stop must include a safety device to prevent accidental withdrawal of Injection/Diffuser solution tube.
   3. Injector/Diffuser solution tube sized to match pump discharge line or injection flow rate:
      a. Tube shall extend 1/3- to 1/2-diameter of water main into center of main.
      b. Able to safely withdraw or insert injector/diffuser tube into center of water main while under pressure and without having to shut down the main.
      c. Ball check valve located on injector/diffuser solution tube.
      d. Stainless steel safety chain located on injector/diffuser solution tube.

B. Materials:
   1. Injector/Diffuser: Compatible with chemical solution.

C. Manufacturers: The following or equal:
   1. Saf-T-Flo.

2.08 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Drawings supersede conflicts with this Section.

C. Bellows type expansion joints and vibration control joints:
   1. Protect joints against damage during pressure test.

3.02 INSTALLATION

A. Expansion control joints:
   1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
   2. Install bellows type expansion joints so as to allow 2-1/4 inch expansion per 100 linear feet of piping.
   3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
      a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
   4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
   5. Provide control rods and additional guides where indicated on the Drawings but at no greater intervals than recommended by the joint manufacturer in published instructions.
   6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.

B. Pipe saddles:
   1. Coat threads on bolts with anti-gall coating prior to installation.

C. Tapping sleeves:
   1. Verify existing pipe material and outer diameter prior to ordering materials.
   2. Large diameter pipe:
      a. Verify the existence of lining material.
      b. Verify lining material type.
      c. Repair lining after hot tap operations are complete with similar lining or equal.
      d. Demonstrate ability to accomplish hot tap by staging a dry run simulation of the procedure prior to the initiation of the hot tap procedure.
         1) Walk through each step of the hot tap installation, and show the Engineer every component needed to install the hot tap, including, but not limited to, tools and materials, to ensure that the required components are on-site and in place prior to beginning the procedure.
   3. Coat threads on bolts with anti-gall coating prior to installation.

3.03 FIELD QUALITY CONTROL

A. Manufacturer services:
   1. Required only for:
      a. Transition couplings.
      b. Tapping sleeves for large diameter pipe.
   2. Provide Manufacturer's Certificate of Installation.

B. Field testing:
   1. As specified in Section 15052 - Common Work Results for General Piping.
   2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION

SECTION 15230

PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic pipe, tubing, and fittings for systems that are not plumbing systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.12 - Cast Iron Threaded Drainage Fittings.

B. ASTM International (ASTM):
   1. D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
   2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   4. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
   5. D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   6. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   7. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   8. D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.
   9. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   10. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
   11. 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.
   12. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   13. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
   14. D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
   15. D3350 - Standard Specification for Polyethylene Plastic Pipes and Fittings Materials.
   16. D4101 - Standard Specification for Polypropylene Injection and Extrusion Materials.

17. F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
18. F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
19. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
20. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
21. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
22. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
23. F679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
24. F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. American Water Works Association (AWWA):
   1. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches, for Water Transmission Distribution.

D. NSF International (NSF).

E. Plastics Pipe Institute (PPI):
   1. TR 31 - Underground Installation of Polyolefin Piping.

1.03 ABBREVIATIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. CPVC: Chlorinated polyvinyl chloride.

C. DR: Dimension ratio.

D. DWV: Drain, waste, and vent.

E. HDPE: High-density polyethylene.

F. ID: Inside diameter of piping or tubing.

G. NPS: Nominal pipe size followed by the size designation.

H. NS: Nominal size of piping or tubing.

I. PE: Polyethylene.

J. PP: Polypropylene.

K. PVC: Polyvinyl chloride.

L. 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.

C. Shop Drawings:
   1. Describe materials, pipe, fittings, gaskets, and solvent cement.
   2. Installation instructions.

1.05 QUALITY ASSURANCE

A. Plastic pipe in potable water applications: Provide pipe and tubing bearing NSF seal.

B. Fusion machine technician qualifications: 1-year experience in the installation of similar PE piping systems from the same manufacturer.

C. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

D. Test containment piping leak detection system in accordance with system manufacturer's instructions and recommendations to verify proper operation.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings 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.

B. Fittings: Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.

C. Unions 2-1/2 inches and smaller: Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft EPDM gasket.

2.02 PVC PIPING, SCHEDULE TYPE

A. Materials:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated on the Drawings.
   2. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
      c. DWV fittings: In accordance with ASTM D2665.
   3. Solvent cement: In accordance with ASTM D2564:
      a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
         1) Primer: IPS Corp., Type P70.
         2) Cement: IPS Corp., Type 724 cement or another cement certified by the manufacturer for chemical service.

2.03 PE TUBING AND FITTINGS

A. Materials:
   1. Small bore PE tubing: Black flexible virgin PE tubing, OD copper tubing size.
      a. Plastic tubing ID as follows:
         1) For NS 1/4 inch, ID of 0.170 inch.
         2) For NS 5/16 inch, ID of 0.187 inch.
         3) For NS 3/8 inch, ID of 0.251 inch.
         4) For NS of 1/2 inch, an ID of 0.375 inch.
   2. Fittings: Compression fittings, Dekoron E-Z; or equal.
   3. Protective sheath:
      a. Manufacturers: One of the following or equal:
         1) Dekoron, "Poly-Cor."
         2) Parker Hannifin Corp./Fluid connector Products, Parflex Division, Multitube.
   4. Plug-in fittings for connection to instruments: Brass quick-connect fittings.

2.04 PE PIPING FOR DRAIN, WASTE, AND VENT PIPING SYSTEMS

A. General:
   1. Pipe and fittings: High-density polyethylene.
   2. Dimensions of pipe and fittings: Based on controlled outside diameter in accordance with ASTM F714:
      a. SDR: Maximum of 11.

B. Manufacturers: One of the following or equal:
   1. DuPont, Sclairpipe.
   2. Polaris, Duratuff; or equal.

C. Pipe, fittings, and adapters: Furnished by the same manufacturer, and compatible with components in the same system and with components of other systems to which connected.

D. Materials:
   1. Polyethylene: In accordance with ASTM D1248, Type III, Class C, Category 5, Grade P34; listed by the Plastic Pipe Institute under the designation PE 3408; and have a minimum cell classification, in accordance with ASTM D3350.
   2. Pipe and fittings: Manufactured from material with the same cell classification.

2.05 SOURCE QUALITY CONTROL

A. PVC piping, Schedule Type:
   1. Mark pipe and fittings in accordance with ASTM D1785.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.
   3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
   4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of PVC piping, Schedule Type:
   1. Solvent weld joints in accordance with ASTM D2855:
      a. For PVC pipe in chemical service use IPS Corp., Type 724 cement in accordance with manufacturer's instructions.
   2. Install piping in accordance with manufacturer's published instructions.
   3. Provide TEE on containment pipe with 1 foot of clear pipe and a valve for visual inspection at all low points and at maximum spacing of 50 feet. Provide electronic leak detection as indicated on the drawings.

C. Installation of polyethylene (PE) tubing and fittings:
   1. Install small bore PE tubing in accordance with manufacturer's printed instructions, in neat straight lines, supported at close enough intervals to avoid sagging, and in continuous runs wherever possible.
   2. Bundle tubing in groups of parallel tubes within protective sheath.
   3. Tubes within protective sheath may be color coded, but protect tubing other than black outside the sheath by wrapping with black plastic electrician's tape.
   4. Grade tubing connected to meters in one direction.

D. Installation of PE piping for drain, waste, and vent:
   1. Install piping as recommended in manufacturer's published instructions.

E. Leak detection system for containment piping
   1. Install in accordance with system manufacturer's instructions and recommendations.

END OF SECTION

SECTION 15238

POLYETHYLENE (PE) TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Small bore polyethylene tubing and fittings.

1.02 REFERENCES

A. American Water Works Association (AWWA).

B. ASTM International (ASTM):
   1. D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.

1.03 ABBREVIATIONS

A. ID: Inside diameter of piping or tubing.

B. NS: Nominal size of piping or tubing.

C. OD: Outside diameter of piping or tubing.

D. PE: Polyethylene.

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 QUALITY ASSURANCE

A. Mark tubing with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM D1248 and AWWA standards.

1.06 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. Black flexible virgin PE tubing, OD copper tubing size.
   1. Plastic tubing ID as follows:
      a. For NS 1/4 inch, ID of 0.170 inch.
      b. For NS 5/16 inch, ID of 0.187 inch.
      c. For NS 3/8 inch, ID of 0.251 inch.
      d. For NS of 1/2 inch, an ID of 0.375 inch.
   2. Temperature rating: 175 degrees Fahrenheit.
   3. Working pressure rating: 125 pounds per square inch.
   4. Tubing shall have high resistance to stress cracking.
   5. Tubing shall be chemically inert.
   6. Tubing shall be ultraviolet resistant.
   7. Fittings:
      a. Compression fittings, Dekoron E-Z; or equal.
      b. Provide plug-in fittings for connection to instruments (brass quick-connect fittings).
   8. Provide protective sheath:
      a. Manufacturers: One of the following or equal:
         1) Dekoron, "Poly-Cor."
         2) Parker Hannifin Corp., Fluid Connector Products.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install small bore PE tubing in accordance with manufacturer's printed instructions, in neat straight lines, supported at close enough intervals to avoid sagging, and in continuous runs wherever possible.

B. Bundle tubing in groups of parallel tubes within protective sheath.

C. Tubes within protective sheath may be color coded, but protect tubing other than black outside the sheath by wrapping with black plastic electrician's tape.

D. Grade tubing connected to meters in one direction.

END OF SECTION

SECTION 15249

POLYVINYL CHLORIDE (PVC) PIPE: SCHEDULE TYPE

PART 1 GENERAL

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. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   4. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   5. 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.
   6. 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 80 unless otherwise indicated on the Drawings or specified in the Piping Schedule.
   2. Fittings: In accordance with ASTM D2467.
      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 or another primer certified by the manufacturer for chemical service.
            b) Cement: Type 724 or another cement certified by the manufacturer for chemical service.
      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.

F. For PVC containment piping, install leak detection system in accordance with system manufacturer's instructions and recommendation.

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 15956

PIPING SYSTEMS TESTING

PART 1 GENERAL

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. 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 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.

B. Provide Installation and Functional Testing Plans.

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 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Commissioning of equipment as specified in:
   1. This Section.
   2. 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. Operation of related existing equipment:
   1. Owner will operate related existing equipment or facilities necessary to accomplish the testing.
   2. Schedule and coordinate testing as required.

D. 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.

E. 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.

3.02 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.

3.03 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.

3.04 DRIVERS TESTS

A. Test motors as specified.

B. Test other drivers as specified in the equipment section.

3.05 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.

3.06 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.

3.07 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
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type)	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
Vertical Solids Handling Centrifugal Pumps	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.

3.08 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 as specified.
            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 as specified.
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 as specified.
                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 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Requirements specified within this section apply to all sections in Division 16, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 ELECTRICAL SUBCONTRACTOR QUALIFICATIONS

A. The electrical subcontractor shall meet or exceed the criteria described below:
   1. The electrical subcontractor shall be licensed in the State of Florida.
   2. The electrical subcontractor shall have successfully completed electrical construction on three water treatment plants related projects within the past six years.
   3. It is preferred that the electrical subcontractor have prior electrical construction experience with the City of Punta Gorda Shell Creek WTP within the previous six years.
   4. The electrical subcontractor shall have, in their employ, the following full time employees that will be assigned to perform the electrical work of this contract:
      a. A minimum of (1) Licensed Master Electrician who is overall responsible for the supervision of personnel performing the construction, installation startup and testing of all electrical related facilities and systems.
      b. A minimum of (1) Licensed Journeyman Electrician responsible for the daily construction activities and guidance of the electrical Contractor's on site employees. The Licensed Journeyman's primary assignment will be the construction of the electrical facilities of this project until project completion. The Licensed Journeyman shall be certified in Broward County or shall meet the reciprocity standards of Florida State Statue 489 Part II.
   5. The electrical subcontractor shall not be involved in any current or pending litigation which may have a material negative impact on the ability to complete the project. The electrical subcontractor shall provide a statement advising all current or pending litigations.

1.03 DESIGN REQUIREMENTS

A. All electronic boards as part of electrical equipment shall meet the atmospheric conditions of the space the equipment is installed in. All electronic boards which are not installed in a conditioned environment shall be fungus-resistant.

B. All electrical equipment shall be rated for the conditions the equipment is installed in.

1.04 STANDARDS, CODES, PERMITS, AND REGULATIONS

A. Perform all work; furnish and install all materials and equipment in full accordance with the latest applicable rules, regulations, requirements, and specifications of the following:
   1. Local Laws and Ordinances.
   2. State and Federal Laws.
   3. National Electrical Code (NEC).
   4. State Fire Marshal.
   5. Underwriters' Laboratories (UL).
   6. National Electrical Safety Code (NESC).
   7. American National Standards Institute (ANSI).
   8. National Electrical Manufacturer's Association (NEMA).
   9. National Electrical Contractor's Association (NECA) Standard of Installation.
   10. Institute of Electrical and Electronics Engineers (IEEE).
   11. Insulated Cable Engineers Association (ICEA).
   12. Occupational Safety and Health Act (OSHA).
   13. National Electrical Testing Association (NETA).
   14. American Society for Testing and Materials (ASTM).
   15. Florida Building Code, including Broward County amendments.

B. Conflicts, if any, which may exist between the above items, will be resolved at the discretion of the Engineer.

C. Wherever the requirements of the Specifications or Drawings exceed those of the above items, the requirements of the Specifications or Drawings govern. Code compliance is mandatory. Construe nothing in the Contract Documents as permitting work not in compliance with these codes.

D. Obtain all permits and pay all fees required by any governmental agency having jurisdiction over the work. Arrange all inspections required by these agencies. On completion of the work, furnish satisfactory evidence to the Engineer that the work is acceptable to the regulatory authorities having jurisdiction.

1.05 ELECTRICAL COORDINATION

A. Work Provided Under this Contract:
   1. Provide and install the complete electrical power distribution system shown on the drawings including equipment space.
   2. Provide and install all electrical equipment indicated on the drawings and described in the specifications including manual modifications of panel boards, modifications of motor control centers, disconnects, local starters, wire, raceway etc. complete in place.
   3. Provide and install all new underground conduit duct banks and wiring indicated on drawings complete in place.
   4. Provide all miscellaneous electrical including switches, terminations, fittings, wiring, conduit, junction boxes, etc. not specified but obviously necessary for a complete working system in place.

B. Temporary Power:
   1. Provide temporary power for all office trailers and for all construction areas. Coordinate with local power and telephone utility for temporary construction power and telephone service during construction.

1.06 SUBMITTALS

A. Quality Control Submittals:
   1. Voltage Field Test Results.
   2. Voltage Balance Report.
   3. Equipment Line Current Report.
   4. Factory test certification and reports for all major electrical equipment.
   5. Site test certification and reports as specified in other Division 16, Electrical sections.
   6. As part of the electrical submittal, the Contractor shall provide a minimum of 1/2”=1’-0” scaled layout of the electrical equipment in the electrical room or major electrical equipment in a mechanical room showing sizes of all equipment and their spatial relationship. Non-electrical equipment shall be approved before finalizing the electrical layout in mechanical rooms.

B. The following information shall be provided for electrical equipment furnished under specifications 16050 Basic Electrical Materials and Methods;:
   1. A copy of each specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined shall signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation.

C. Electrical equipment submittals shall be made by specification section. Submit one package per specification section and do not group multiple specification sections under one submittal package.

D. Provide complete conduit and equipment layouts: a scaled plan layout of the electrical room(s) showing spatial relationships of all equipment as well as the overall size of the room. Minimum scale shall be 1/2”=1’-0”.

E. Provide a conduit plan for major power, instrumentation and control conduits, both interior and exterior, showing routing, size and stub up locations for buried or in slab conduits.

1.07 ENVIRONMENTAL CONDITIONS

A. All chemical rooms and areas shall be designated as corrosive.

B. All indoor chemical and process equipment areas shall be considered wet locations.

C. Electrical equipment in rooms designated as Classified by NFPA 70 (national electrical code) as Division 1 or Division 2 shall meet all requirements set forth for that classification as described in NEC article 500.

1.08 INSPECTION OF THE SITE AND EXISTING CONDITIONS

A. The Electrical Drawings were developed from past record drawings and information supplied by the Owner. Verify all scaled dimensions prior to submitting bids.

B. Before submitting a bid, visit the site and determine conditions at the site and at all existing structures in order to become familiar with all existing conditions and electrical system which will, in any way or manner, affect the work required under this Contract. No subsequent increase in Contract cost will be allowed for additional work required because of the Contractor's failure to fulfill this requirement.

C. Carry out any work involving the shutdown of the existing services to any piece of equipment now functioning in existing areas at such time as to provide the least amount of inconvenience to the Owner. Do such work when directed by the Engineer.

D. After award of Contract, locate all existing underground utilities at each area of construction activity. Protect all existing underground utilities during construction. Pay for all required repairs without increase in Contract cost, should damage to underground utilities occur during construction.

1.09 RESPONSIBILITY

A. The Contractor shall be responsible for:
   1. Complete systems in accordance with the intent of these Contract Documents.
   2. Coordinating the details of facility equipment and construction for all Specification Divisions which affect the work covered under Division 16, Electrical.
   3. Furnishing and installing all incidental items not actually shown or specified, but which are required by good practice to provide complete functional systems.

1.10 INTENT OF DRAWINGS

A. Electrical plan Drawings show only general location of equipment, devices, and raceway, unless specifically dimensioned. The Contractor shall be responsible for the proper routing of raceway, subject to the approval of the Engineer.

B. All electrical equipment sizes and characteristics have been based on manufacturer Eaton Electrical. If the Contractor chooses to and is allowed to substitute, the Contractor shall be responsible for fitting all the equipment in the available space as shown on the Drawings.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide materials and equipment listed by UL wherever standards have been established by that agency. If a UL listing is not available, equipment shall have a label and listing from a nationally recognized testing laboratory (NRTL) acceptable to the authority having jurisdiction (AHJ) over the project location.

B. Equipment Finish:
   1. Provide manufacturers' standard finish and color, except where specific color is indicated.
   2. If manufacturer has no standard color, provide equipment with ANSI No. 61, light gray color.

PART 3 EXECUTION

3.01 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.

B. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

3.02 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on switchboards, panel boards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.03 CHECKOUT AND STARTUP

A. Voltage Field Test:
   1. Check voltage at point of termination of power company supply system to project when installation is essentially complete and is in operation.
   2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
   3. Record supply voltage (all three phases simultaneously on the same graph) for 24 hours during normal working day.
      a. Submit Voltage Field Test Report within 5 days of test.

4. Unbalance Corrections:
    a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
    b. Obtain a written certification from a responsible power company official that the voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:
    1. Check line current in each phase for each piece of equipment.
    2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
    3. If any phase current for any piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

C. Startup:
    1. Demonstrate satisfactory operation of all 480-volt electrical equipment. Participate with other trades in all startup activities.
    2. Assist the Instrumentation and Control (I&C) Contractor in verifying signal integrity of all control and instrumentation signals.

END OF SECTION

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:
   1. American National Standards Institute (ANSI):
      a. C55.1 - Standard for Shunt Power Capacitors.
      b. C62.11 - Standard for Metal-Oxide Surge Arrestors for AC Circuits.
      c. Z55.1 - Gray Finishes for Industrial Apparatus and Equipment.
   2. American Society for Testing and Materials (ASTM):
      a. A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
      b. A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
      c. A570 - Standard Specification for Steel, Sheet, and Strip, Carbon, Hot-Rolled, Structural Quality.
   3. Federal Specifications (FS):
      a. W-C-596 - Connector, Receptacle, Electrical.
      b. W-S-896E - Switches, Toggle, Flush Mounted.
   4. National Electrical Contractor's Association, Inc. (NECA): 5055, Standard of Installation.
   5. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
      c. CP I - Shunt Capacitors.
      d. ICS 2 - Industrial Control Devices, Controllers, and Assemblies.
      e. KS 1 - Enclosed Switches.
      f. LA I - Surge Arrestors.
      g. PB 1 - Panelboards.
      h. ST 20 - Dry-Type Transformers for General Applications.
      i. WD I - General Requirements for Wiring Devices.
   6. National Fire Protection Association (NFPA): 70 - National Electrical Code (NEC).
   7. Underwriters Laboratories, Inc. (UL):
      a. 67 - Standard for Panelboards.
      b. 98 - Standard for Enclosed and Dead-Front Switches.
      c. 198C - Standard for Safety High-Interrupting-Capacity Fuses, Current-Limiting Types.
      d. 198E - Standard for Class Q Fuses.
      e. 486E - Standard for Equipment Wiring Terminals.
      f. 489 - Standard for Molded Case Circuit Breakers and Circuit Breaker Enclosures.
      g. 508 - Standard for Industrial Control Equipment.
      h. 810 - Standard for Capacitors.

i. 943 - Standard for Ground-Fault Circuit Interrupters.
j. 1059 - Standard for Terminal Blocks.
k. 1561 - Standard for Dry-Type General-Purpose and Power Transformers.

1.02 SUBMITTALS

A. Shop Drawings:
1. Device boxes for use in hazardous areas.
2. Junction and pull boxes used at, or below, grade.
3. Hardware.
4. Terminal junction boxes.
5. Panelboards and circuit breaker data.
6. Fuses.
7. Contactors.
8. Transformers.
9. All other miscellaneous material part of this project.
10. Wire pulling compound.

1.03 QUALITY ASSURANCE

A. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

B. Hazardous Areas: Materials and devices shall be specifically approved for hazardous areas of the class, division, and group shown and of a construction that will ensure safe performance when properly used and maintained.

1.04 SPARE PARTS

A. Furnish, tag, and box for shipment and storage the following spare parts:
1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

PART 2 PRODUCTS

2.01 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc- or cadmium-plated.

B. Cast Metal:
1. Box: Cast ferrous metal.
2. Cover: Gasketed, weatherproof, cast ferrous metal, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs (Cast Mounting) Manufacturer:
a. Crouse-Hinds; Type FS or FD.
b. Appleton; Type FS or FD.

C. Cast Aluminum:
   1. Material:
      a. Box: Cast, copper-free aluminum.
      b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
   2. Hubs: Threaded.
   3. Lugs: Cast mounting.
   4. Manufacturers:
      a. Crouse-Hinds; Type FS-SA or FD-SA.
      b. Appleton; Type FS or FD.

D. PVC-Coated Sheet Steel:
   1. Type: One-piece.
   2. Material: Zinc- or cadmium-plated.
   3. Coating: All surfaces; 40-mil PVC.
   4. Manufacturer: Appleton.

E. Nonmetallic:
   1. Box: PVC.
   2. Cover: PVC, weatherproof, with stainless steel screws.
   3. Manufacturer: Carlon; Type FS or FD, with Type E98 or E96 covers.

2.02 JUNCTION AND PULL BOXES

A. Outlet Boxes Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Large Sheet Steel Box: NEMA 250, Type 1:
   1. Box: Code-gauge, galvanized steel.
   2. Cover: Full access, screw type.
   3. Machine Screws: Corrosion-resistant.

C. Large Cast Metal Box: NEMA 250, Type 4:
   1. Box: Cast malleable iron, hot-dip galvanize finished, with drilled and tapped conduit entrances.
   2. Cover: Hinged with screws.
   3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   4. Manufacturers, Surface Mounted Type:
      a. Crouse-Hinds; Series W.
      b. O-Z/Gedney; Series Y.
   5. Manufacturers, Recessed Type:
      a. Crouse-Hinds; Type WJBF.
      b. O-Z/Gedney; Series YR.

D. Large Stainless Steel Box: NEMA 250, Type 4X:
   1. Box: 14-gauge, ASTM A240, Type 316 stainless steel.
   2. Cover: Hinged with screws.
   3. Hardware and Machine Screws: ASTM A167, Type 304 stainless steel.
   4. Manufacturers:
      a. Hoffman Engineering Co.
      b. Robroy Industries.

E. Large Steel Box: NEMA 250, Type 4:
   1. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces, with final ANSI Z55.1, No. 61 gray enamel on exterior surfaces.
   2. Cover: Hinged with screws.
   3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   4. Manufacturers:
      a. Hoffman Engineering Co.
      b. Robroy Industries.

F. Large Nonmetallic Box:
   1. NEMA 250, Type 4X.
   2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
   3. Cover: Hinged with screws.
   4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   5. Conduit hubs and mounting lugs.
   6. Manufacturers:
      a. Crouse-Hinds; Type NJB.
      b. Carlon; Series N, C, or H.
      c. Robroy Industries.

G. Concrete Box:
   1. Box: Reinforced, cast concrete.
   2. Cover: Cast iron.
   3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
   4. Manufacturers:
      a. Brooks Products Inc.; No. 36/36T.
      b. Qwikset; W 17.

2.03 WIRING DEVICES

A. Switches:
   1. NEMA WD I and FS W-S-896E.
   2. Specification grade, totally-enclosed, ac type, with quiet tumbler switches and screw terminals.
   3. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
   4. Rating: 20 amps, 120/277 volts.
   5. Color:
      a. Office Areas: Ivory.
      b. Other Areas: Brown.
   6. Switches with Pilot Light: 125-volt, neon light with red jewel, or lighted toggle when switch is ON.
   7. Manufacturers:
      a. Bryant.
      b. Leviton.
      c. Hubbell.
      d. Pass and Seymour.
      e. Arrow Hart.

B. Receptacle, Single and Duplex:
   1. NEMA WD 1 and FS W-C-596.
   2. Specification grade, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.
   3. High strength, thermoplastic base color.
   4. Color:
      a. Office Areas: Ivory.
      b. Other Areas: Brown.
   5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
   6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
   7. Manufacturers:
      a. Bryant.
      b. Leviton.
      c. Hubbell.
      d. Pass and Seymour.
      e. Sierra.
      f. Arrow Hart.

C. Receptacle, Ground Fault Circuit Interrupter: Duplex, specification grade, tripping at 5 mA.
   1. Color: Ivory.
   2. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, capable of interrupting 5,000 amps without damage.
   3. Size: For 2-inch by 4-inch outlet boxes.
   4. Standard Model: NEMA WD 1 with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
   5. Feed-Through Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
   6. Manufacturers:
      a. Pass and Seymour.
      b. Bryant.
      c. Leviton.
      d. Hubbell.
      e. Arrow Hart.

D. Receptacle, Special-Purpose:
   1. Rating and number of poles as indicated or required for anticipated purpose.
   2. Matching plug with cord-grip features for each special-purpose receptacle.

E. Multioutlet Surface Raceway System: Three-wire grounding receptacles, spaced on 6-inch centers with insulated grounding conductor to each receptacle:
   1. Color: Gray with black receptacles.
   2. Manufacturers:
      a. Plugmold; 2000.
      b. Walker; Duct 2GW.

2.04 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Plastic:
   1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
   2. Color: To match associated wiring device.
   3. Mounting Screw: Oval-head metal, color matched to plate.

C. Metal:
   1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
   2. Finish: ASTM A167, Type 302/304, satin.
   3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:
   1. Material: Malleable ferrous metal, with gaskets.
   2. Screw: Oval-head stainless steel.

E. Engraved:
   1. Character Height: 3/16 inch.
   2. Filler: Black.

F. Weatherproof:
   1. For Receptacles: Gasketed, cast metal or stainless steel, with individual cap over each receptacle opening.
   2. Mounting Screw: Stainless steel:
      a. Cap Spring: Stainless steel.
      b. Manufacturers:
         1) General Electric.
         2) Bryant.
         3) Hubbell.
         4) Sierra.
         5) Pass and Seymour.
         6) Crouse-Hinds; Type WLRD or WLRS.
         7) Bell.
         8) Arrow Hart.
   3. For Switches: Gasketed, cast metal incorporating external operator for internal switch:
      a. Mounting Screw: Stainless steel.
      b. Manufacturers.
      c. Crouse-Hinds; DS-181 or DS-185.
      d. Appleton; FSK-LVTS or FSK-IVS.

G. Raised Sheet Metal: 1/2-inch high zinc- or cadmium-plated steel designed for 1-piece drawn type sheet steel boxes.

2.05 LIGHTING AND POWER DISTRIBUTION PANELBOARD (LP, IP, AND PP PANEL)

A. NEMA PB I, NFPA 70, and UL 67, including panelboards installed in motor control equipment.

B. Panelboards and Circuit Breakers: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

C. Short-Circuit Current Equipment Rating: Fully rated; series connected unacceptable.

D. Rating: If not otherwise shown in plans. Applicable to a system with available short-circuit current of 22,000 amperes rms symmetrical at 208Y/120 or 120/240 volts and 65,000 amperes rms symmetrical at 480Y/277 volts.

E. Where ground fault interrupter circuit breakers are indicated or required by code: 5 mA trip, 10,000 amps interrupting capacity circuit breakers.

F. Cabinet: As shown on plans.

G. Bus Bar:
   1. Material: Copper, full sized throughout length.
   2. Provide for mounting of future circuit breakers along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.
   3. Neutral: Insulated, rated 150 percent of phase bus bars with at least 1 terminal screw for each branch circuit.
   4. Ground: Copper, installed on panelboard frame, bonded to box with at least one terminal screw for each circuit.
   5. Lugs and Connection Points:
      a. Suitable for either copper or aluminum conductors.
      b. Solderless main lugs for main, neutral, and ground bus bars.
      c. Subfeed or through-feed lugs as shown.
   6. Bolt together and rigidly support bus bars and connection straps on molded insulators.

H. Circuit Breakers:
   1. NEMA AB 1 and UL 489.
   2. Thermal-magnetic, quick-make, quick-break, molded case, of the indicating type showing ON/OFF and TRIPPED positions of operating handle.
   3. Noninterchangeable, in accordance with NFPA 70.
   4. Locking: Provisions for handle padlocking, unless otherwise shown.
   5. Type: Bolt-on circuit breakers in all panelboards.
   6. Multipole circuit breakers designed to automatically open all poles when an overload occurs on one pole.
   7. Do not substitute single-pole circuit breakers with handle ties for multipole breakers.
   8. Do not use tandem or dual circuit breakers in normal single-pole spaces.
   9. Ground Fault Interrupter:
      a. Equip with conventional thermal-magnetic trip and ground fault sensor rated to trip in 0.025 second for a 5-milliampere ground fault (UL 943, Class A sensitivity).
      b. Sensor with same rating as circuit breaker and a push-to-test button.

I. Manufacturers:
   1. Eaton Electrical.
   2. Schneider Electric
   3. Or approved equal.

2.06 MINI-POWER CENTER (MPC)

A. General: Transformer, primary and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 4X enclosure. Complete MPC shall be rated for 22,000 amperes RMS symmetrical.

B. Transformer:
   1. Type: Dry, self-cooled, encapsulated.
   2. Insulation: Manufacturer's standard, with UL 1561 temperature rise.
   3. Full capacity, 2-1/2 percent voltage taps, 2 above and 2 below normal voltage.
   4. Primary Voltage: See plans.
   5. Secondary Voltage: See plans.

C. Panelboard: Full, UL 489, short-circuit current rated:
   1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
   2. Number and Breaker Ampere Ratings: Refer to Panel Schedule.

2.07 CIRCUIT BREAKER, INDIVIDUAL, 0 TO 600 VOLTS

A. NEMA AB I, UL 489 listed for use at location of installation.

B. Minimum Interrupt Rating: As shown or as required.

C. Thermal-magnetic, quick-make, quick-break, indicating type, showing ON/OFF and TRIPPED indicating positions of the operating handle.

D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees Celsius ampacity.

E. Locking: Provisions for padlocking handle.

F. Multipole breakers to automatically open all poles when an overload occurs on 1 pole.

G. Enclosure: NEMA 250, Type 12, Industrial Use, 4X - outdoors, wet locations and corrosive areas, unless otherwise shown.

H. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position.

I. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.

2.08 FUSED DISCONNECT SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. UL 98 listed for use and location of installation.

B. NEMA KS 1 and UL 98 Listed for application to system with available short circuit current of 22,000 amps rms symmetrical.

C. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees Celsius ampacity.

E. Fuse mountings shall reject Class H fuses and accept only current-limiting fuses specified.

F. Enclosure: NEMA 250, Type 12, Industrial Use, 4X - outdoors, wet locations and corrosive areas, unless otherwise shown.

G. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

2.09 NONFUSEDDISCONNECT SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees Celsius ampacity.

D. Enclosure: NEMA 250, Type 12, industrial use, 4X - outdoors, wet locations and corrosive areas, unless otherwise shown.

E. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

2.10 FUSE, 0 TO 600 VOLTS

A. Current-limiting, with 200,000 ampere rms interrupting rating.

B. Provide to fit mountings specified with switches and features to reject Class H fuses.

C. Motor and Transformer Circuits, 0- to 600-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-1, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPS-RK.
      b. Littlefuse; Type LLS-RK.

D. Motor and Transformer Circuits, 0- to 250-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-1, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPN-RK.
      b. Littlefuse; Type LLN-RK.

E. Feeder and Service Circuits, 0- to 600-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-I, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPS-RK.
      b. Littlefuse; Type LLS-RK.

F. Feeder and Service Circuits, O- to 250-Volt:
   1. Amperage: 0 to 600.
   2. UL 198E, Class RK-I, dual element, with time delay.
   3. Manufacturers:
      a. Bussmann; Type LPN-RK.
      b. Littlefuse; Type LLN-RK.

G. Feeder and Service Circuits, 0- to 600-Volt:
   1. Amperage: 601 to 6,000.
   2. UL 198C, Class L, double O-rings and silver links.
   3. Manufacturers:
      a. Bussmann; Type KRP-C.
      b. Littlefuse; Type KLPC.

2.11 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCHES

A. Contact Rating: NEMA ICS 2, Type A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Lights: Push-to-test, LED type. Minimum 22 mm diameter.

D. Pushbutton Color:
   1. ON or START: Black.
   2. OFF or STOP: Red.

E. Pushbuttons and selector switches lockable in the OFF position where indicated.

F. Legend Plate:
   1. Material: Aluminum.
   2. Engraving: 11 character/spaces on one line, 14 character/spaces on each of 2 lines, as required, indicating specific function.
   3. Letter Height: 7/64 inch.

G. Manufacturers:
   1. Heavy-Duty, Oiltight Type:
      a. Allen Bradley: 800T.
      b. No approved equal.
   2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
      a. Allen Bradley: 800H.
      b. No approved equal.

2.12 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Terminal Blocks: Provide separate connection point for each conductor entering or leaving box:
   1. Spare Terminal Points: 25 percent.

C. Interior Finish: Paint with white enamel or lacquer.

2.13 TERMINAL BLOCK (0 TO 600 VOLTS)

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of all control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between the compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:
   1. Capable of wire connections without special preparation other than stripping.
   2. Capable of jumper installation with no loss of terminal or rail space.
   3. Individual, rail mounted.

I. Marking system allow use of preprinted or field-marked tags.

J. Manufacturers:
   1. Allen Bradley: 1492-J6 series.
   2. No approved equal.

2.14 MAGNETIC CONTROL RELAY

A. NEMA ICS 2, Class A600 (600 volts, 10 amps continuous, 7,200VA make, 720VA break), industrial control with field convertible contacts.

B. Time Delay Relay Attachment:
   1. Pneumatic type, timer adjustable from 0.2 to 60 seconds (minimum).
   2. Field convertible from ON delay to OFF delay and vice versa.

C. Latching Attachment: Mechanical latch having unlatching coil and coil clearing contacts.

D. Manufacturers:
   1. Eaton Electrical; Type M-600.
   2. General Electric; Type CR120B.

2.15 RESET TIMER

A. Drive: Synchronous motor, solenoid operated clutch.

B. Mounting: Semiflush, panel.

C. Contacts: 10-amp, 120-volt.

D. Manufacturers:
   1. Eagle Signal; Bulletin 125.
   2. Automatic Timing and Controls; Bulletin 305.

2.16 ELAPSED TIME METER

A. Drive: Synchronous motor.

B. Range: 0 to 99,999.9 hours, nonreset type.

C. Mounting: Semiflush, panel.

D. Manufacturers:
   1. General Electric; Type 240, 2-1/2-inch Big Look.
   2. Eagle Signal; Bulletin 705.

2.17 MAGNETIC CONTACTOR

A. NEMA ICS 2, UL 508.

B. Electrically operated, electrically held.

C. Main Contacts:
   1. Power driven in one direction with gravity dropout.
   2. Silver alloy with wiping action and arc quenchers.
   3. Continuous-duty, rated 30 amperes, 600-volt.
   4. Three-pole.

D. Control: 2-wire.

E. One normally open and one normally closed auxiliary contacts rated 10 amperes at 480-volt.

F. Enclosure: NEMA 250, Type 12, unless otherwise shown.

G. Manufacturers:
   1. Eaton Electrical.
   2. General Electric; CR 353.
   3. Allen-Bradley; Bulletin 500 Line.

2.18 MAGNETIC LIGHTING CONTACTOR

A. NEMA ICS 2, UL 508.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and electrically held in both OPEN and CLOSED position.

D. Main Contacts:
   1. Power driven in both directions.
   2. Double-break, continuous-duty, rated 20 amperes, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts.
   3. Marked for electric discharge lamps, tungsten, and general-purpose loads.
   4. Position not dependent on gravity, hooks, latches, or semi-permanent magnets.
   5. Capable of operating in any position.
   6. Visual indication for each contact.

E. Auxiliary contact relay for three-wire control.

F. One normally open and one normally closed auxiliary contacts rated 10 amperes at 480-volt.

G. Fully rated neutral plate.

H. Provision for remote pilot lamp with use of auxiliary contacts.

I. Clamp type, self-rising terminal plates for solderless connections.

J. Enclosure: NEMA 250, Type 12, Dust-Tight, Drip-Tight, Industrial Use, unless otherwise shown.

K. Manufacturers:
   1. ASCO.
   2. Westinghouse; Class A202.
   3. General Electric; Class 360.
   4. Eaton Electrical.
   5. Square D.

2.19 INDUSTRIAL CAPACITORS

A. UL 810, NEMA CP1, ANSI C55.1, and NFPA 70, Article 460.

B. Enclosed, outdoor, weatherproof, three-phase capacitor units containing internally mounted, indicating type, high interrupting-capacity, current limiting fuses and discharge resistors.

C. Units containing PCB dielectric fluid are unacceptable.

D. Kilovar Ratings:
   1. Kilovar ratings of capacitors connected to individual motor circuits were selected based on expected motor power factor.

2. Check motor nameplate and manufacturer's power factor and no-load current data for actual motor installed.
3. Reduce capacitor kVAR if required, so the size does not exceed the motor manufacturer's recommended maximum size, and so it does not exceed the value required to raise motor no-load power factor to 0.95.
4. Manufacturers:
   a. ABB.
   b. Square D.

2.20 THERMOSTAT

A. Rating: 7.4 amps continuous, 44 amps locked rotor current at 120 volts and 3.7 amps continuous, 22 amps locked rotor current at 240 volts.

B. Line voltage, single-stage, treated to resist corrosion, dust, dirt, and humidity with sealed SPDT contacts.

C. Heating Adjustment Range: 35 to 100 degrees Fahrenheit.

D. Cooling or Ventilating Adjustment Range: 70 to 140 degrees Fahrenheit.

E. Manufacturer: Honeywell; Type T631F1084.

2.21 DRY TYPE TRANSFORMER (0- TO 600-VOLT PRIMARY)

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Self-cooled, 2-winding, UL K-4 rated for nonlinear loads.

C. Insulation Class and Temperature Rise: Manufacturer's standard.

D. Core and Coil:
   1. Encapsulated for single-phase units 1/2 to 25 kVA and for 3-phase units 3 to 15 kVA.
   2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for 3-phase units 30 kVA and above.

E. Enclosure:
   1. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated.
   2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
   3. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, nonventilated.
   4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
   5. Outdoor Transformers: NEMA 250, Type 3R.

F. Wall Bracket: For single-phase units, 15 to 37-1/2 kVA, and for 3-phase units, 15 to 30 kVA.

G. Voltage Taps:
   1. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; 2 above and 2 below normal voltage rating.

2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; 2 above and 2 below normal voltage rating.
3. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; 2 above and 2 below normal voltage rating.
4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; 2 above and 2 below normal voltage rating.

H. Impedance: 4.5 percent minimum on units 75 kVA and larger.

I. Maximum Sound Level: NEMA ST 20:
1. 40 decibels for 0 to 9 kVA.
2. 45 decibels for 10 to 50 kVA.
3. 50 decibels for 51 to 150 kVA.
4. 55 decibels for 151 to 300 kVA.
5. 60 decibels for 301 to 500 kVA.

J. Vibration Isolators:
1. Rated for transformer's weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

K. Manufacturers:
1. Square D.
2. General Electric.
3. Eaton (Cutler Hammer).
4. Or approved equal.

2.22 LOW VOLTAGE, SECONDARY SURGE PROTECTIVE EQUIPMENT

A. NEMA LA1, ANSI C62. 11.

B. Surge Capacitor:
1. Impregnated with non-PCB, biodegradable dielectric fluid.
2. Integral discharge resistor which will drain residual voltage to 50 volts crest in less than I minute after disconnection from circuit.

C. Arrestor: High strength metal oxide valve elements enclosed in high strength, corrosion resistant, molded resin housing.

D. Equip capacitor and arrestor with mounting nipple, flat washer, and nut suitable for knockout or bracket mounting.

2.23 SUPPORT AND FRAMING CHANNELS

A. Material:
1. Dry indoors - galvanized.

2. All Other Areas: ASTM A167, Type 316 stainless steel or fiber-reinforced epoxy, as required.

B. Finish:
   1. Dry indoors - galvanized.
   2. All Other Areas: ASTM A167, Type 316 stainless steel or fiber-reinforced epoxy, as required.

C. Inserts: Continuous.

D. Beam Clamps: Gray cast iron.

E. Manufacturers:
   1. B-Line.
   2. Unistrut.

2.24 NAMEPLATES

1. Refer to WMWD Electrical ID Standard document to section 3 and section 4 for exact Physical Tag Specification requirements.

2.25 SURGEPROTECTIVE DEVICES

A. This section describes the material and installation requirements for transient voltage surge suppression devices (SPD) in switchboards, panelboards, and motor control centers for the protection of all AC electrical circuits.

B. SPD shall be listed and component recognized in accordance with UL 1449 and UL 1283.

C. SPD shall be installed and warranted by and shipped from the electrical distribution equipment manufacturer’s factory.

D. SPD shall provide surge current diversion paths for all modes of protection; L-L, L-N, L-G, N-G in WYE systems, and L-L, L-G in DELTA systems.

E. SPD shall be modular in design. Each module shall be fused with a surge rated fuse.

F. A UL approved disconnect switch shall be provided as a means of disconnect in the switchboard device only.

G. SPD shall meet or exceed the following criteria:
   1. Maximum surge current capability (single pulse rated) shall be:
      a. Service entrance switchboard 300kA.
      b. Branch panelboards 150kA.
      c. Motor control centers 80kA.

2. UL 1449 Listed and Recognized Component Suppression Voltage Ratings shall not exceed the following:

Voltage	L-N	L-G	N-G
208Y/120	400V		400V
480Y/277	800V		800V

H. SPD shall have a minimum EMI/RFI filtering of -44dB at 100kHz with an insertion ration of 50:1 using MIL STD. 220A methodology.

I. SPD shall be provided with 1 set of NO/NC dry contacts.

J. SPD shall have a warranty for a period of five years, incorporating unlimited replacements of suppressor parts if they are destroyed by transients during the warranty period. Warranty will be the responsibility of the electrical distribution equipment manufacturer.

K. Approve manufactures are:
1. Eaton Electrical.
2. Cutler Hammer CPS Series.
3. General Electric Tranquell Series.
4. Siemens TPS Series.
5. Square D Company XTE Series.
6. Current Technology.

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with NECA 5055.

3.02 OUTLET AND DEVICE BOXES

A. Install suitable for conditions encountered at each outlet or device in the wiring or raceway system, sized to meet NFPA 70 requirements.

B. Size:
1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted:
   a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
2. Ceiling Outlet: Minimum 4-inch octagonal sheet steel device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch sheet steel device box.

C. Locations:
1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by engineer.

3. Light Switch: Install on lock side of doors.
4. Light Fixture: Install in symmetrical pattern according to room layout unless otherwise shown.

D. Mounting Height:
   1. General:
      a. Measured to centerline of box.
      b. Where specified heights do not suit building construction or finish, mount as directed by Engineer.
   2. Light Switch: 48 inches above floor.
   3. Thermostat: 54 inches above floor.
   4. Telephone Outlet: 6 inches above counter tops or 15 inches above floor.
   5. Wall Mounted Telephone Outlet: 52 inches above floor.
   6. Convenience Receptacle:
      a. General Interior Areas: 15 inches above floor.
      b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of splashback, or 6 inches above countertops without splashback.
      c. Industrial Areas, Workshops: 48 inches above floor.
      d. Outdoor, All Areas: 24 inches above finished grade.
   7. Special-Purpose Receptacle: 54 inches above floor or as shown.

E. Install plumb and level.

F. Flush Mounted:
   1. Install with concealed conduit.
   2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
   3. Holes in surrounding surface shall be no larger than required to receive box.

G. Support boxes independently of conduit by attachment to building structure or structural member.

H. Install bar hangers in frame construction, or fasten boxes directly with wood screws on wood, bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws threaded into steelwork.

I. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

J. Provide plaster rings where necessary.

K. Boxes embedded in concrete or masonry need not be additionally supported.

L. Install stainless steel mounting hardware in industrial areas.

M. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

N. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.

O. Box Type (Steel Raceway System):
   1. Exterior Locations:
      a. Exposed Raceways: Cast metal.
      b. Concealed Raceways: Cast metal.
      c. Concrete Encased Raceways: Cast metal.
      d. Class I, II, or III Hazardous Areas: Cast metal.
   2. Interior Dry Locations:
      a. Exposed Rigid Conduit: Cast metal.
      b. Concealed Raceways: Sheet steel.
      c. Concrete Encased Raceways: Cast metal.
      d. Lighting Circuits, Ceiling: Sheet steel.
      e. Class I, II, or III Hazardous Areas: Cast metal.
   3. Interior Wet Locations:
      a. Exposed Raceways: Cast metal.
      b. Concealed Raceways: Cast metal.
      c. Concrete Encased Raceways: Cast metal.
      d. Lighting Circuits, Ceiling: Sheet steel.
      e. Class I, II, or III Hazardous Areas: Cast metal.
   4. Cast-In-Place Concrete Slabs: Sheet steel.

P. Box Type (Rigid Aluminum Raceway System): Cast aluminum.

Q. Box Type (Nonmetallic Raceway System):
   1. Corrosive Locations: Nonmetallic.
   2. Exposed Raceways: Nonmetallic.
   3. Concealed Raceways: Nonmetallic.
   4. Concrete Encased Raceways: Nonmetallic.

R. Box Type, Corrosive Locations (PVC-Coated Rigid Galvanized Steel Raceway System): PVC coated cast metal.

3.03 JUNCTION AND PULL BOXES

A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.

B. Install pull boxes where necessary in raceway system to facilitate conductor installation.

C. Install in conduit runs at least every 150 feet or after the equivalent of 3 right-angle bends.

D. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.

E. Installed boxes shall be accessible.

F. Do not install on finished surfaces.

G. Install plumb and level.

H. Support boxes independently of conduit by attachment to building structure or structural member.

I. Install bar hangers in frame construction, or fasten boxes directly with wood screws on wood, bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws or welded threaded studs on steelwork.

J. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

K. Boxes embedded in concrete or masonry need not be additionally supported.

L. At or Below Grade:
   1. Install boxes for below grade conduits flush with finished grade in locations outside of paved areas, roadways, or walkways.
   2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
   3. Obtain Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.
   4. Use boxes and covers suitable to support anticipated weights.

M. Flush Mounted:
   1. Install with concealed conduit.
   2. Holes in surrounding surface shall be no larger than required to receive box.
   3. Make edges of boxes flush with final surface.

N. Mounting Hardware:
   1. Noncorrosive Interior Areas: Galvanized.
   2. All Other Areas: Stainless steel.

O. Location/Type:
   1. Finished, Indoor, Dry: NEMA 250, Type 1.
   2. Unfinished, Indoor, Dry: NEMA 250, Type 12.
   3. Unfinished, Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X.
   4. Unfinished, Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.
   5. Unfinished, Indoor and Outdoor, Hazardous: NEMA 250, Type 7 and Type 9, where indicated.
   6. Underground Conduit: Concrete Encased.
   7. Corrosive Locations: Nonmetallic.

3.04 WIRING DEVICES

A. Switches:
   1. Mounting Height: See Paragraph Outlet and Device Boxes.
   2. Install with switch operation in vertical position.
   3. Install single-pole, two-way switches such that toggle is in up position when switch is on.

B. Receptacles:
   1. Install with grounding slot down except where horizontal mounting is shown, in which case install with neutral slot up.

2. Ground receptacles to boxes with grounding wire only.
3. Weatherproof Receptacles:
    a. Install in cast metal box.
    b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for "downstream" conventional receptacles.
5. Special-Purpose Receptacles: Install in accordance with manufacturer's instructions.

C. Multioutlet Surface Raceway System:
1. Install in accordance with manufacturer's instructions.
2. Wire alternate outlets to each circuit where two-circuit, 3-wire supply is shown.

3.05 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to the box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Engrave with designated titles.

F. Types (Unless Otherwise Shown):
1. Office: Stainless Steel.
2. Exterior: Weatherproof.
3. Interior:
    a. Flush Mounted Boxes: Stainless Steel.
    b. Surface Mounted, Cast Metal Boxes: Cast metal.
    c. Surface Mounted, Sheet Steel Boxes: Stainless Steel.
    d. Surface Mounted, Nonmetallic Boxes: Plastic.

3.06 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Heavy-Duty, Oiltight Type: Locations (Unless Otherwise Shown): Nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

B. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
1. Locations (Unless Otherwise Shown): Nonhazardous, outdoor, or normally wet areas.
2. Mounting: NEMA 250, Type 4X enclosure.

3.07 TERMINAL JUNCTION BOX

A. Install in accordance with Paragraph JUNCTION AND PULL BOXES.

B. Label each block and terminal with permanently attached, nondestructible tag.

C. Do not install on finished outdoor surfaces.

D. Location:
   1. Finished, Indoor, Dry: NEMA 250, Type 1.
   2. Unfinished, Indoor, Dry: NEMA 250, Type 12.
   3. Unfinished, Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X.
   4. Unfinished, Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.

3.08 LIGHTING AND POWER DISTRIBUTION PANELBOARD

A. Install securely, plumb, in-line and square with walls.

B. Install top of cabinet 6 feet above floor unless otherwise shown.

C. Provide typewritten circuit directory for each panelboard.

3.09 INDUSTRIAL CAPACITORS

A. Provide suitable hangers or mounting brackets for wall or ceiling mounting.

3.10 DRY TYPE TRANSFORMER (0- TO 600-VOLT PRIMARY)

A. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

B. Provide moistureproof, flexible conduit for electrical connections.

C. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

D. Provide wall brackets for single-phase units, 15 to 167-1/2 kVA, and 3-phase units, 15 to 112 kVA.

3.11 SUPPORT AND FRAMING CHANNEL

A. Furnish zinc-rich primer; paint cut ends prior to installation, where applicable.

B. Install where required for mounting and supporting electrical equipment and raceway systems.

3.12 MOTOR SURGE PROTECTION

A. Ground in accordance with NFPA 70.

B. Low Voltage: Ground terminals to equipment bus.

END OF SECTION

SECTION 16110

RACEWAYS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:
   1. American Association of State Highway and Transportation Officials (AASHTO): Division I, Standard Specifications for Highway Bridges, Fourteenth Edition.
   2. American National Standards Institute (ANSI):
      a. C80.1, Rigid Steel Conduit-Zinc Coated.
      b. C80.3, Electrical Metallic Tubing-Zinc Coated.
   3. American Society for Testing and Materials (ASTM):
      a. A123 El, Standard Specification for Zinc-Coated (Galvanized) Coatings on Iron and Steel Products.
      b. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   4. National Electrical Contractor's Association, Inc. (NECA): 5055, Standard of Installation.
   5. National Electrical Manufacturers Association (NEMA):
      a. RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
      b. TC 2, Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
      c. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
      d. TC 6, PVC and ABS Plastic Utilities Duct for Underground Installation.
   6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   7. Underwriters Laboratories, Inc. (UL):
      a. 1, Standard for Safety Flexible Metal Conduit.
      b. 6, Standard for Safety Rigid Metal Conduit.
      c. 360, Standard for Safety Liquid-Tight Flexible Steel Conduit.
      d. 514B, Standard for Safety Fittings for Conduit and Outlet Boxes.
      e. 514C, Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
      f. 651, Standard for Safety Schedule 40 and 80 PVC Conduit.
      g. 651A, Standard for Safety Type EB and Rigid PVC Conduit and HDPF Conduit.
      h. 870, Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings.
      i. 1660, Standard for Safety Liquid-Tight Flexible Nonmetallic Conduit.

1.02 SUBMITTALS

A. Shop Drawings:
   1. Manufacturer's Literature:
      a. Rigid galvanized steel conduit.

b. PVC Schedule 40 and schedule 80 conduit.
c. PVC-coated rigid galvanized steel conduit.
d. Flexible metal, liquid-tight conduit.
e. Flexible, nonmetallic, liquid-tight conduit.
f. Conduit fittings.
g. Wireways.

2. Precast Manholes and Handholes:
   a. Dimensional drawings and descriptive literature.
   b. Traffic loading calculations.
   c. Accessory information.
3. Conduit Layout:
   a. Plan and section type, showing arrangement and location of conduit required for:
      1) Low voltage feeder and branch circuits.
      2) Instrumentation and control systems.
      3) Communications systems.
      4) Empty conduit for future use.
   b. Reproducible drawings; scale not greater than 1/2 inch equals 1 foot.
      1) Equipment and machinery proposed for bending metal conduit.
      2) Method for bending PVC conduit less than 30 degrees.

1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):
   1. Meet requirements of ANSI C80.1 and UL6.
   2. Material: Hot-dip galvanized, with chromated protective layer.

B. PVC Schedule 40 Conduit:
   1. Meet requirements of NEMA TC 2 and UL 651.
   2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

C. PVC-Coated Rigid Galvanized Steel Conduit:
   1. Meet requirements of NEMA RN 1.
   2. Material:
      a. Conduit: Meet requirements of ANSI C80.1 and UL 6
      b. PVC Coating: 40 mils nominal thickness, bonded to metal.

D. Flexible Metal, Liquid-Tight Conduit:
   1. UL 360 listed for 105 degrees C insulated conductors.
   2. Material: Galvanized steel, with an extruded PVC jacket.

E. Rigid Aluminum Conduit:
   1. Meet requirements of ANSI C80.5 and UL 6.
   2. Material: Type 6063, copper-free aluminum alloy.

F. Flexible, Nonmetallic, Liquid-Tight Conduit:
   1. Material: PVC core with fused flexible PVC jacket.
   2. UL 1660 listed for:
      a. Dry Conditions: 80 degrees C insulated conductors.
      b. Wet Conditions: 60 degrees C insulated conductors.
   3. Manufacturers:
      a. Carlon; Carflex or X-Flex.
      b. T & B; Xtraflex LTC or EFC.

2.02 FITTINGS

A. Rigid Galvanized Steel Conduit:
   1. General:
      a. Meet requirements of UL 514B.
      b. Type: Threaded, galvanized. Set screw fittings not permitted.
   2. Bushing:
      a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
      b. Manufacturers:
         1) Thomas & Betts; Type BIM.
         2) O.Z./Gedney; Type HB.
   3. Grounding Bushing:
      a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
      b. Manufacturers:
         1) Appleton; Series GIB.
         2) O.Z./Gedney; Type HBLG.
   4. Conduit Hub:
      a. Material: Malleable iron with insulated throat.
      b. Manufacturers:
         1) O.Z./Gedney; Series CH.
         2) T & B; Series 370.
   5. Conduit Bodies:
      a. Material: Malleable iron, sized as required by NFPA 70.
      b. Manufacturers (For Normal Conditions):
         1) Appleton; Form 35 threaded Unilets.
         2) Crouse-Hinds; Form 7 or 8 threaded condulets.
         3) Killark; Series O Electrolets.
      c. Manufacturers (For Hazardous Locations):
         1) Appleton.
         2) Crouse-Hinds.
         3) Killark.
   6. Couplings: As supplied by conduit manufacturer.
   7. Conduit Sealing Fitting Manufacturers:
      a. Appleton; Type EYF, EYM, or ESU.
      b. Crouse-Hinds; Type EYS or EZS.
      c. Killark; Type EY or EYS.

8. Drain Seal Manufacturers:
    a. Appleton; Type SF.
    b. Crouse-Hinds; Type EYD or EZD.
9. Drain/Breather Fitting Manufacturers:
    a. Appleton; Type ECDB.
    b. Crouse-Hinds; ECD.
10. Expansion Fitting Manufacturers:
    a. Deflection/Expansion Movement:
        1) Appleton; Type DF.
        2) Crouse-Hinds; Type XD.
    b. Expansion Movement Only:
        1) Appleton; Type XJ.
        2) Crouse-Hinds; Type XJ.
11. Cable Sealing Fittings:
    a. To form watertight non-slip cord or cable connection to conduit.
    b. For Conductors With OD of 1/2 Inch or Less: Neoprene bushing at connector entry.
    c. Manufacturers:
        1) Crouse-Hinds; CGBS.
        2) Appleton; CG-S.

B. PVC Conduit and Tubing:
1. Meet requirements of NEMA TC-3.
2. Type: PVC, slip-on.

C. PVC-Coated Rigid Galvanized Steel Conduit:
1. Meet requirements of UL 514B.
2. Type: Rigid galvanized steel, PVC coated by conduit manufacturer.
3. Overlapping pressure sealing sleeves.
4. Conduit Hangers, Attachments, and Accessories: PVC-coated.

D. Flexible Metal, Liquid-Tight Conduit:
1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
2. Insulated throat and sealing O-rings.
3. Long design type extending outside of box or other device at least 2 inches.
4. Manufacturer: T & B; Series 5300.

E. Flexible, Nonmetallic, Liquid-Tight Conduit: Meet requirements of UL 514B.
1. Type: One-piece fitting body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
2. Manufacturers:
    a. Carlon; Type LT.
    b. Kellems; Polytuff.
    c. T & B; LT Series.

F. Watertight Entrance Seal Device:
1. New Construction:
    a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
    b. Manufacturer: O.Z./Gedney; Type FSK or WSK, as required.

2. Gored-Hole Application:
    a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
    b. Manufacturer: O.Z./Gedney; Series CSM.

G. Hazardous Locations: Approved for use in the atmosphere involved.
1. Manufacturer: Crouse-Hinds; Type ECGJH.

H. Corrosive Locations:
1. Material: 40-mil PVC-coated rigid steel.
2. Manufacturers:
    a. Robroy Industries.
    b. Carlon.
    c. Crouse-Hinds.

2.03 WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, with removable, hinged cover.

C. Rating: Outdoor rain-tight if outdoor, and indoor if indoor.

D. Finish: Gray, baked enamel.

E. Manufacturers:
1. Square D.
2. B-Line Systems, Inc.

2.04 PRECAST MANHOLES AND HANDHOLES

A. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.

B. Loading: AASHTO Division 1, H-20 in accordance with ASTM C857.

C. Access: Provide cast concrete 6- or 12-inch risers and access adapters between top of manhole and finished grade at required elevations.

D. Drainage:
1. Slope floors toward drain points, leaving no pockets or other non-draining areas.
2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and 4-inch minimum outlet and outlet pipe.

E. Raceway Entrances:
1. Provide on all four sides.
2. For raceways to be installed under this Contract, provide knockout panels or precast individual raceway openings.
3. At entrances where raceways are to be installed by others, provide minimum 12-inch high by 24-inch wide knockout panels for future raceway installation.

F. Embedded Pulling Iron:
   1. Material: 3/4-inch diameter stock, fastened to overall steel reinforcement before concrete is placed.
   2. Location:
      a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
      b. Floor: Centered below manhole or handhole cover.

G. Cable Racks:
   1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
   2. Wall Attachment:
      a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
      b. Insert Spacing: Maximum 3-foot on center entire inside perimeter of manhole.
      c. Arrange so that spare raceway ends are clear for future cable installation.

H. Manhole Frames and Covers:
   1. Material: Machined cast iron.
   2. Diameter: 32 inches.
   3. Cover Type: Indented, solid top design, with two drop handles each.
   4. Cover Loading: AASHTO Division I, H-20.
   5. Cover Designation: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
      a. Above 600 Volts: ELECTRIC HV.
      b. 600 Volts and Below: ELECTRIC LV.
      c. TELEPHONE.
      d. Instrumentation: SIGNAL.

I. Manhole/handhole Frames and Covers:
   1. Material: Steel, hot-dipped galvanized.
   2. Cover Type: Solid, bolt-on, of checkered design.
   3. Cover Loading: H-20.
   4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
      a. 600 Volts and Below: ELECTRIC LV.
      b. TELEPHONE.
      c. Instrumentation: SIGNAL.

J. Hardware: Steel, hot-dip galvanized.

K. Furnish knockout for ground rod in each handhole and manhole.

L. Manufacturers:
   1. U.S. Precast.
   2. Brooks Products, Inc.
   3. Penn-Cast Products, Inc.
   4. Concrete Conduit Co.
   5. Associated Concrete Products, Inc.

6. Utility Vault Co.
7. Pipe, Inc.

2.05 ACCESSORIES

A. Duct Bank Spacers:
   1. Type: Nonmetallic, interlocking, for multiple conduit sizes.
   2. Suitable for all types of conduit.
   3. Manufacturer: Underground Device, Inc.; Type WUNPEECE.

B. Identification Devices:
   1. Raceway Tags:
      a. Material: Permanent, nylon.
      b. Shape: Round.
      c. Raceway Designation: Pressure stamped, embossed, or engraved.
      d. Tags relying on adhesives or taped-on markers not permitted.
   2. Warning Tape:
      a. Material: Polyethylene, 4-mil gauge.
      b. Color: Red.
      c. Width: Minimum 6-inch.
      d. Designation: Warning on tape that electric circuit is located below tape.
      e. Manufacturers:
         1) Blackburn, Type RT.
         2) Griffolyn Co.
   3. Buried Raceway Marker:
      a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where change direction runs.
      b. Designation: Incise to depth of 3/32 inch, ELECTRIC CABLES, in letters 1/4-inch high.
      c. Minimum Dimension: 1/4-inch thick, 10 inches long, and 3/4-inch wide.

C. Raceway Coating:
   1. Material: Bitumastic or plastic tape coating.
   2. Manufacturers:
      a. Koppers bitumastic; No. 505.
      b. Scotchwrap; No. 51, plastic tape.

D. Wraparound Duct Band:
   1. Material: Heat-shrinkable, cross-linked polyolefin, pre-coated with hot-melt adhesive.
   2. Manufacturer: Raychem; Type TWDB.

PART 3 EXECUTION

3.01 GENERAL

A. Conduit and Tubing sizes shown are based on the use of copper conductors. Reference Section 16120, CONDUCTORS, concerning conduit sizing for aluminum conductors.

B. All installed Work shall comply with NECA 5055.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

L. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.

M. Install watertight fittings in outdoor, underground, or wet locations.

N. Paint threads, before assembly of fittings, of galvanized conduit installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

O. All metal conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams.

Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

3.02 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum cover 1-1/2 inches.

B. Provide support during placement of concrete to ensure raceways remain in position.

C. Floor Slabs:
   1. Outside diameter of conduit not to exceed one-third of the slab thickness.
   2. Separate conduit by minimum six times conduit outside diameter, except at crossings.

3.03 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch.

B. Exterior, Exposed:
   1. Rigid Aluminum.

C. Interior, Exposed:
   1. Rigid Aluminum.
   2. Electric metallic tubing for ceiling portion of lighting circuits in a conditioned environment.

D. Interior, Concealed (Not Embedded in Concrete):
   1. Rigid Aluminum.

E. Direct Earth Burial: PVC Schedule 80.

F. Concrete-Encased Raceways: PVC Schedule 40.

G. Under Slabs-On-Grade: PVC Schedule 40.

H. Corrosive Areas, Exterior: PVC-coated rigid galvanized steel.

I. Corrosive Areas, Interior: PVC-coated rigid galvanized steel.

J. Lightning Protection: PVC Schedule 40.

3.04 CONNECTIONS

A. For motors, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:
   1. Conduit Size 4 Inches or Less: Flexible metal, liquid-tight conduit.
   2. Conduit Size Over 4 Inches: Nonflexible.
   3. Corrosive Areas: Flexible, nonmetallic, liquid or PVC-coated metallic, liquid-tight.
   4. Length: 18-inch minimum, 60-inch maximum, of sufficient length to allow movement or adjustment of equipment.

B. Lighting Fixtures in Dry Areas: Flexible steel, non-liquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas required being Oil tight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Transition From Underground or Concrete Embedded to Exposed: PVC Coated Rigid galvanized steel conduit.

E. Under Equipment Mounting Pads: Rigid galvanized steel conduit.

F. Exterior Light Pole Foundations: Rigid galvanized steel conduit.

3.05 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Fire-stop openings around penetrations to maintain fire-resistance rating.

D. Apply single layer of wraparound duct band to all metallic conduit in contact with concrete floor slabs to a point 2 inches above concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide non-shrink grout dry-pack, or use watertight seal device.

F. Entering Structures:
   1. General: Seal raceway at the first box or outlet with minimum 2 inches thick expandable plastic compound to prevent the entrance of gases or liquids from one area to another.
   2. Concrete Roof or Membrane Waterproofed Wall or Floor:
      a. Provide a watertight seal.
      b. Without Concrete Encasement: Install watertight entrance seal device on each side.
      c. With Concrete Encasement: Install watertight entrance seal device on the accessible side.
      d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
      e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
   3. Heating, Ventilating, and Air Conditioning Equipment:
      a. Penetrate equipment in area established by manufacturer.
      b. Terminate conduit with flexible metal conduit at junction box or condulets attached to exterior surface of equipment prior to penetrating equipment.
      c. Seal penetration with silicone type sealant.
   4. Corrosive-Sensitive Areas:
      a. Seal all conduit entering field panels containing electronic equipment.
      b. Seal all conduit entering equipment panel boards and field panels containing electronic equipment.
      c. Seal penetration with silicone type sealant.
   5. Existing or Precast Wall (Underground): Core drill wall and install a watertight entrance seal device.
   6. Non-waterproofed Wall or Floor (Underground, without Concrete Encasement):
      a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.

b. Fill space between raceway and sleeve with an expandable plastic compound on each side.

7. Manholes and Pullboxes:
   a. Metallic Raceways: Provide insulated grounding bushings.
   b. Nonmetallic Raceways: Provide bell ends flush with wall.
   c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.06 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 40 percent extra space for future conduit.

C. Provide and attach wall brackets or strap hangers:
   1. Wood: Wood screws.
   2. Hollow Masonry Units: Toggle bolts.
   3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
   4. Steelwork: Machine screws.

D. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.07 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:
   1. Bends 30-Degree and Larger: Provide factory-made elbows.
   2. 90-Degree Bends: Provide rigid steel elbows.
   3. Use manufacturer's recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.08 EXPANSION/DEFLECTION FITTINGS

A. Provide on all raceways at all structural expansion joints, and in long tangential runs.

B. Provide expansion/deflection joints for 50 degrees F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

3.09 PVC CONDUIT

A. Solvent Welding:
   1. Provide manufacturer recommended solvent; apply to all joints.
   2. Install such that joint is watertight.

B. Adapters:
   1. PVC to Metallic Fittings: PVC terminal type.
   2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

C. Belied-End Conduit: Bevel the un-belled end of the joint prior to joining.

3.10 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer's instructions.

B. Provide PVC boot to cover all exposed threading.

3.11 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

3.12 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Provide manufacturer's pre-molded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Sheet Metal Boxes, Cabinets, and Enclosures:
   1. Rigid Galvanized Conduit:
      a. Provide one lock nut each on inside and outside of enclosure.
      b. Install grounding bushing.
      c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad; if neither ground bus nor pad exists, connect jumper to lag bolt attached to metal enclosure.

d. Install insulated bushing on ends of conduit where grounding is not required.
e. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.

2. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
3. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
4. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
5. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut.

C. Motor Control Center, Switchboard, Switchgear, and Free-Standing Enclosures: Terminate conduit entering bottom with grounding bushing; provide a grounding jumper extending to equipment ground bus or grounding pad.

3.13 UNDERGROUND RACEWAYS

A. This section applies to all underground conduit installations including underground installation on open field, under the slab, under the roadways, etc.

B. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

C. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.

D. Make routing changes as necessary to avoid obstructions or conflicts.

E. Couplings: In multiple conduit runs, stagger so that couplings in adjacent runs are not in same transverse line.

F. Union type fittings not permitted.

G. Spacers:
1. Provide preformed, nonmetallic spacers, designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

H. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.

I. Installation with Other Piping Systems:
1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

J. Metallic Raceway Coating: At couplings and joints and along entire length, apply wraparound duct band with one-half tape width overlap to obtain two complete layers.

K. Concrete Encasement: As specified in Section 03301 - Concrete Work.
   1. Concrete Color: Gray, dust top of concrete ductbank with powdered red concrete dye before concrete sets and trowel dry onto top of ductbank.

L. Backfill:
   1. Do not backfill until inspected by Engineer.

3.14 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade back to original state.

B. Do not install until final raceway grading has been determined.

C. Install such that raceways enter at nearly right angles and as near as possible to one end of wall, unless otherwise shown.

D. Grounding: As specified in GROUNDING section.

E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.15 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Paragraph IDENTIFICATION DEVICES, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.16 IDENTIFICATION DEVICES

A. Raceway Tags:
   1. Identify origin and destination.
   2. Install at each terminus, near midpoint, and at minimum intervals of every 50 feet of exposed Raceway, whether in ceiling space or surface mounted.
   3. Provide nylon strap for attachment.

B. Warning Tape: Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of runs.

C. Buried Raceway Markers:
   1. Install at grade to indicate direction of underground raceways.
   2. Install at all bends and at intervals not exceeding 100 feet in straight runs.
   3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.17 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over all conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up damage to coating on PVC-coated conduit with patching compound approved by manufacturer.

END OF SECTION

SECTION 16120

CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:
   1. American Society for Testing and Materials (ASTM):
      a. A167, Standard Specification for Stainless and Heat Resisting Chromium-Nickel-Plated Steel Plate, Sheet, and Strip.
      b. B3, Standard Specification for Soft or Annealed Copper Wire.
      c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
      d. B263, Standard Test Method for Determination of Cross- Sectional Area of Stranded Conductors.
   2. Insulated Cable Engineer's Association, Inc. (ICEA): T-29-250, Procedure for Conducting Vertical Cable Tray Flame Test with a Theoretical Heat Input of 210,000 Btu/hour.
   3. National Electrical Contractors Association, Inc. (NECA): 5055, Standard of Installation.
   4. National Electrical Manufacturers' Association (NEMA):
      a. WC 5, Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
      b. WC 7, Crosslinked-Thermosetting-Polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
      c. WC 8, Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
      d. WC 55, Instrumentation Cables and Thermocouple Wire.
   5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   6. Underwriters Laboratories, Inc. (UL):
      a. 13, Standard for Safety Power-Limited Circuit Cables.
      b. 44, Standard for Safety Rubber-Insulated Wires and Cables.
      c. 62, Standard for Safety Flexible Cord and Fixture Wire.
      d. 486A, Standard for Safety Wire Connector and Soldering Lugs for Use with Copper Conductors.
      e. 510, Standard for Safety Insulating Tape.
      f. 854, Standard for Safety Service-Entrance Cables.
      g. 910, Standard for Safety Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air Handling Spaces.
      h. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
      i. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Shop Drawings:
   1. Wire and cable descriptive product information.
   2. Wire and cable accessories descriptive product information.

B. Quality Control Submittals:
   1. Certified Factory Test Report for conductors 600 volts and below.
   2. Certified Factory Test Report per AEIC CS6, including AEIC qualification report for conductors above 600 volts.

1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 3, WC 5, and WC 7.

B. Conductor Type:
   1. 480V power circuits: stranded copper.
   2. 120-Volt power circuits, No. 10 AWG and smaller: stranded copper.
   3. All Other Circuits: Stranded copper.

C. Insulation: Type THHN/THWN for No. 6 AWG and smaller. XHHW for No.4 AWG and larger, or installations in wet locations.

D. Direct Burial and Aerial Conductors and Cables:
   1. Type USE/RHH/RHW insulation, UL t(54 listed, Type RHW-2/USE-2.
   2. Conform to physical and minimum thickness requirements of NEMA WC 3.

E. Flexible Cords and Cables:
   1. Type SOW-A50 with ethylene propylene rubber insulation in accordance with UL 62.
   2. Conform to physical and minimum thickness requirements of NEMA WC 8.

F. Cable Tray Conductors and Cables: Type TC.

2.02 600-VOLT RATED CABLE

A. General:
   1. Type: TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 20,000 Btu/hr, and NFPA 70, Article 340, or UL 13 Listed Power Limited Circuit Cable meeting requirements of NFPA 70, Article 725.
   2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
   3. Suitable for installation in open air, in cable trays, or conduit.

4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Wire and Connectors:
1. Cable shall be rated for 600 volts and shall meet the requirements below:
2. Conductors shall be stranded.
3. All wire shall be brought to the job in unbroken packages and shall bear the data of manufacturing; not older than 12 months.
4. Type of wire shall be XHHW or THHN, rated 75 degrees C suitable for wet locations except where required otherwise by the drawings.
5. No wire smaller than No. 12 gauge shall be used unless specifically indicated.
6. Conductor metal shall be copper.
7. All conductors shall be meg-ohm tested after installation and insulation must be in compliance with the Insulated Power Cable Engineers Association Minimum Values of Insulation Resistance.

C. Type I-Multiconductor Control Cable:
1. Conductors:
   a. No. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-I.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with NEMA WC 5, Method 1, Sequence K-2.
2. Cable: Passes the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.
3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (inches)	Jacket Thickness (mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	00.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
   a. Okonite Co.
   b. General Cable.
   c. Southwire.

D. Type 2-Multiconductor Power Cable:
1. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: Chemically crosslinked ethylene-propylene with CPE jacket.

c. UL 1581 listed as Type EPR, rated VW-1.
d. Color Code: Conductors, size No. 8 AWG and smaller, colored conductors, NEMA WC74 Method 1, color 5 per Article POWER CONDUCTOR COLOR CODING. Conductors, size No. 6 AWG and larger, NEMA WC5, Method 4.

2. Cable shall pass the ICEA T-29-520 210,000 Btu/hr Vertical Tray Flame Test.
3. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2	0.42	45
		3	0.45	45
		4	0.49	45
10	10	2	0.54	60
		3	0.58	60
		4	0.63	60
8	10	3	0.66	60
		4	0.72	
6	8	3	0.74	60
		4	0.81	
4	6	3	0.88	60
		4	0.97	80
2	6	3	1.01	80
		4	1.11	
1/0	6	3	1.22	80
		4	1.35	
2/0	4	3	1.32	80
		4	1.46	
4/0	4	3	1.56	80
		4	1.78	

4. Manufacturers:
   a. Okonite Co.
   b. General Cable.
   c. Southwire.

E. Type B-No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements. Insulation shall be rated for 600V, 300V insulation is not acceptable.
   1. Outer Jacket: 45-mil nominal thickness.
   2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
   3. Dimension: 0.31-inch nominal OD.

4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nominal nylon.
    e. Color Code: Pair conductors black and red.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. General Cable.
6. The following test shall be performed on instrumentation and control system cables. All tests shall be end-to-end test of installed cables with the ends supported in free air, not adjacent to any ground object. All test data shall be recorded on forms acceptable to the Engineer. Complete records of all tests shall be made and delivered to the Engineer.
    a. Continuity tests shall be performed by measuring wire/shield loop resistances of signal cable as the wires, taken one at a time, are shorted to the channel shield. No loop resistance measurement shall carry by more than +2 ohms from the calculated average loop resistance valve.
    b. Insulation resistance tests shall be performed by using a 500 volt megohmeter to measure the insulation resistance between each channel wire and channel shield, between individual channel shields in a multi-channel cable, between each individual channel and the overall cable shield in multi-channel cable, between each wire and ground, and between each shield and ground. Values of resistance less than 10 megohms shall be unacceptable.

F. Type B1-No. 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements. Insulation shall be rated for 600V, 300V insulation is not acceptable.
1. Outer Jacket: 45-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.32-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand, tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nylon.
    e. Color Code: Triad conductors black, red, and blue.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. General Cable.

G. Type B2-No. 18 AWG, Multi-Twisted, Shielded Pairs with a Common, Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 55 requirements. Insulation shall be rated for 600V, 300V insulation is not acceptable.
   1. Conductors:
      a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
      b. Tinned copper drain wires.
      c. Pair drain wire size AWG 20, group drain wire size AWG 18.
      d. Insulation: 15-mil PVC.
      e. Jacket: 4-mil nylon.
      f. Color Code: Pair conductors black and red with red conductor numerically printed for group identification.
      g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
   2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
   3. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (inches)	Nominal Jacket Thickness (mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

   4. Manufacturers:
      a. Okonite Co.
      b. Alpha Wire Corp.
      c. General Cable.
      d. Belden.

H. Type B3-No. 18 AWG, Multi-twisted Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 55. Insulation shall be rated for 600V, 300V insulation is not acceptable.
   1. Conductors:
      a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
      b. Tinned copper drain wire size 18 AWG
      c. Insulation: 15-mil nominal PVC.
      d. Jacket: 4-mil nylon.
      e. Color Code: Pair conductors black and red, with red conductor numerically printed for group identification.
   2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

3. Cable Sizes:

Number Of Pairs	Maximum Outside Diameter (inches)	Nominal Jacket Thickness (mils)
4	0.46	45
8	0.63	60
12	0.75	60
16	0.83	60
24	1.06	80
36	1.21	80
50	1.42	80

4. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

I. Variable Frequency Drive (VFD) Output Power Cable:
   1. Section applies to power cables routed between the output of VFDs and motor terminals.
   2. Cable shall be rated for 600 volts type VFD rated and shall meet the requirements below:
      a. Conductors shall be stranded copper.
      b. All wire shall be brought to the job in unbroken packages and shall bear the data of manufacturing; not older than 12 months.
      c. Type of wire shall be XLPE rated 90 degrees Celsius suitable for wet locations.
      d. No wire smaller than No. 12 gauge shall be used unless specifically indicated.
      e. Cable construction shall consist of three insulated current-carrying phase conductors and three bare ground conductors, symmetrically placed between the phase conductors, and twisted beneath a continuous copper tape shield and overall polymeric jacket.
   3. Each ground conductor size (circular mil area) shall be 1/3 of the NEC required size (circular mil area) for a single ground conductor. If one third of the required circular mil area does not correspond to a standard size (circular mil area) of construction, the next largest size of standard construction shall be us All conductors shall be megger tested after installation and insulation must be in compliance with the Insulated Power Cable Engineers Association Minimum Values of Insulation Resistance.
   4. Manufacturers:
      a. Southwire-.
      b. Belden.
      c. Approved Equal.

J. Ethernet Cat. 6e UTP Cable (Copper):
   1. Section applies to all Ethernet Cable (Copper) except for Fiber Optic cable.

2. Conductor Physical Characteristics: 4 twisted pairs (8 conductors), 23 AWG solid bare Copper with Polyolefin Insulation. Overall Nominal Diameter: 0.235 inch. Operating Temperature Range: -20'C to +75'C. Model Number – 7881A, Belden Inc.
3. NEC/UL specification CMR, UL444, UL verified category 6.
4. Manufacturer:
    a. Belden Inc.
    b. Or equal.

2.03 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried: Bare stranded copper.

2.04 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:
1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arcs and Fireproofing:
    a. 30-mil, elastomer.
    b. Manufacturers and Products:
        1) Scotch; Brand 77, with Scotch Brand 69 glass cloth tape binder.
        2) Plymount; Plyarc 30, with Plymount Plyglas glass cloth tape binder.

B. Identification Devices:
1. Sleeve: Permanent, PVC, yellow or white, with legible machine-printed black markings.
2. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
3. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:
1. Nylon, Self-Insulated Crimp Connectors:
    a. Manufacturers and Products:
        1) Thomas & Betts; Sta-Kon.
        2) Burndy; Insulink.
        3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
    a. Manufacturers and Products:
        1) Thomas & Betts; Sta-Kon.
        2) Burndy; Insulink.
        3) ILSCO.

D. Cable Lugs:
1. In accordance with NEMA CC I.
2. Rated 600 volts of same material as conductor metal.

3. Insulated, Locking-Fork, Compression Lugs:
    a. Manufacturers and Products:
        1) Thomas & Betts; Sta-Kon.
        2) ILSCO; ILSCONS.
4. Un-insulated Crimp Connectors and Terminators:
    a. Manufacturers and Products:
        1) Square D; Versitide.
        2) Thomas & Betts; Color-Keyed.
        3) ILSCO.
5. Un-insulated, Bolted, Two-Way Connectors and Terminators:
    a. Manufacturers and Products:
        1) Thomas & Betts; Locktite.
        2) Burndy; Quiklug.
        3) ILSCO.

E. Cable Ties: Nylon, adjustable, self-locking, and reusable.
    1. Manufacturers and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation: Thermally stabilized, crosslinked polyofin.
    1. Manufacturers and Product: Thomas & Betts; SHRINK-KON.

2.05 PULLING COMPOUND

A. Nontoxic, non-corrosive, noncombustible, nonflammable, wax-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

D. Manufacturers and Products:
    1. Ideal Co.; Yellow 77.
    2. Polywater, Inc.
    3. Cable Grip Co.

2.06 WARNING TAPE

A. As specified in Section 16110, RACEWAYS.

2.07 FIBER OPTIC DATA CABLE AND ACCESSORIES

A. The fiber optic cable shall be a three-fiber outdoor type cable suitable for installation and pulling through a duct bank. For simple point to point fiber optic link, the cable shall be six fiber 62.5/125 microns as manufactured by Belden Wire and Cable Company, Catalog No. 225716, or approved equal.

B. Furnish compatible connectors and breakout kits with the cable. Furnish sufficient connectors and breakout kits to meet the project requirements and install connectors on all fiber optic cable. Use Contract Drawings as a guide in determining lengths, taking into account actual field conditions. Use the fiber optic connectors, termination kits, and cable test kits per cable manufacturer that is compatible with specified data concentrators.

2.08 SOURCE QUALITY CONTROL

A. Conductors 600-Volts and Below: Test in accordance with UL 44 and 854 Standards.

2.09 ACCESS CONTROL CABLES

A. 2C/ 18 AWG shielded communication plenum cable. Match model with existing.

B. 6C/ 18 AWG shielded communication plenum cable. Match model with existing.

PART 3 EXECUTION

3.01 GENERAL

A. Conductor installation to be in accordance with NECA 5055.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

D. Tighten screws and terminal bolts in accordance with UL 486A for copper conductors.

E. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

F. Bundling: Where single conductors and cables in pullboxes, and other indicated locations, are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.

G. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

H. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4-inch smaller than raceway inside diameter.

I. Cable Tray Installation:
   1. Install wire and cable parallel and straight in tray.

2. Bundle, in groups, all wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet.
3. Clamp cable bundles prior to making end termination connections.
4. Separate cables of different voltage rating in same cable tray with barriers.
5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
   a. Horizontal Runs: 20 feet.
   b. Vertical Runs: 5 feet.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:
   1. No. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 to 2 inches wide.
   2. No. 8 AWG and Smaller: Provide colored conductors.
   3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	Gray Brown Orange Yellow
Note: Phase A, B, C implies direction of positive phase rotation		

   4. Tracer: Outer covering of white with an identifiable colored strip other than green in accordance with NFPA 70.

3.03 CIRCUIT IDENTIFICATION

A. Circuits Appearing in Circuit Schedules: identify power, instrumentation, and control conductor circuits, using circuit schedule designations, at each termination and in accessible locations such as manholes, hand holes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Not Appearing in Circuit Schedules:
   1. Assign circuit name based on device or equipment at load end of circuit.

2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

C. Method:
   1. Conductors No. 3 AWG and Smaller: Identify with sleeves.
   2. Cables, and Conductors No. 2 AWG and Larger:
      a. Identify with marker plates.
      b. Attach marker plates with nylon tie cord.
   3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring.

B. Connections and Terminations:
   1. Install wire nuts only on solid conductors.
   2. Install nylon self-insulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 6 AWG and smaller.
   3. Install un-insulated crimp connectors and terminators for instrumentation, control, and power circuit conductors No. 4 AWG through No. 2/0 AWG.
   4. Install un-insulated, bolted, two-way connectors and terminators for power circuit conductors No. 4/0 AWG and larger.
   5. Install un-insulated bolted, two-way connectors for motor circuit conductors No. 12 and larger.
   6. Tape insulates all un-insulated connections.
   7. Place no more than one conductor in any single-barrel pressure connection.
   8. Install crimp connectors with tools approved by connector manufacturer.
   9. Install terminals and connectors acceptable for type of material used.
   10. Compression Lugs
      a. Attach with a tool specifically designed for purpose.
      b. Tool shall provide complete controlled crimp and shall not release until crimp is complete.
      c. Do not use plier-type crimpers.

C. Do not use soldered mechanical joints.

D. Splices and Terminations:
   1. Indoors: Use general purpose, flame retardant tape.
   2. Outdoors: Use flame retardant, cold- and weather-resistant tape.

E. Cap spare conductors and conductors with UL listed end caps.

F. Cabinets, Panels, and Motor Control Centers:
   1. Remove surplus wire, bridle and secure.
   2. Where conductors pass through openings or over edges in sheet metal, remove bums, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

G. Control and Instrumentation Wiring:
   1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
   2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
   3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
   4. Cable Protection:
      a. Under Infinite Access Floors: May be installed without bundling.
      b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under the floor or grouped into bundles at least 1/2-inch in diameter.
      c. Maintain integrity of shielding of instrumentation cables.
      d. Ensure grounds do not occur because of damage to jacket over the shield.

H. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

I. Variable Frequency Drive (VFD) Output Power Cable:
   1. Install cables in raceway.
   2. Terminate the three ground conductors together at the motor and at the ground bus of the VFD.
   3. Terminate aluminum armor at motor and at VFD. At motor, terminate shield with cable manufacturer recommended termination kit. Termination shall be to the motor junction box. At the VFD, terminate armor to the inverter drive frame. The termination kit must provide a 360-degree connection of the armor to frame and motor junction box.
   4. Cable armor and ground conductors shall be made continuous through disconnects or splice boxes where un-grounded conductors are terminated on a terminal block or cable lug. Use manufacturer recommended shield termination kits and connect pigtails together. The cable shield shall not be connected to the disconnect switch or box enclosure.

3.05 CONDUCTORS ABOVE 600 VOLTS

A. Do not splice unless specifically indicated or approved by the Engineer.

B. Make joints and terminations with splice and termination kits, in accordance with kit manufacturer's instructions

C. Install splices or terminations as continuous operation in accessible locations under clean, dry conditions.

D. Single Conductor Cable Terminations: Provide heat shrinkable stress control and outer non-tracking insulation tubing, high relative permittivity stress relief mastic for insulation shield cutback treatment, and a heat-activated sealant for environmental sealing, plus a ground braid and clamp.

E. Install terminals or connectors acceptable for type of conductor material used.

F. Provide outdoor rain skirts for all riser pole and outdoor switchgear terminations.

G. Provide shield termination and grounding for all terminations.

H. Provide necessary mounting hardware, covers, and connectors.

I. Where elbow connectors are specified, install in accordance with manufacturer's instructions.

J. Connections and Terminations:
   1. Install un-insulated crimp connectors and terminators for power circuit conductors No. 4 AWG through No. 2/0 AWG.
   2. Install un-insulated, bolted, two-way connectors and terminators for power circuit conductors No. 4/0 AWG and larger.
   3. Install un-insulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.
   4. Insulate bus connections with heat shrinking tubing, tape, and sheets.
   5. Make all bus connections removable and reusable in accordance with manufacturer’s instructions.

K. Give 2 working days' notice to ENGINEER prior to making splices or terminations.

3.06 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing, tape on 600-volt single conductors and cables except those rated Type TC in manholes, hand holes, vaults, cable trays, and other indicated locations.

B. Install arc and fireproofing tape on 25 kV cables throughout their entire exposed length in manholes, hand holes, vaults, cable trays, and other indicated locations.

C. Wrap conductors of same circuit entering from separate conduit together as a single cable.

D. Follow tape manufacturer's installation instructions.

E. Secure tape at intervals of 5 feet with bands of tape binder. Each tape band shall consist of a minimum of two wraps directly over each other.

3.07 UNDERGROUND DIRECT BURIAL CABLE

A. Install in trench as required.

B. Warning Tape: Install approximately 12 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

3.08 FIELD QUALITY CONTROL

A. Visual and Mechanical Inspection:
   1. Inspect Each Individual Exposed Power Cable No. 6 and Larger for:
      a. Physical damage.
      b. Proper connections in accordance with single-line diagram.

c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
d. Color coding conformance with specifications.
e. Proper circuit identification.

2. Mechanical Connections for:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables for:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4. Control Cables for:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:
1. Insulation Resistance Tests:
   a. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures for 1 minute.
   b. Evaluate ohmic values by comparison with conductors of same length and type.
   c. Investigate values less than 50 megohms.
   d. Utilize 1,000V dc megohmmeter for 600V insulated conductors.
2. Continuity test by ohmmeter method to ensure proper cable connections.

END OF SECTION

SECTION 16405

ELECTRIC MOTORS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and any deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Anti-Friction Bearing Manufacturers' Association (AFBMA):
      a. 9, Load Ratings and Fatigue Life for Ball Bearings.
      b. 11, Load Rating and Fatigue Life for Roller Bearings.
   2. American National Standards Institute (ANSI): C50.41, Polyphase Induction Motors for Power Generating Stations.
   3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 85, Test Procedure for Airborne Sound Measurements on Rotating Machines.
      b. 112, Standard Test Procedures for Polyphase Induction Motors and Generators.
      c. 114, Standard Test Procedures for Single-Phase Induction Motors.
      d. 620, Guide for Construction and Interpretation of Thermal Limit Curves for Squirrel-Cage Motors Over 500 Horsepower.
      e. 841, Recommended Practice for Chemical Industry Severe-Duty Squirrel-Cage Induction Motors, 600V and Below.
   4. National Electrical Manufacturers Association (NEMA):
      a. MG 1, Motors and Generators.
      b. MG 13, Frame Assignments for Alternating Current Integral Horsepower Induction Motors.
      c. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   5. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC)
   6. Underwriters Laboratories (UL):
      a. 547, Thermal Protectors for Electric Motors.
      b. 674, Electric Motors and Generators Used in Hazardous (Classified) Locations.

1.03 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. DIP: Dust-ignition-proof enclosure.

C. EXP: Explosion-proof enclosure.

D. ODP: Open drip-proof enclosure.

E. TEFC: Totally enclosed, fan cooled enclosure.

F. TENV: Totally enclosed, non-ventilated enclosure.

G. WPI: Open weather protected enclosure, Type I.

H. WPII: Open weather protected enclosure, Type II.

I. Motor Nameplate Horsepower: That rating after any derating required allowing for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

1.04 SUBMITTALS

A. Shop Drawings:
   1. Descriptive information.
   2. Nameplate data in accordance with NEMA MG 1.
   3. Additional Rating Information:
      a. Service factor.
      b. Locked rotor current.
      c. No load current.
      d. Safe stall time for motors 200 horsepower and larger.
      e. Multispeed load classification (e.g., variable torque).
      f. Variable frequency drive motor load classification (e.g., variable torque) and minimum allowable motor speed for that load classification.
   4. Enclosure type and mounting (e.g. horizontal, vertical).
   5. Dimensions and total weight.
   6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
   7. Bearing type.
   8. Bearing lubrication.
   9. Bearing life.
   10. Space heater voltage and watts.
   11. Description and rating of motor thermal protection.
   12. Motor sound power level in accordance with NEMA MG 1.
   13. Maximum brake horsepower required by the equipment driven by the motor.
   14. Description and rating of submersible motor moisture-sensing system.

B. Quality Control Submittals:
   1. Factory test reports, certified.
   2. Manufacturer's Certificate of Proper Installation, 100 horsepower and larger.
   3. Operation and Maintenance Manual

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. U.S. Motors.

B. No “or approved equal”.

2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, use a single supplier to provide a drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. Frame assignments in accordance with NEMA MG 13.

E. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

F. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

G. Lifting lugs on all motors weighing 100 pounds or more.

H. Operating Conditions:
   1. Maximum ambient temperature not greater than 40 degrees C.
   2. Motors shall be suitable for operating conditions without any reduction being required in the nameplate rated horsepower or exceeding the rated temperature rise.
   3. Overspeed in either direction in accordance with NEMA MG 1.

2.03 HORSEPOWER RATING

A. As designated in motor-driven equipment specifications.

B. Constant Speed Applications: Brake horsepower of the driven equipment at any head capacity point on the pump curve not to exceed motor nameplate horsepower rating, excluding any service factor.

C. Variable Frequency, Variable Speed Applications: Driven equipment brake horsepower at any head capacity point on the pump curve not to exceed motor nameplate horsepower rating, excluding any service factor.

2.04 SERVICE FACTOR

A. 1.15 minimum at rated ambient temperature, unless otherwise indicated. 1.0 for variable speed drive applications.

2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60-Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specifications:

Size	Voltage	Phases
1/2 hp and smaller	115	1
3/4 hp through 400 hp	460	3
450 hp and larger	4,000	3

C. Suitable for full voltage starting and/or variable speed drive control.

D. One hundred horsepower and larger also suitable for reduced voltage starting with 65 or 80 percent voltage tap settings on reduced inrush motor starters.

E. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 horsepower, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:
   1. Efficiency:
      a. Tested in accordance with NEMA MG 1, paragraph 12.54.1. Tested efficiency shall meet or exceed listed in NEMA MG 1 Table 12-10.
      b. Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.
   2. Power Factor: Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.

2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower if motor horsepower not covered by NEMA MG 1 tables.

B. Safe stall time 15 seconds or greater.

2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Three-Phase and Integral Horsepower Motors, Unless Otherwise Indicated in Motor-Driven Equipment Specifications: Class F with Class B rise at nameplate horsepower and designated operating conditions, except EXP and DIP motors which must be Class B with Class B rise. Insulation shall be chemical and humidity resistant.

C. Variable frequency drive applications: requirements of three phase and integral horsepower motors apply with adjustment for inverter duty rated motor classification.

2.09 ENCLOSURES

A. All enclosures to conform to NEMA MG 1.

B. Unless otherwise noted, all motors shall be TEFC and shall be furnished with a drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP):
1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class 1, Division 1, Group C and D hazardous locations.
2. Drain holes with drain and breather fittings.
3. Integral thermostat opening on excessive motor temperature in accordance with UL 547 and NFPA 70.
4. Thermostat leads to terminate in a terminal box separate from main terminal box.

D. Dust-Ignition-Proof (DIP):
1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class II, Division 1, Group E, F, and G.
2. Integral thermostat opening on excessive motor temperature in accordance with UL 547 and NFPA 70.
3. Thermostat leads to terminate in a terminal box separate from main terminal box.

E. Submersible: In accordance with Paragraph SPECIAL MOTORS.

F. Chemical Industry, Severe-Duty (CISD-TEFC): In accordance with Paragraph SPECIAL MOTORS.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for all motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1-11.06 and 20.62 and NFPA 70, Article 430:

Voltage	Horsepower	Percentage
Below 600	15 thru 125	500
Below 600	150 thru 300	275
Below 600	350 thru 600	225
Above 600	All Sizes	200

E. Terminal for connection of equipment grounding wire in each terminal box.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:
   1. 3/4 horsepower and Smaller: Permanently lubricated and sealed ball bearings or re-greasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
   2. 1 through 400 horsepower: Re-greasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
   3. Above 400 horsepower: Re-greasable antifriction bearings in labyrinth sealed end bells with removable grease relief plugs.
   4. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in AFBMA 9 and 11.
   5. Variable frequency drive applications: insulate inner and outer bearings to eliminate the effects of high frequency harmonics on bearing surfaces that lead to premature bearing failure.

B. Vertical Motors:
   1. Thrust Bearings:
      a. Antifriction bearing.
      b. Manufacturer's standard lubrication 100 horsepower and smaller.
      c. Oil lubricated 125 horsepower and larger.
      d. Minimum 100,000 hours L-10 bearing life.
   2. Guide Bearings:
      a. Manufacturer's standard bearing type.
      b. Manufacturer's standard lubrication 100 horsepower and smaller.
      c. Oil lubricated 125 horsepower and larger.
      d. Minimum 100,000 hours L-10 bearing life.
   3. Variable frequency drive applications: insulate upper and lower bearings to eliminate the effects of high frequency harmonics on bearing surfaces that lead to premature bearing failure.

C. Re-greasable Antifriction Bearings:
   1. Readily accessible, grease injection fittings.
   2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:
   1. Oil reservoirs with sight level gauge.
   2. Oil fill and drain openings with opening plugs.
   3. Provisions for necessary oil circulation and cooling.

2.12 NOISE

A. Measured in accordance with IEEE 85 and NEMA MG 1 and be less than levels in 12.53.3 at no load.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1-12.06 and 1-12.07.

2.14 EQUIPMENT FINISH

A. External Finish: Prime and finish coat manufacturer's standard. Field painting in accordance with Section 09960, HIGH PERFORMANCE COATINGS.

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

A. Screen over Air Openings: Stainless steel on motors with ODP, WPI, and WPII enclosures meeting requirements for Guarded Machine in NEMA MG 1.

B. Winding Thermal Protection:
   1. Thermostats:
      a. Motors for constant speed and adjustable speed application 30 horsepower and larger.
      b. Bi-metal disk or rod type thermostats embedded in stator windings (normally closed contact).
      c. Automatic reset contacts rated 120 volts ac, 5 amps minimum, opening on excessive temperature. (Manual reset will be provided at motor controller.)
   2. Motor Space Heaters: All motors 30 horsepower and larger except if otherwise noted, shall be furnished with 120V ac space heaters. The rating of the space heaters shall be determined in accordance with the motor manufacturer's standard for particular frame size and type. Coordinate the power requirements of the space heater with the manufacturer of motor starters or variable frequency drive for sizing of the control transformer. Space heater wire leads shall be brought out in the conduit box on the motor and clearly identified.

C. Vertical Motor Shaft Grounding:
   1. Install a circumferential conductive micro fiber shaft grounding ring below lower bearing and before shaft coupling to discharge shaft currents to ground. Connect circumferential conductive micro fiber shaft grounding ring with a solid aluminum conductor to motor terminal box for connection to motor grounding system.
   2. Grounding ring shall be constructed of 6061 aluminum and attach to the motor housing with an aluminum bracket.

3. Apply a colloidal silver shaft coating to the shaft surface that passes through the grounding ring.
4. Manufacturers:
   a. Electro Static Technology: Aegis Bearing Protection Ring.

2.16 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Motors for Variable Frequency Drives (VFD's): These motors shall be specially designed inverter duty motors and comply with NEMA MG 1.31. Motor insulation shall withstand high voltages caused by fast rise time voltage pulses associated with PWM type inverters. Motor design shall take into account motor heating caused by harmonics in the drive output. Each motor for VFD application shall have a label certifying that the motor is suitable for inverter duty. Coordinate the motor full load current data with the drive manufacturer.

2.17 FACTORY TESTING

A. Tests:
   1. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.
   2. Routine (production) tests on all motors in accordance with NEMA MG 1, plus no load power at rated voltage and polyphase, rated voltage measurement of locked rotor current. Test multispeed motors at all speeds.
   3. For energy efficient motors, test efficiency at 50, 75, and 100 percent of rated horsepower:
      a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, paragraphs 12.54 and 12.57.
      b. For motors 500 horsepower and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
   4. Power factor:
      a. Speed.
      b. Current at rated horsepower.
      c. kW input at rated horsepower.
      d. On motors of 100 horsepower and smaller, furnish a certified copy of a motor efficiency test report on an identical motor.

B. Test Report Forms:
   1. Routine Tests: IEEE 112, Form A-1.

2.18 MOTOR LEAD TERMINATION

A. Motor Lead Pigtail Splicing Kits:
   1. The motor lead boot assembly must have a voltage class rating equal to or greater than the cable being terminated. The rating shall be 5 or 8.7 kV as an IEEE Standard 48-1990 Class 1 termination. It must have the maximum continuous operating temperature rating of 90°C, with an emergency overload rating of 130°C. The termination stress control shall be capacitive and

constructed of a Hi-K EPDM rubber tube. The installation procedure shall require using silicone grease. The motor load boot kit shall include all materials required (except lug) and shall accommodate shielded cables (tape, wire or unshielded) and non-shielded cables.

2. Physical characteristic:
    a. 300 percent Modulus of 480 pounds per square inch.
    b. Ultimate Tensile Strength of 1400 pounds per square inch.
    c. Ultimate Elongation of 750 percent.
    d. Die C Tear of 150pounds per inch.
    e. Dielectric strength:
        1) Original 365 V/mil.
        2) 7 Days in H2O 282 V/mil.
3. Manufacturers:
    a. 3M Motor Lead Pigtail Splicing Kit 5380 Series.
    b. Or approved equal.

B. Split Bolt Connectors:
1. Split bolt connector copper alloy material, for copper – to-copper connections.
2. Shall include copper pressure bar and square-style head, UL listed 486A-486B, CSA.
3. Manufacturer:
    a. BURNDY Copper Alloy Split-Bolt connectors.
    b. Or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts. Provide anchor bolts meeting manufacturer's recommendations and of sufficient size and number for the specified seismic conditions.

D. Motor Lead Termination
1. Motors up to 20Hp (or wire size up to 10AWG) shall use Split Bolt connectors
2. Motors 25Hp and larger (or wire size 8AWG and larger) shall use Motor Lead Pigtail Splicing Kits.

3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative at site in accordance with Section 15958 - Mechanical Equipment Testing, for installation assistance, inspection, equipment testing, and startup assistance for motors larger than 75 horsepower.

B. Manufacturer's Certificate of Proper Installation.

3.03 SUPPLEMENTS

A. Table supplements, following "END OF SECTION," are a part of this Specification.

END OF SECTION

TABLE 1									
MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				%Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
1	1800	80.0	81.5			Mfr.'s Std.	Mfr.'s Std.		
	1200	78.5	79.3			Mfr.'s Std.	Mfr.'s Std.		
1.5	3600	79.3	81.5			Mfr.'s Std.	Mfr.'s Std.		
	1800	79.3	82.0			Mfr.'s Std.	Mfr.'s Std.		
	1200	82.5	84.0		82.0	Mfr.'s Std.	Mfr.'s Std.		Mfr.'s Std.
2	3600	82.0	84.0			Mfr.'s Std.	Mfr.'s Std.		
	1800	81.5	83.7			Mfr.'s Std.	Mfr.'s Std.		
	1200	85.5	85.5	83.7	83.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	82.9	82.5	82.9	81.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
3	3600	82.0	84.0	82.0	82.0	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	84.8	86.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	87.5	88.1	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	84.1	82.9	84.1	82.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
5	3600	84.8	86.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	86.5	86.5	84.8	84.8	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	87.5	88.1	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	87.5	86.5	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
7.5	3600	86.5	88.1	84.8	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	89.3	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	88.5	88.5	88.4	87.5	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	87.5	86.5	87.5	86.6	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
10	3600	89.3	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	89.3	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	89.5	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	89.3	88.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.

TABLE 1									
MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				%Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
15	3600	88.5	89.8	88.4	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	91.0	91.0	90.9	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	90.2	90.2	90.2	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	89.3	88.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
20	3600	91.0	90.6	90.9	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	91.7	91.7	91.7	90.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	91.0	90.6	90.2	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	90.2	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
25	3600	91.7	91.0	91.7	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	92.4	92.4	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	91.7	91.0	90.9	89.3	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	90.2	89.5	89.3	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
30	3600	91.7	91.4	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1800	92.4	92.4	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	1200	91.7	91.0	91.7	90.2	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
	900	91.7	91.7	90.9	90.9	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.	Mfr.'s Std.
40	3600	91.7	91.7	90.2	89.3	86.6	86.1	87.0	89.0
	1800	93.6	93.0	92.8	91.7	78.2	78.2	83.0	84.5
	1200	92.4	92.4	91.7	90.9	81.5	81.5	81.5	81.5
	900	91.7	91.0	90.9	90.2	70.0	70.5	70.0	70.5
50	3600	92.0	92.0	90.2	89.3	85.1	86.7	89.0	89.0
	1800	93.6	93.0	92.8	91.7	79.5	79.4	82.5	82.5
	1200	92.4	92.4	91.7	90.9	81.5	81.5	81.5	81.5
	900	91.7	91.7	90.9	90.9	78.5	72.9	78.5	80.0
60	3600	92.7	93.0	91.7	90.9	85.8	88.3	87.5	89.0
	1800	93.6	94.1	93.5	92.8	80.5	79.9	80.5	80.5
	1200	93.0	93.0	92.8	91.7	81.5	81.5	81.5	81.5

TABLE 1									
MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				%Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
	900	92.4	91.7	91.7	90.9	79.5	73.2	79.5	79.5
70	3600	93.6	93.6	91.7	91.7	87.1	88.5	88.5	88.5
	1800	94.5	94.5	93.5	93.5	81.0	81.5	81.0	81.5
	1200	93.6	93.5	93.5	92.8	82.0	82.0	82.0	82.0
	900	92.8	92.4	92.8	91.7	80.5	74.5	80.5	81.0
100	3600	93.6	93.3	91.7	90.7	87.0	88.2	87.0	88.5
	1800	95.1	94.5	94.0	93.5	81.0	81.0	81.0	81.0
	1200	93.6	93.6	92.8	92.8	82.1	81.7	85.5	85.5
	900	93.5	92.4	92.8	91.7	77.0	77.3	77.0	80.0
125	3600	93.6	93.7	91.7	91.7	86.4	89.1	87.0	90.5
	1800	94.5	94.7	93.5	92.8	85.4	85.5	87.5	86.0
	1200	93.6	94.1	93.5	92.8	82.7	82.3	85.5	85.5
	900	93.5	93.0	92.8	92.4	78.5	78.5	78.5	78.5
150	3600	93.6	93.7	92.4	91.7	86.5	90.0	86.5	90.5
	1800	95.0	95.2	94.5	94.0	82.5	85.0	84.5	85.0
	1200	94.5	94.5	93.5	94.0	81.5	81.5	81.5	81.5
	900	93.5	93.0	92.8	92.4	78.0	78.5	78.0	78.5
200	3600	94.3	94.3	92.4	93.0	87.8	89.4	91.0	91.0
	1800	95.0	95.2	94.0	94.0	85.2	86.5	87.0	87.0
	1200	94.5	94.5	93.5	93.5	79.0	82.5	79.0	82.5
250	3600	94.3	94.7	91.7	92.4	85.0	86.5	85.0	96.5
	1800	85.4	95.4	94.5	94.5	79.0	79.0	79.0	79.0
	1200	95.0	94.5	94.5	93.5	82.0	82.0	82.0	82.0
300	3600	93.7	94.3			89.8	89.9		
	1800	95.4	95.2	94.5	94.0	80.0	80.0	800	80.0
	1200	93.7	93.7			84.5	90.1		

TABLE 1									
MOTOR PERFORMANCE REQUIREMENTS									
		% Guar. Min. Full Load Efficiency				%Guar. Min. Full Load Power Factor			
		Horizontal		Vertical		Horizontal		Vertical	
hp	Nom.Speed rpm	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC	Drip-proof ODP	TEFC
350	3600	94.3	94.7			89.4	85.9		
	1800	94.7	94.7			85.9	85.9		
400	3600	94.3				88.4			
	1800	9437				86.8			
450	3600	94.7				89.1			
500	3600	94.7				88.3			

SECTION 16450

GROUNDING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI):
      a. C2 - National Electrical Safety Code (NESC).
   2. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).

1.02 SUBMITTALS

A. Shop Drawings:
   1. Product Data:
      a. Exothermic weld connectors.
      b. Mechanical connectors.

1.03 UL COMPLIANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND ROD

A. Material: Copper clad.

B. Diameter: Minimum 5/8 inch.

C. Length: 20 feet.

2.02 GROUND CONDUCTORS

A. As specified in Section 16120 - Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:
   1. Outdoor Weld: Suitable for exposure to elements or direct burial.
   2. Indoor Weld: Utilize low-smoke, low-emission process.
   3. Manufacturers:
      a. Erico Products, Inc.; Cadweld and CadweldExolon.
      b. Thermoweld.

B. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material:
   1. Manufacturers:
      a. Burndy Corp.
      b. Thomas and Betts Co.

2.04 GROUNDING WELLS

A. Ground rod box complete with cast iron riser ring and traffic cover marked GROUND ROD.

B. Manufacturers:
   1. Christy Co.; No. G5.
   2. Lightning and Grounding Systems, Inc.; I-R Series.

PART 3 EXECUTION

3.01 GENERAL

A. Grounding shall be in compliance with NFPA 70 and ANSI C2.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.

C. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode.

D. Bond together system neutrals, service equipment enclosures, exposed non-current-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

F. Shielded Control Cables:
   1. Ground shield to ground bus at power supply for analog signal.
   2. Expose shield minimum I inch at termination to field instrument and apply heat shrink tube.
   3. Do not ground control cable shield at more than one point.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to non current-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to non current-carrying grounding bus.

C. Motors Less Than 10 hp: Furnish mechanical-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Tap motor frame or equipment housing; furnish mechanical-type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

3.05 GROUNDING WELLS

A. Install inside buildings, asphalt, and paved areas.

B. Install riser ring and cover flush with surface.

C. Place 9 inches crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:
   1. Above grade Connections: Use either exothermic weld or mechanical-type connectors.
   2. Below grade Connections: Install exothermic weld type connectors.

3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:
1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Mechanical Type:
1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

3.07 METAL STRUCTURE GROUNDING

A. Ground metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.08 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each.

B. Ground Rod Floor Protrusion: 4 to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all non current-carrying metal parts, and any metallic raceway grounding bushings to ground rod with No. 6 AWG copper conductor.

3.09 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.

B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.

C. Bond neutrals of pad-mounted transformers to four locally driven ground rods and buried ground wire encircling transformer and system ground network.

3.10 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

3.11 INSTRUMENT GROUND - SURGE SUPPRESSION

A. Connect all instrument surge protection with #6 insulated copper ground wire (in conduit where above grade) to closest plant ground system.

3.12 BONDING

A. Bond to Main Conductor System:
   1. All roof mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails, and other sizeable metal objects.
   2. Roof flashing, gravel stops, insulation vents, ridge vents, roof drains, soil pipe vents, and other small metal objects if located within 6 feet of main conductors or another grounded object.
   3. Provide air terminals as required.

B. Bond steel columns or major framing members to grounding system per National Electrical Code.

C. Bond each main down conductor to grounding system.

D. All conduits terminations in panels shall be grounded using appropriate ground bushing and conductor to nearest ground point.

3.13 GROUNDING SYSTEM

A. Grounding Conductor:
   1. Completely encircle building structure.
   2. Bury minimum 30” below finished grade.
   3. Minimum 2 feet distance from foundation walls.

B. Interconnect ground rods by direct-buried copper cables.

C. Connections:
   1. Install ground cables continuous between connections.
   2. Exothermic welded connections to ground rods, cable trays, structural steel, handrails, and buried and nonaccessible connections.
   3. Provide bolted clamp type mechanical connectors for all exposed secondary connections.
   4. Use bolded offset parapet bases or through-roof concealed base assemblies for air terminal connections.
   5. Provide interconnections with electrical and telephone systems and all underground water and metal pipes.
   6. Provide electric service arrestor ground wire to building water main.

3.14 FIELD QUALITY CONTROL

A. As specified in Section 16950 - Electrical Testing.

END OF SECTION

SECTION 16480

LOW VOLTAGE MOTOR CONTROL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standard Institute (ANSI):
      a. C2, National Electrical Safety Code (NESC).
      b. C57.12.28, Switchgear and Transformers - Pad-Mounted Equipment-Enclosure Integrity.
      c. Z55, Gray Finishes for Industrial Apparatus and Equipment.
   2. National Electrical Manufacturers Association (NEMA):
      a. AB 1 Molded Case Circuit Breakers.
      b. ICS 1, General Standards for Industrial Control and Systems.
      c. ICS 2, Standards for Industrial Control Devices, Controllers, and Assemblies.
      d. ICS 2.3, Instructions for Handling, Installation, Operation, and Maintenance of Motor Control Centers
      e. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
      f. 250-1997, Enclosures for Electrical Equipment (1,000 volts maximum).
   3. National Fire Protection Association (NFPA): 70-90, National Electrical Code. (NEC) Latest Edition.
   4. Underwriters Laboratories, Inc. (UL):
      a. 98, Standard for Safety Enclosed and Dead-Front Switches, Eleventh Edition.
      b. 489, Standard for Safety Molded Case Circuit Breakers and Circuit Breaker Enclosures, Seventh Edition.
      c. 845, Standard for Safety Motor Control Centers, Third Edition.
      d. 508A Industrial Control Equipment.
   5. InterNational Electrical Testing Association (NETA) Acceptance Testing Specifications, latest edition.
   6. Institute of Electrical and Electronics Engineers (IEEE):
      a. 112, latest revision, Standard Test Procedure for Polyphase Induction Motors and Generators.
      b. 43, latest edition, Recommended Practice for Testing Insulation Resistance of Rotating Machinery.

1.02 SUBMITTALS

A. Shop Drawings:
   1. Itemized bill of material.
   2. Descriptive information.
   3. Dimensional drawings.
   4. Conduit entrance locations/provisions.

5. Bus data including horizontal and vertical bus capacities, voltage rating and interrupting capacity. Include materials of construction.
6. Protective Devices: Copies of time-current characteristics.
7. Anchoring instructions and details.
8. Typed tabulation:
    a. Motor name; tag (equipment) numbers as shown on Drawings.
    b. Motor horsepower.
    c. Nameplate full load current.
    d. Measured load current and voltage.
    e. Heater catalog number.
    f. Protective device trip settings.
9. Attach above typed, tabulated data to a copy of starter manufacturer's overload heater selection tables for the starters provided.
10. Control Diagrams:
    a. NEMA ICS 2, Section 322.08 Type I.
    b. Wiring Type B.
    c. In addition to standard NEMA control diagrams, provide the following:
        1) Remote control devices.
        2) Remote indication and/or pilot lights.
        3) Interconnections and interlocking circuits between starter and remote equipment.
        4) Remote sensors.
        5) Tag numbers associated with all control devices and equipment.
        6) Clearly identify items provided by others.
11. One-line diagrams.
12. Schematic (elementary) diagrams. Custom schematics shall be furnished. Diagrams shall include all remote devices. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the Contractor stamped "REJECTED-RESUBMIT".
13. Outline diagrams.
14. Interconnection diagrams.
15. Enclosure NEMA rating and color.
16. Ground bus size and material of construction.
17. Main incoming line entry provision (top or bottom).
18. Control unit nameplate schedule.
19. All circuit breaker types, frames, and settings.
20. All starter NEMA sizes, auxiliary contact provisions, coil voltage Relays, timers, pilot devices, control transformer VA and fuse sizes.
21. Short circuit rating of the complete assembly.
22. Replacement parts lists and operation and maintenance procedures.
23. Plan and elevation dimensional views of each MCC section.

B. Quality Control Submittals:
1. Manufacturer's installation instructions.
2. Operation and Maintenance Manual.
3. Factory test reports, certified.

1.03 UL COMPLIANCE

A. Products manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL Listing Mark. Where shown or required motor control centers shall be suitable for service entrance.

1.04 PACKING AND SHIPPING

A. Shipping Splits: Established by Contractor to facilitate ingress of equipment to final installation location within the building.

1.05 RESPONSIBILITIES:

A. The information provided on the drawings is for guidance only and does not limit the equipment size. When motors furnished differ from the expected rating indicated the Contractor shall make the necessary adjustments to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate the motors actually installed.

1.06 INSPECTION COORDINATION:

A. The Contractor shall provide access to the WORK for the Engineer as requested for inspection. The Contractor shall provide 48 hours' notice of its intention to begin new WORK activities.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton Electrical.

B. Square D.

C. Or approved equal.

2.02 MOTOR CONTROL

A. General:
   1. Provide each motor with a suitable controller and devices that will function as specified for the respective motors and meeting NEMA ICS 2, (class A), the NEC, and UL.
   2. Like Items of Equipment: Same manufacturer as low voltage switchboard and panelboards for standardization. Devices of the same type shall be products of the same manufacturer. This requirement applies to all control devices, and insofar as practical, to equipment manufactured on a production basis. It also applies without exception to equipment custom fabricated for this project.
   3. Make adjustments as necessary to wiring, conduit; disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.

4. Overload Protection:
    a. Each motor shall have a direct current sensing solid-state overload protection in all ungrounded phases. This protection shall have current overload relays sensitive to motor current, and mounted within the motor controller. Reset of the protection shall be manually activated with externally operated reset button. All overload protection devices shall be the inverse time limit type and match the motor characteristic.
5. Control Transformer:
    a. Two winding, 120-volt secondary, primary voltage to suit.
    b. Two current-limiting fuses for primary circuit.
    c. One fuse in secondary circuit.
    d. Mount within starter unit.
6. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
7. Lifting lugs on all equipment and devices weighing over 100 pounds.
8. Anchor Bolts: Galvanized, sized by equipment manufacturer, and as specified in Section 05500, METAL FABRICATIONS.
9. Operating Conditions:
    a. Ambient Temperature: Maximum 40 degrees C.
    b. Equipment to be fully rated without any derating for operating conditions listed above.
10. Enclosures: In accordance with NEMA 250 and ANSI C57.12.28.
11. Equipment Finish:
    a. Electro-coating process applied over a rust-inhibiting phosphated base coating.
    b. Exterior Color: Manufacturer's standard.
12. All manual starters and combination motor starters shall be lockable in the off position.
13. All indication lights shall be push-to-test type LED as stated in specification 16050.

B. Manually Operated Starter, Fractional Horsepower:
1. Rating: 16 amperes continuous at 277 volts maximum.
2. Single-phase, non-reversing, full voltage with overload protection.
3. Toggle operated, keyed where shown.
4. Enclosure: NEMA 250, Type 4, unless shown otherwise.
5. Neon Light: Red.
6. Handle guard/lock-off attachment.

C. Manually Operated Starter, Integral Horsepower:
1. Rating: Horsepower rated to maximum of 10 horsepower at 600 volts with overload protection.
2. Single or three-phase, non-reversing, full voltage.
3. Control: Toggle or pushbutton.
4. Enclosure: NEMA 250, Type 4, unless shown otherwise.
5. Red pilot light in series with an auxiliary contact.
6. Locking in OFF position.
7. Two spare auxiliary, field-convertible contacts.

D. Combination Full-Voltage, Magnetic Starter:
   1. Rating: Horsepower rated at 600 volts, UL labeled for 100,000 amperes with overload protection.
   2. Three-phase, non-reversing, full voltage.
   3. Control: As shown.
   4. Disconnect Type: Motor circuit protector.
   5. Enclosure: As shown.
   6. Pilot Lights: As shown.
   7. Pad-lockable operating handles.

2.03 MOTOR CONTROL CENTERS

A. General:
   1. In accordance with NEMA ICS 2 and UL 845.
   2. The motor control centers shall be 600-volt class suitable for operation on a three-phase, 60-Hz system. The system operating voltage and number of wires shall be as indicated, on project drawings.
   3. MCC designated as service entrance rated shall include provision for termination of an incoming neutral conductor in conformance to NEC requirements.
   4. Short Circuit Rating: Amperes rms symmetrical as shown on Drawings for entire motor control center as a complete assembly.
   5. All controllers, main and branch circuit breakers, wire connections, and other devices to be front mounted and accessible unless otherwise noted.
   6. NEMA ICS 2, Section 322.08.
      a. Class: IIS.
      b. Type: B. Diagrams and wiring.
      c. Provide blank spaces on interconnection diagrams to add control conductor code designations during installation of equipment.
   7. Size and Arrangement
      a. Motor control centers shall be of mechanical groupings of control center units, assembled into a lineup of control center sections. Each control section shall be nominally 90-inches tall by minimum 20-inches deep.
      b. MCC's shall be designed to not exceed the space requirements as indicated on the Contract Drawings, including spaces, spares, and future compartments. MCC's shall be subject to rejection for exceeding the lengths indicated where allotted space is critical.
      c. Equipment within the MCC may be rearranged at the discretion of the manufacturer, providing the MCC provides the spares, space, and future provisions indicated.
      d. All switches and circuit breakers used as switches shall be located so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, will not be more than 6-feet 7-in.

B. Enclosure:
   1. Type: NEMA 250, Type 1, gasketed.
   2. Construction:
      a. Sheet steel reinforced with channel or angle irons.
      b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
      c. Removable top cover plates and bottom cover plates.

d. Removable plates on end panels for future bus extension.
e. Structural members shall be fabricated of not less than 12 gauge steel and side and top panels and doors shall be not less than 14 gauge steel.

3. Section Mounting: Removable formed-steel channel sills and lifting angles.
4. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
5. Vertical Wiring Compartment: Full height, isolated from unit starters with separate door.
6. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
7. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
8. Door Interlocking: Interlock starter and feeder doors mechanically so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access at any time.
9. External disconnect handles, pad-lockable in OFF position.
10. Cable Entrance: Main leads enter as shown on the Drawings. Control and feeder circuits enter from top and bottom.
11. Spaces designated as "SPACE" or "BLANK" shall include blank hinged doors and vertical bus bars.
12. Control units inside compartments shall be clearly identified with tags or stencil markings.
13. Each control unit including spares, spaces and blanks, lights, and devices shall be identified by an engraved nameplate. Identification shall include circuit number as indicated.
14. Each motor control center shall be fitted with the manufacturer's nameplate which shall include the NEMA Standard electric rating and other pertinent data, including manufacturer, sales order number, date of manufacture, and place of manufacture.
15. Where "L" or "U" shaped MCC layouts are indicated, corner compartments shall have similar current and short circuit ratings as functional compartments.
16. Fans, heat exchangers, transformers, capacitors, junction boxes, or other devices may not be mounted on the outside of the motor control center enclosure.
17. Finish for motor control center shall be light grey, ANSI 61. The panels shall be given 2 coats of primer inside and out and 2 coats of enamel finish. External colors other than ANSI 61 will not be acceptable.
18. Each section shall be dead-front and dead-back construction. Rear access shall not be necessary for inspection and maintenance. The structure arrangement shall be for front only mounting of units.
19. Power cables to the motor control center shall be either top or bottom feed as indicated on the project drawings. Provide all necessary lugs, clamps, and supports to terminate incoming power cables.

C. Bus:
1. Horizontal Power Bus:
a. Three-phase tin-plated, copper, entire width of control center, rated as indicated.
b. Silver-plated at joints.
c. Construct to allow future extension of additional sections.

d. Pressure type solderless lugs for each incoming line cable.
e. Isolated from top horizontal wireway.
f. Provide Belleville washers on bus connection bolts.

2. Vertical Power Bus:
   a. Three-phase tin-plated, copper, full height of section, rated as required by the load but not less than 300 amperes, minimum.
   b. Silver-plated at joints.
   c. Sandwich type bus insulation providing deadfront construction with starter units removed except for bus stab openings.
   d. Insulated and isolated barrier complete with shutters.
   e. Provide Belleville washers on bus connection bolts.
3. Neutral Bus: None.
4. Ground Bus:
   a. Copper, tin-plated, 33 percent minimum of phase bus ampacity, entire width of control center.
   b. Provide Belleville washers on bus connection bolts.
5. Bus Bracing: 65,000 amperes rms symmetrical.

D. Motor Controller Unit:
1. Provide indicated individual components and control devices including pushbuttons, selector switches, indicating lights, control relays, time delay relays, and elapsed time meters as specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.
2. Each motor starter unit shall consist of a combination magnetic contactor and short circuit protective device. Short circuit protective device shall be an instantaneous, magnetic only circuit breaker or thermal magnetic circuit breaker as defined in the project one line diagrams. All circuit breakers provided as part of a motor starter unit shall be capable of being padlocked in the open position. Reset of thermal overload elements shall be possible with unit door closed. Three phase overload trip units shall be furnished to suit the full load current of the equipment installed. Overload relays shall be solid state type capable of detecting phase loss and ground faults and shall meet NEMA class 20 tripping characteristics.
3. Magnetic starters shall have auxiliary contacts as required by electrical motor control diagrams, including N-O and N-C contacts as indicated, plus one each spare N-O and N-C contact. As a minimum, provide one normally open and one normally closed auxiliary contact.
4. Each starter unit shall have its own control power transformer. It shall have a 115-volt grounded secondary. One secondary fuse and 2 primary fuses shall be provided. Control power transformers shall be sized to accommodate the control devices indicated. Minimum transformer size is 50 VA. Local control devices shall be mounted independently of the cover door. All starters shall have a local "running" lamp and an "off" light to indicate the presence of control power when the motor is not running. Indicating lights shall be push-to-test type. Starters shall be provided with elapsed time meters, hand/off/auto selector switches, and other devices as indicated. All cubicle control wires shall be terminated at a pull apart disconnecting terminal block at the cubicle.

5. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with wrap-around permanent plastic markers. Each control wire shall be identified at both ends. Markers shall be produced from a device specifically made to produce tags, such as manufactured by Brady Corporation or Thomas & Betts. Hand lettered markers are not acceptable.
6. Motor starters shall be designed to NEMA ratings. Starters designed to IEC ratings or with dual IEC/NEMA ratings will not be acceptable, either as part of any MCC, as remote starters, or as part of any equipment package.
7. Construction:
    a. Draw out combination type with stab connections for starters NEMA ICS, Size 4 and smaller. The fixed-type unit assembly shall be constructed so that it can be easily removed from its panel after disconnecting the wires to the terminal block and withdrawing from the primary bus. Removal of a unit assembly shall be possible without rear access and without disturbing any other unit in the motor control center.
    b. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 5 and larger.
    c. Readily interchangeable with starters of similar size.
    d. Pull-apart unit control wiring terminal boards on all units.

E. Starters:
1. NEMA ICS 2, Section 322.08 standard rating, except none smaller than NEMA ICS, Size 1.
2. Rating: Horsepower rated at 600 volt, UL labeled for 65,000 amperes with overload protection.
3. Three-phase, non-reversing, unless otherwise shown.
4. Disconnect Type: Motor circuit protector.
5. Combination Full Voltage, Magnetic Starter:
    a. Control: As shown.
    b. Pilot Lights: Red-ON and Green-OFF.
6. Combination Reduced Voltage Auto-Transformer Starters:
    a. Reduced voltage auto-transformer starters shall consist of a molded-case motor circuit protector in combination with a closed transition type auto-transformer starter with 50 percent, 65 percent, and 80 percent taps, and shall be set on the 65 percent tap.
    b. The starter shall have three phase solid state overload relays capable of sensing phase loss and ground fault with manual reset.
    c. The auto-transformer shall include a thermal switch wired to protect itself from overheating.
    d. Timing of the starting period shall be controlled by an adjustable accelerating relay. Requirements set forth in paragraph 2.03 for enclosures and devices apply herein.
7. Solid State Reduced Voltage Starters:
    a. Solid state reduced voltage starters shall meet the requirements of UL 508 and shall consist of an incoming power circuit breaker, a power section; logic board, isolation contactor, and paralleling full load bypass contactor.

b. Soft Starters shall conform to the following:
   1) The SCR-based power section shall consist of 6 back-to-back SCRs, two SCRs per phase, and shall be rated for a minimum peak inverse voltage rating of 2.5 times line voltage, 1200 PIV for 480 volts. Units using triacs or SCR/diode combinations shall not be acceptable. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt characteristics of the electrical system.
   2) Starters shall include the following logic and control functions:
      a) Adjustable maximum starting current from 200 percent to 500 percent.
      b) Ramp time adjustment from 1 to 40 seconds.
      c) Adjustable linear voltage deceleration
      d) Kick start.
      e) Phase loss protection.
      f) Adjustable Undervoltage/ overvoltage protection.
      g) Current unbalance protection.
      h) Instantaneous overcurrent detection.
      i) Phase rotation protection (prevents starting).
      j) Shorted SCR detection.
      k) Selectable Class 10, 20, 30 electronic overload protection. Heat sink overtemperature protection shall be provided.
      l) Dry contacts for remote indication of RUN and TRIP status.
      m) Battery “back up” of set starter parameters.
      n) Event recorder.
      o) Elapsed time meter.
      p) LCD status display.
   3) The paralleling bypass contactor shall energize when the motor reaches full speed. The contactor shall be fully rated for across-the-line starting duty. The effect of the bypass contactor during normal operation is the elimination of heat buildup resulting from the voltage drop across the SCR’s. The bypass contactor may also be used as a means of starting the motor should problems be encountered with the soft starter. A door mounted selector switch shall be furnished such that the starting means can be selected as being either via the soft starter or via the bypass contactor as across-the-line.
   4) An isolation contactor shall be supplied. The isolation contactor shall remove three phase power from the input side of the solid state controller when the bypass contactor is selected for across-the-line starting.
   5) The starter shall be housed in an appropriate NEMA rated enclosure as directed by project drawings. Heaters and cooling fans shall be provided if required to maintain the equipment within the manufacturer’s environmental guidelines.
   6) The enclosure shall be of two-door compartment type construction. The left hand compartment shall contain the starter power section and any equipment rated at line voltage. The right hand compartment shall include only that equipment rated at 120 VAC or less including the starter’s CPU PC card and LCD display. The enclosure shall include a partition dividing the two compartments. Each compartment shall be designed to provide a barrier between the equipment at line voltage and the equipment at 120 VAC or less.

7) The starter shall be provided with a control power transformer sized to accommodate all controls indicated on the Contract Drawings. An input power circuit breaker shall be provided. Lug termination of the incoming power conductors shall not be permitted. The starter and circuit breaker shall be rated for 65 KAIC RMS at 480V.
8) The starter shall have door mounted LED indication of run, phase rotation, phase loss, undervoltage, current unbalance, and current trip.
9) Door mounted LCD / keyboard display assembly designed to:
a) Set or examine operating parameters.
b) Provide starter status information.
c) Provide real-time information about line current, voltage, and frequency.
d) Provide a means to start and stop the starter.

c. Pad-lockable operating handle when de-energized.
d. Unit door interlocked to prevent opening when disconnect is in closed position.
e. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
f. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.

8. Two Speed Starters:
a. Two Speed Starters shall be of the two-winding type unless otherwise indicated.
b. Requirements set forth in paragraph 2.03 for enclosures and devices apply herein.
9. Disconnecting Device:
a. In each starter, control circuit disconnect to de-energize circuits in unit which are not de-energized by starter power disconnect device.
b. Pad-lockable in OPEN position.
10. Circuit Breaker:
a. Meeting the requirements of NEMA AB1 and UL 489.
b. Molded case with manufacturer's recommended trip setting for maximum motor protection.
c. Magnetic trip only.
d. Tripping indicated by operating-handle position.
e. Interrupting capacity required for connection to system with short circuit capacity indicated.
11. Fused Switch:
a. Heavy-duty, motor rated load-break, quick-make, quick-break type meeting the requirements of UL 98 and NEMA KS 1.
b. Current-limiting fuses, with rejection clips.
12. Load Detector Relay:
a. Manual reset with adjustable differential.
b. Manufacturer:
1) Cutler-Hammer; Type D60LA.
2) Allen-Bradley; Bulletin 2100.
13. Motor Overload Protection:
a. Direct current sensing solid-state overload protection in all ungrounded phases.
b. Manual-reset overload relays.

14. Motor Thermal Protector Interface: Manual-reset interposing relay for connection to motor-mounted thermal protector system.
15. Ground Fault Protection: Where indicated and as specified in paragraph Feeder Units and Main Protective Device, except provide instantaneous operation device.
16. Capacitor Connection: Terminals to allow easy connection of power factor correction capacitors on source side of starter overload relays on starters where capacitor connection is shown.

F. Control Unit:
1. Disconnecting Device: Capable of de-energizing external source control circuits in unit.
2. Control Devices: As indicated and as specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.
3. Control Wiring:
a. Minimum wire size 14 AWG copper.
b. Permanent sleeve type markers with wire numbers applied to each end of wires.
c. Terminate wires using insulated locking fork or ring type crimp terminals.
d. Terminate current transformer leads on shorting type terminal blocks.

G. Incoming Line Terminal:
1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable entering section as shown.
3. Maximum short-circuit rating of 65,000 amperes.
4. Mechanical type CU-/AL lugs for 75 degrees C cable.

H. Feeder Unit and Main Protective Device:
1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable entering section as shown.
3. Molded Case Circuit Breaker:
a. In accordance with NEMA AB 1 and UL 489.
b. Main and feeder protective device.
c. UL labeled as suitable for service entrance.
d. Thermal-magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
e. Indicate tripping by operating-handle position.
f. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
g. Circuit breakers having a frame size of 150 amperes or less shall be molded-case type with thermal magnetic non-interchangeable, trip-free, sealed trip units.
h. Circuit breakers with a frame size of 225 amperes to 1,200 amperes shall be molded case with interchangeable thermal and adjustable magnetic trip or RMS sensing electronic trip elements.
i. The interrupting capacity of all main, and feeder branch circuit breakers shall be a minimum of 65,000 RMS symmetrical amperes. Service disconnects rated 1000A or more shall provide ground fault protection of equipment.

4. Ground Fault Protection:
    a. Suitable for 480-volt, three-phase, three-wire, solidly grounded wye system.
    b. Ground sensors to encircle all phase conductors and neutral conductor where used and connected to ground relays with adjustable pickup settings and time-current characteristics indicated.
    c. Circuit breaker shunt trip and relay operating from fused 120-volt ac control source within control center.
    d. Manufacturers:
        1) Ground Fault System ITE; Ground Shield.
        2) General Electric; Ground Break.
5. Phase Monitoring Relay:
    a. Three-phase monitoring relay to protect against low voltage, voltage unbalance, and phase reversal.
    b. Manufacturer: Furnas; Class 47.

I. Instruments:
1. Provide solid state type metering where indicated. Include CT's and PT's of ratios as indicated.
    a. Solid state “metering” shall include but not be limited to the following functions:
        1) Metering: Device shall monitor Voltage (VLL/VLN), Current (Amps per phase), Real Power (W), Reactive Power (VAR) and Apparent Power (VA). Device shall have data gathering ability for analysis. The device(s) shall conform to the requirements of UL 508.
        2) Alarms: Device shall utilize assignable output relays to trigger alarms for specific applications. Alarm messages shall be displayed on the front panel of the device. Alarm outputs via dry contacts shall alarm Over/Under Current, Over/Under Voltage, Current Unbalance/Neutral Current, Phase Sequence, Over/Under Frequency, Power Factor, and Switch Inputs.
        3) Communications: Device shall be able to communicate with current and future process control systems using standard protocols such as Devicenet, Ethernet, Modbus, Profibus, or as called for on project drawings. Front and rear panel communications ports shall be available for information access. Display of monitored values shall be available both locally and remotely.

J. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30 mm. Miniature style devices are not acceptable. All devices shall conform to the requirements of UL 508.
1. Lens colors for “run,” “stop”, “on,” “off,” “open,” and “closed” shall be coordinated with the Owner’s requirements.
2. Pilot lights shall be LED, push-to-test type.
3. Provide hazardous location type pilot devices in classified locations per the NEC.

K. Elapsed Time Meters: As specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.

L. Time Delay Relays: As specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.

M. Relays shall be 3 PDT with 10 amp contacts, plug-in type utilizing rectangular blades and provided with sockets for screw-type termination and hold-down clips.

N. Reset Timers: As specified in Section 16050, BASIC ELECTRICAL MATERIALS AND METHODS.

O. Nameplates:
   1. Laminated plastic; white, engraved to black core.
   2. Provide for each motor control center and each unit.
   3. Engrave with inscription shown on single-line diagram.
   4. Provide blank nameplates on spaces for future units.
   5. Attach with stainless steel pan head screws on face of control center.

P. Factory Testing: NEMA ICS 1, Section 109.

2.04 SPARE PARTS

A. The Contractor shall furnish the following for each MCC as a minimum:
   1. One unit control transformer or power supply of each size furnished in magnetic starters or solid state reduced voltage starter installed in MCC.
   2. One spare SSRVS unit for each size of SSRVS.
   3. Three bezels of each color installed for pilot indicators.
   4. One dozen panel lamps.
   5. One dozen control fuses of each size installed.

B. Spare parts shall be identified by MCC number, type, size, and manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with NEMA ICS 2.3, Submittal Drawings, and Manufacturer's Instructions and Recommendations.

B. Secure equipment to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

E. Grout mounting channels into floor or mounting pads.

F. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.

G. Motor control centers shall be installed on 3-1/2-inch concrete pads. After leveling and shimming, the Contractor shall anchor motor control centers to concrete pads and shall grout so that no space exists between the pad and support beams.

H. The Contractor shall:
   1. Torque all bus bar bolts to manufacturer's recommendations. Tighten all sheet metal and structure assembly bolts.
   2. Adjust all Motor Circuit Protector (MCP) devices to the instantaneous trip setting position recommended for the actual horsepower and full load amps of the motor. Verify that overload devices are proper for equipment installed; make necessary changes in overload devices as required for motors having power factor correcting capacitors.
   3. After equipment is installed, touch up scratches and verify that nameplate, and other identification is accurate.
   4. Provide high voltage switchboard matting in front of the MCC. The mat shall be 1/4-inch thick and 36-inches wide.

3.02 TESTING

A. Factory Test: All motor control centers, microprocessor based soft starters and their components shall be given manufacturer's standard electrical and mechanical production tests and inspections. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of all components including controls, protective devices, metering, and alarm devices.

B. Field Test MCC:
   1. Visual and mechanical inspection after installation.
      a. Inspect for physical damage, proper anchorage, and grounding.
      b. Verify that the ratings of the solid state overload relays match the motor full-load current nameplate data.
      c. Check tightness of bolted connections.

C. Electrical Tests
   1. Insulation tests
      a. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute. Test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.
      b. Measure insulation resistance of each starter section phase to phase and phase to ground with the starter contacts closed and the protective device open. Test voltage and minimum acceptable resistance shall be in accordance with the manufacturer's recommendations.
      c. Measure insulation resistance of each control circuit with respect to ground.
   2. Verify proper operation of control logic in all modes of control.

3.03 SOLID STATE REDUCED VOLTAGE STARTER INSTALLATION

A. The Contractor shall:
   1. Verify that the overload devices are properly adjusted for the equipment installed.

3.04 CIRCUIT BREAKERS

A. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.

B. Adjust to approximately 2 times motor rated current.

C. Determine motor rated current from motor nameplate following installation.

3.05 OVERLOAD RELAY

A. Adjust overload relays after the actual nameplate full-load current rating of motor has been determined.

3.06 MOTOR DATA

A. Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:
   1. Motor served by tag number and equipment name.
   2. Nameplate horsepower.
   3. Motor code letter.
   4. Full load amperes.
   5. Service factor.
   6. Installed overload relay heater catalog number.

3.07 FIELD QUALITY CONTROL

A. In accordance with Section 16950, ELECTRICAL TESTING.

3.08 MANUFACTURERS' SERVICES

A. Furnish manufacturer's representative for the following services at jobsite or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:
   1. 1 person-day for installation assistance, and inspection of installation.
   2. 1 person-day for functional and performance testing.
   3. 1 person-day for plant startup.

END OF SECTION

SECTION 16950

ELECTRICAL TESTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI):
      a. 450 - Recommended Practice for Maintenance, Testing, and Replacement of Large lead Storage Batteries for Generator Stations and Substations.
      b. C2 - National Electrical Safety Code.
      c. C37.20.1 - Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
      d. C37.20.2 - Metal-Clad and Station-Type Cubicle Switchgear.
      e. C37.20.3 - Metal-Enclosed Interrupter Switchgear.
      f. C62.33 - Standard Test Specifications for Varistor Surge-Protective Devices.
   2. American Society for Testing and Materials (ASTM):
      a. D665 - Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
      b. DS77 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
      c. D923 - Standard Test Method for Sampling Electrical Insulating Liquids.
      d. D924 - Standard Test Methods for A-Class Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
      e. D971 - Standard Test Method for Interfacial Tension of 0.1 Against Water by the Ring Method.
      f. D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
      g. D1298 - Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
      h. D1500 - Standard Test Method for ASTM Color of Petroleum Products.
      i. D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
      j. D1533 - Standard Test Methods for Water in Insulating Liquids.
      k. D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
      l. D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop- Weight Method.
   3. Institute of Electrical and Electronics Engineers (IEEE):
      a. 43 - Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
      b. 48 - Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators.

c. 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
d. 95 - Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage.
e. 118 - Standard Test Code for Resistance Measurement.
f. 400 - Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.

4. National Electrical Manufacturers Association (NEMA):
   a. AB 4 - Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2 - Deadfront Distribution Switchboards.
   c. WC 7 - Cross-Linked-Thermosetting-Polyethylene- Wire and Cable for the Transmission and Distribution of Electrical Energy.
   d. WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
5. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
6. National Fire Protection Association (NFPA):
   a. 70 - National Electrical Code (NEC).
   b. 70E - Standard for Electrical Safety Requirements for Employee Workplaces.

1.02 SUBMITTALS

A. Administrative Submittals: Submit 30 days prior to performing inspections or tests:
   1. Schedule for performing inspection and tests.
   2. List of references to be used for each test.
   3. Sample copy of equipment and materials inspection form(s).
   4. Sample copy of individual device test form.
   5. Sample copy of individual system test form.

B. Quality Control Submittals: Submit within 30 days after completion of test:
   1. Test or inspection reports and certificates for each electrical item tested.

C. Contract Closeout Submittals:
   1. Operation and Maintenance Data:
      a. In accordance with District General Conditions.
      b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in operation and maintenance manual.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:
   1. Corporately and financially independent organization functioning as an unbiased testing authority.
   2. Professionally independent of manufacturers, suppliers, and installers, of electrical equipment and systems being tested.
   3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.

4. Supervising engineer accredited as Certified Electrical Test Technologist by National Institute for Certification of Engineering Technologists (NICET), or International Electrical Testing Association and having a minimum of 5 years testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Registered Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA Title 29, Part 1907 criteria for accreditation of testing laboratories or a full Member Company of International Electrical Testing Association.

B. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment are to be:
1. Scheduled with engineer prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Engineer at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 GENERAL

A. Tests specified in this section are to be performed in accordance with the requirements of Section 15958 – Mechanical Equipment Testing.

B. Tests and inspection shall establish that:
1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. Installation operates properly.

3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, and ANSI C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate protective relays, circuit breakers, fuses, and other applicable devices.

E. Adjust mechanisms and moving parts for free mechanical movement.

F. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents.

H. Realign equipment not properly aligned and correct unevenness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Inform Engineer of working clearances not in accordance with NFPA 70.

N. Investigate and repair or replace:
1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

O. Electrical Enclosures:
1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer, door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer, poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
    a. Provide matching paint and touch up scratches and mars.

b. If required due to extensive damage, as determined by Engineer, refinish the entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents.

Q. Replace transformer insulating oil not in compliance with ASTM D923.

3.02 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:
1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.
3. Proper operation of indicating devices.
4. Improper blockage of air cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check Door and Device Interlocking System By:
   a. Closure attempt of device when door is in OFF or OPEN position.
   b. Opening attempt of door when device is in ON or CLOSED position.
8. Check Key Interlocking Systems For:
   a. Key captivity when device is in ON or CLOSED position.
   b. Key removal when device is in ON or CLOSED position.
   c. Closure attempt of device when key has been removed.
   d. Correct number of keys in relationship to number of lock cylinders.
   e. Existence of other keys capable of operating lock cylinders.
      1) Destroy duplicate sets of keys.
9. Check Nameplates for Proper Identification Of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbutton.
   c. Control switch.
   d. Pilot light.
   e. Control relay.
   f. Circuit breaker.
   g. Indicating meter.
10. Verify that fuse and circuit breaker ratings, sizes, and types conform to those specified.
11. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench thermographic survey applied to bolted joints:
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 10. 1, unless otherwise specified by manufacturer.
    c. Thermographic survey temperature gradient of 2 degrees Celsius, or less.
12. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
13. Verify performance of each control device and feature.

14. Control Wiring:
    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Proper conductor lacing and bundling.
    c. Proper conductor identification.
    d. Proper conductor logs and connections.
15. Exercise active components.
16. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:
    1. Insulation Resistance Tests:
        a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.1.1.
        b. Each phase of each bus section.
        c. Phase-to-phase and phase-to-ground for 1 minute.
        d. With switches and breakers open.
        e. With switches and breakers closed.
        f. Control wiring except that connected to solid state components.
        g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
    2. Overpotential Tests:
        a. Applied ac or dc voltage and test procedure in accordance with ANSI C37.20.3 and NEMA PB 2.
        b. Each phase of each bus section.
        c. Phase-to-phase and phase-to-ground for 1 minute.
        d. Test results evaluated on a pass/fail basis.
    3. Current Injection Tests:
        a. For entire current circuit in each section.
        b. Secondary injection for current flow of 1 ampere.
        c. Test current at each device.
    4. Control Wiring:
        a. Apply secondary voltage to control power and potential circuits.
        b. Check voltage levels at each point on terminal boards and each device terminal.
    5. Operational Test:
        a. Initiate control devices.
        b. Check proper operation of control system in each section.

3.03 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:
    1. Physical and insulator damage.
    2. Proper winding connections.
    3. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
    4. Defective wiring.
    5. Proper operation of fans, indicators, and auxiliary devices.
    6. Removal of shipping brackets, fixtures, or bracing.
    7. Free and properly installed resilient mounts.
    8. Cleanliness and improper blockage of ventilation passages.

9. Verify that tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.2.3 for each:
         1) Winding-to-winding.
         2) Winding-to-ground.
      b. 10-minute test duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      c. Results temperature corrected in accordance with NETA ATS, Table 7.2.4.
      d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
      e. Insulation resistance test results to compare within 1 percent of adjacent windings.
   2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.04 SAFETY DISCONNECT SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
   1. Proper blade pressure and alignment.
   2. Proper operation of switch operating handle.
   3. Adequate mechanical support for each fuse.
   4. Proper contact-to-contact tightness between fuse clip and fuse.
   5. Cable connection Bolt torque level in accordance with NETA ATS, Table 10.1.
   6. Proper phase barrier material and installation.
   7. Verify that fuse sizes and types correspond to one-line diagram.
   8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.
      b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
      c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   2. Contact Resistance Tests:
      a. Contact resistance in microhms across each switch blade and fuse holder.
      b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.05 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
   1. Inspect Each Individual Exposed Power Cable No. 6 and Larger for:
      a. Physical damage.
      b. Proper connections in accordance with single-line diagram.
      c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
      d. Color coding conformance with specifications.
      e. Proper circuit identification.
   2. Mechanical Connections for:
      a. Proper lug type for conductor material.
      b. Proper lug installation.
      c. Bolt torque level in accordance with NETA ATS, Table 10. 1, unless otherwise specified by manufacturer.
   3. Shielded Instrumentation Cables for:
      a. Proper shield grounding.
      b. Proper terminations.
      c. Proper circuit identification.
   4. Control Cables for:
      a. Proper termination.
      b. Proper circuit identification.
   5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:
   1. Insulation Resistance Tests:
      a. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures for 1 minute.
      b. Evaluate ohmic values by comparison with conductors of same length and type.
      c. Investigate values less than 50 megohms.
      d. Utilize 1,000V dc megohmmeter for 600V insulated conductors.
   2. Continuity test by ohmmeter method to ensure proper cable connections.

3.06 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 70 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:
   1. Proper mounting.
   2. Proper conductor size.
   3. Feeder designation according to nameplate and one-line diagram.
   4. Cracked casings.
   5. Connection bolt torque level in accordance with NETA ATS, Table 10.1.
   6. Operate breaker to verify smooth operation.
   7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
   8. Verify that terminals are suitable for 75 degrees Celsius rated insulated conductors.

C. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Utilize 1,000-volt dc megohmmeter for 480- and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
      b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
      c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
      d. Test values to comply with NETA ATS, Table 10.2.
   2. Contact Resistance Tests:
      a. Contact resistance in microhms across each pole.
      b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
   3. Primary Current Injection Test to Verify:
      a. Long-time minimum pickup and delay.
      b. Short-time pickup and delay.
      c. Ground fault pickup and delay.
      d. Instantaneous pickup by run-up or pulse method.
      e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
      f. Trip times shall be within limits established by NEMA AB 4, Table 5-3.
      g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4.

3.07 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:
   1. Visually Check Each Relay for:
      a. Tight cover gasket and proper seal.
      b. Unbroken cover glass.
      c. Condition of spiral spring and contacts.
      d. Disc clearance.
      e. Condition of case shorting contacts if present.
   2. Mechanically Check Each Relay for:
      a. Freedom of movement.
      b. Proper travel and alignment.
   3. Verify That Each Relay:
      a. Complies with Contract Documents and application.
      b. Is set in accordance with recommended settings.

B. Electrical Tests:
   1. Insulation resistance test on each circuit to frame except for solid state devices.
   2. Tests on Nominal Recommended Setting for:
      a. Pickup parameters on each operating element.
      b. Timing at three points on time-current curve.
      c. Pickup target and seal-in units.
      d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.
   3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.

4. Current Injection Tests:
    a. For entire current circuit in each section.
    b. Secondary injection for current flow of 1 ampere.
    c. Test current at each device.

3.08 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:
    1. Visually Check Current, Potential, and Control Transformers for:
        a. Cracked insulation.
        b. Broken leads or defective wiring.
        c. Proper connections.
        d. Adequate clearances between primary and secondary circuit wiring.
    2. Verify Mechanically That:
        a. Grounding and shorting connections have good contact.
        b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
    3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:
    1. Current Transformer Tests:
        a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
        b. Polarity test.
    2. Potential Transformer Tests:
        a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 7.1.1 for 1 minute on:
            1) Winding-to-winding.
            2) Winding-to-ground.
        b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
    3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 7.1.1.

3.09 METERING

A. Visual and Mechanical Inspection:
    1. Verify meter connections in accordance with appropriate diagrams.
    2. Verify meter multipliers.
    3. Verify that meter types and scales conform to Contract Documents.
    4. Check calibration of meters at cardinal points.
    5. Check calibration of electrical transducers.

3.10 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:
    1. Equipment and circuit grounds in motor control centers, panelboards, switchboards, and switchgear assemblies for proper connection and tightness.
    2. Ground bus connections in motor control centers, panelboards, switchboards, and switchgear assemblies for proper termination and tightness.
    3. Effective transformer core and equipment grounding.

4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:
   1. Fall-of-Potential Test:
      a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
      b. Main ground electrode system resistance to ground to be no greater than 5 ohms.
   2. Two-Point Direct Method Test:
      a. In accordance with IEEE 81, Section 8.2. 1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
      b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.11 GROUND FAULT SYSTEMS

A. Inspection and Testing Limited to:
   1. Zero sequence grounding systems.
   2. Residual ground fault systems.

B. Visual and Manual Inspection:
   1. Neutral Main Bonding Connection to Ensure:
      a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
      b. Ground strap sensing system is grounded through sensing device.
      c. Neutral ground conductor is solidly grounded.
   2. Verify that control power has adequate capacity for system.
   3. Manually Operate Monitor Panels for:
      a. Trip test.
      b. No trip test.
      c. Nonautomatic rest.
   4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
   5. Relay check for pickup and time under simulated ground fault conditions.
   6. Verify nameplate identification by device operation.

C. Electrical Tests:
   1. Test system neutral insulation resistance with neutral ground link removed. System neutral insulation resistance minimum 1 megohm.
   2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
   3. Test relay timing by injecting 300 percent of pickup current, or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.

D. Test system operation at 55 percent rated control voltage, if applicable.

E. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.12 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 horsepower and larger.

B. Visual and Mechanical Inspection:
   1. Proper electrical and grounding connections.
   2. Shaft alignment.
   3. Blockage of ventilating air passageways.
   4. Operate Motor and Check For:
      a. Excessive mechanical and electrical noise.
      b. Overheating.
      c. Correct rotation.
      d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
      e. Excessive vibration.
   5. Check operation of space heaters.

C. Electrical Tests:
   1. Insulation Resistance Tests:
      a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 10.2 for:
         1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
         2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.
      b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
   2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
   3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
   4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.
   5. Overpotential Tests:
      a. Applied dc voltage in accordance with IEEE 95.
      b. Limited to 4,000-volt motors rated 1,000 horsepower and greater.
      c. Test results evaluated on pass/fail basis.

3.13 LOW VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:
   1. Proper barrier and shutter installation and operation.
   2. Proper operation of indicating and monitoring devices.
   3. Proper overload protection for each motor.
   4. Improper blockage of air cooling passages.

5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check Door and Device Interlocking System by:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check Key Interlocking Systems for:
    a. Key captivity when device is in ON or CLOSED position.
    b. Key removal when device is in OFF or OPEN position.
    c. Closure attempt of device when key has been removed.
    d. Correct number of keys in relationship to number of lock cylinders.
    e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check Nameplates for Proper Identification of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbuttons.
    c. Control switches.
    d. Pilot lights.
    e. Control relays.
    f. Circuit breakers.
    g. Indicating meters.
10. Verify that fuse and circuit breaker sizes and types conform to Contract Documents.
11. Verify that current and potential transformer ratios conform to Contract Documents.
12. Check Bus Connections for High Resistance by Low Resistance Ohmmeter and Thermographic Survey:
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
    c. Thermographic survey temperature gradient of 2 degrees Celsius, or less.
13. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
14. Verify performance of each control device and feature furnished as part of the motor control center.
15. Control Wiring:
16. Compare wiring to local and remote control, and protective devices with elementary diagrams.
17. Check for proper conductor lacing and bundling.
18. Check for proper conductor identification.
    a. Check for proper conductor lugs and connections.
19. Exercise active components.
20. Inspect Contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of all connections.
21. Compare overload heater rating with full-load current for proper size.

22. Compare motor protector and circuit breaker with motor characteristics and power factor correction capacitors for proper size.
23. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.
      b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
      c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
      d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
      e. Test values to comply with NETA ATS, Table 10.2.
   2. Overpotential Tests:
      a. Maximum applied ac or dc voltage in accordance with NETA ATS, Table 7.1.2.
      b. Phase-to-phase and phase-to-ground for 1 minute for each phase of each bus section.
      c. Test results evaluated on pass/fail basis.
   3. Current Injection Through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
      a. Trip time in accordance with manufacturer's published data.
      b. Investigate values in excess of 120 seconds.
   4. Control Wiring Tests:
      a. Apply secondary voltage to control power and potential circuits.
      b. Check voltage levels at each point on terminal boards and each device terminal.
      c. Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid state components:
         1) Insulation resistance to be 1 megohm minimum.
   5. Operational test by initiating control devices to affect proper operation.

3.14 BATTERY SYSTEM

A. Visual and Mechanical Inspection:
   1. Physical damage and electrolyte leakage.
   2. Evidence of corrosion.
   3. Intercell bus link integrity.
   4. Battery cable insulation damage and contaminated surfaces.
   5. Operating conditions of ventilating equipment.
   6. Visual check of electrolyte level.

B. Electrical Tests:
   1. Measure:
      a. Bank charging voltage.
      b. Individual cell voltage.

c. Electrolyte specific gravity in each cell.
d. Measured test values to be in accordance with manufacturer's published data.

2. Verify During Recharge Mode:
   a. Charging rates from charger.
   b. Individual cell acceptance of charge.
3. Load tests for integrity and capacity; test values in accordance with ANSI 450.

3.15 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:
   1. Adequate clearances between arrestors and enclosures.
   2. Ground connections to ground bus or electrode.

B. Electrical Tests:
   1. Varistor Type Arrestors:
      a. Clamping voltage test.
      b. Rated RMS voltage test.
      c. Rated dc voltage test.
      d. Varistor arrester test values in accordance with ANSI C62.33, Sections 4.4 and 4.7.

3.16 THERMOGRAPHIC SURVEY

A. Provide a thermographic survey of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 2 and larger at each:
   1. Medium voltage switchgear and transformer.
   2. Switchboard.
   3. Low voltage motor control center.
   4. Panelboard.

B. Provide a thermographic survey of feeder conductors No. 2 and larger terminating at:
   1. Motors rated 30 horsepower and larger.
   2. Medium and low voltage disconnect switches.
   3. Transfer switches.
   4. Engine-generators.

C. Remove necessary enclosure metal panels and covers prior to performing survey.

D. Perform with equipment energized during periods of maximum possible loading.

E. Do not perform survey on equipment operating at less than 20 percent of rated connected operating load.

F. Utilize Thermographic Equipment Capable of:
   1. Detecting emitted radiation.
   2. Converting detected radiation to visual signal.
   3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees Celsius.

G. Temperature Gradients of:
   1. 3 degrees Celsius to 7 degrees Celsius indicates possible deficiency that warrants investigation.
   2. 7 degrees Celsius to 15 degrees Celsius indicates deficiency that is to be corrected as time permits.
   3. 16 degrees Celsius and above indicates deficiency that is to be corrected immediately.

H. Provide Written Report of:
   1. Areas surveyed and the resultant temperature gradients.
   2. Locations of areas having temperature gradients of 3 degrees Celsius or greater.
   3. Cause of heat rise and actions taken to correct the cause of heat rise.
   4. Detected phase unbalance.

END OF SECTION

SECTION 17101A

SPECIFIC CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Loop descriptions for Alum Storage and Feed System.
   2. Loop descriptions for Liquid Ammonium Sulfate (LAS) Storage and Feed System.

1.02 REFERENCES

A. Definitions:
   1. Loop description: Specific control requirements and functional descriptions for individual control loops.

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Develop detailed loop descriptions based on the information in the Contract Documents:
   1. Submit loop descriptions with all implemented modifications from this Section clearly marked.
   2. Remove all markings on final loop descriptions submitted with the applicable operation and maintenance manuals.

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FUNCTIONAL CONTROL DESCRIPTIONS

A. The control strategies are written descriptions of the programming required to implement regulatory and sequential control of the unit processes. Control strategies shall fully reside in the memory of the designated PLC. Coefficients pertaining to control strategies shall be modifiable through the operator interface in the monitoring / control mode. The control strategies listed in this specification are not all-inclusive, but is intended to give a general guidance. I&C supplier shall coordinate with MSS supplier and Owner/Engineer and implement a fully functional PLC program in place.

B. The I&C supplier shall include an additional 160 hours on-site to fine tune control systems and make minor software modifications in order to resolve any logic discrepancies encountered during start-up and supply the Owner with a complete functional system. This shall be part of the bid package with no additional cost to the owner. Only main control strategy will be listed in this specification. Contractor shall also provide other minor control strategies not listed below but stated in the drawings or in other specifications or as required for a complete functional control strategy.

C. Alum storage and feed:
   1. 2 new bulk storage tanks, 2 transfer pumps (1 duty, 1 standby) are used for transfer of alum from the bulk storage tanks to the day tank, 1 new day tank, 2 metering pumps (1 duty, 1 standby) are used to transfer alum from the day tank to the point on injection in the aeration structure (middle of aeration tray). The bulk storage tanks and day tank levels are monitored by a non-contact radar level transmitter. Tank low-low and high-high alarm shall be generated on the PLC for SCADA monitoring.
   2. Alum transfer pumps shall be operated in auto mode where the PLC will automatically start/stop the transfer pump based on the new day tank level. When the level in alum day tank is below the low level setpoint (adjustable) for 5 seconds (adjustable), the PLC logic shall start the transfer pump to fill the day tank. When the level in alum day tank reaches the high level setpoint (adjustable) for 3 seconds (adjustable), the PLC logic shall stop the transfer pump. If low level alarm signal in bulk storage tanks is active, the PLC logic shall stop the transfer pumps until the low-level condition goes away. There will be a manual override “ON” push button on the SCADA screen. If the operator push that “ON” button while the HOA is selected in Auto, the PLC logic shall start the transfer pump and latch that bit until the high level setpoint is reached and unlatch the bit at high level.
   3. Alum transfer pumps shall incorporate protection against run-dry conditions by integrating a flow switch into the common suction line. The flow switch will detect the presence or absence of flow, providing a binary signal indicating whether the pump is operating. In the event that the pump is running but no flow is detected, the system will automatically cease pump operation.
   4. Alum metering pumps shall have one local control panel. Refer to Instrumentation drawing for quantity of local control panel and quantity of metering pump in associated local control panel. Each alum metering pump shall have “Local-Off-Remote” selector switch on associated local control panel. In Local selection, start/stop and local speed control of the metering pump shall be from the local control panel. In Remote selection, start/stop and speed control of the metering pump shall be from SCADA and the PLC logic. In Automatic mode, the Alum metering pumps should be automatically started and stopped based on the status of the raw water station interlock. The operator shall enter the desired dose setpoint (mg/L) to run the selected alum metering pump and the pump shall be flow paced (influent flow to the plant). In manual mode, the operator shall start/stop the pump and enter the pump speed manually from the SCADA screens.
   5. Low-low level setpoint (adjustable) alarm on the Day Tank Level shall shut down the chemical metering pumps and alarm on the SCADA display. It shall also prevent the alum metering pumps from starting until the condition goes away.

D. LAS storage and feed:
   1. 2 new bulk storage tanks, 2 transfer pumps (1 duty, 1 standby) are used for transfer of LAS from the bulk storage tanks to the day tank, 1 new day tank, 2 sets of metering pump skids each with 2 metering pumps (1 duty, 1 standby, per skid) are used to transfer LAS from the day tank to their respective points on injection at the RO permeate clearwell, 36" filter influent pipe segment, and 16" Peace River influent pipe segment. The bulk storage tank and day tank levels are monitored by a non-contact radar level transmitter. Tank low-low and high-high alarms shall be generated on the PLC for SCADA monitoring.
   2. LAS transfer pumps shall be operated in auto mode where the PLC will automatically start/stop the transfer pump based on the new day tank level. When the level in LAS day tank is below the low level setpoint (adjustable) for 5 seconds (adjustable), the PLC logic shall start the transfer pump to fill the day tank. When the level in LAS day tank reaches the high level setpoint (adjustable) for 3 seconds (adjustable), the PLC logic shall stop the transfer pump. If low level alarm signal in bulk storage tanks is active, the PLC logic shall stop the transfer pumps until the low-level condition goes away. There will be a manual override "ON" push button on the SCADA screen. If the operator push that "ON" button while the HOA is selected in Auto, the PLC logic shall start the transfer pump and latch that bit until the high level setpoint is reached and unlatch the bit at high level.
   3. LAS transfer pumps shall incorporate protection against run-dry conditions by integrating a flow switch into the common suction line. The flow switch will detect the presence or absence of flow, providing a binary signal indicating whether the pump is operating. In the event that the pump is running but no flow is detected, the system will automatically cease pump operation.
   4. LAS metering pumps shall have one local control panel. Refer to Instrumentation drawing for quantity of local control panel and quantity of metering pump in associated local control panel. Each LAS metering pump shall have "Local-Off-Remote" selector switch on associated local control panel. In Local selection, start/stop and local speed control of the metering pump shall be from the local control panel. In Remote selection, start/stop and speed control of the metering pump shall be from SCADA and the PLC logic. The LAS should be automatically started and stopped based on the system it is being fed to:
      a. RO Plant Injection Point – The LAS should start and stop based on RO permeate sodium hypochlorite pumps operation. When RO permeate sodium hypochlorite pumps are running the LAS pumps shall run as well.
      b. Surface Water Injection Point – The LAS should start and stop based on the surface water sodium hypochlorite pumps operation. When surface water sodium hypochlorite pumps are running the LAS pumps shall run as well.
      c. 16" Peace River Influent Pipe segment – The LAS (and sodium hypochlorite) pumps should start when following conditions are met:
         1) 3-way valves (67-MPV-23 and 67-MPV-24) need to be in correct position for this injection point.

2) The MGP valves need to be in the correct position for this injection point - the Ok to Flow North to South status is true. This checks to ensure that the valve from Peace River (MOV-3) is in the open position and that the valve to Peace River (MOV-1) is in the closed position as well as confirms that there are no active faults with the valves that could prevent the flow from Peace River to Punta Gorda.
3) FIT-13-1 (Peace River flow meter) flow value shall be greater than trigger set point (adjustable from the SCADA screen) for preset time delay. Confirmation of these conditions will ensure that the bleach and LAS only feed when there is adequate flow coming from Peace River to Punta Gorda.

In Automatic mode, the operator shall enter the ratio of sodium hypochlorite dose to liquid ammonium sulfate dose. The pump will pace in accordance with the sodium hypochlorite pump, based on this ratio. In manual mode, the operator shall start/stop the pump and enter the pump speed manually from the SCADA screens.

5. Low-low level setpoint (adjustable) alarm shall shut down the chemical metering pumps and alarm on the SCADA display. It shall also prevent the LAS metering pumps from starting until the condition goes away.

END OF SECTION

SECTION 17300

INSTRUMENTATION CONTROL AND MONITORING SYSTEM - GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE

A. The Contractor shall provide, through the services of a single instrumentation and control system integrator, (instrumentation subcontractor) all components, system installation services, as well as, all required and specified ancillary services in connection with the Plant Instrumentation Control and Monitoring System. The System includes all materials, labor, tools, fees, charges and documentation required to furnish, install, program, test and place in operation a complete and operable instrumentation, control and information system as shown and/or specified in the contract drawings. The single instrumentation and control system integrator shall complete the detailed design of the Plant Instrumentation Control and Monitoring System. The system shall include all measuring elements, signal converters, transmitters, control panels, cabinets, digital hardware and software, operator workstations, operator interface terminals, signal and data transmission systems, interconnecting wiring, brackets, supports, piping, tubing, valves, mounting hardware, and such accessories as shown, specified, and/or required to provide the functions indicated and a complete working system in place.

B. The scope of the work to be performed includes, but is not limited to, the following:
   1. The Contractor shall retain overall responsibility for the instrumentation and control system as specified herein.
   2. The Contractor shall retain a single instrumentation and control system integrator who shall furnish all services and equipment defined herein and in other Specification sections as listed below under related work.
   3. Furnish and install all digital control system hardware, software, and programming as specified herein.
   4. Furnish and install process instrumentation and associated taps, nipples, valves, tubing, and supports as scheduled or shown on the Drawings, unless otherwise noted or supplied by equipment vendors.
   5. Furnish and install digital control system hardware and software as specified in this Division, including but not limited to:
      a. Modify existing PLC system as shown on drawings, adding additional I/O cards in the existing racks if needed, configuration, termination, I/O mapping, scaling, etc. for a complete and working PLC system. New I/O cards shall match existing type and number of I/O points.
      b. Modify existing SCADA HMI Screens, database, historical collection and reporting to accommodate all new signals and new systems per drawings.
   6. Final termination and testing of all instrumentation and control system signal wiring and power supply wiring at equipment furnished under this Division.
   7. Furnish and install surge protective device systems for all digital equipment, data communications equipment, local control panels, and field instruments provided under this Division, including connections to grounding system(s) provided under Division 16.

8. Coordinate grounding requirements with the Electrical Contractor for all digital equipment, local control panels, and field instrumentation provided under this Division. Terminate grounding system cables at all equipment provided under this Division.
9. Perform control and instrument loop checks to verify and ensure proper loop operation from all HMI and SCADA screens to the physical instrument or control device.
10. Provide system testing, calibration, and startup services as specified herein and as required to make all systems fully operational.
11. Furnish operator training services as described herein. Coordinate with the Owner for the number of training classes required and times.

C. Furnish and install embedded supports, instrument stands, brackets, mounting hardware, piping, tubing, isolation valves and related items required for instrumentation and equipment furnished under Division 17.

D. It is the intent of the Contract Documents to construct a complete and working installation. Items of equipment or materials that may reasonably be assumed as necessary to accomplish this end shall be supplied whether or not they are specifically stated herein.

1.02 GENERAL INFORMATION AND DESCRIPTION

A. The supplier shall provide all materials, equipment, labor and services required to achieve a fully integrated and operational system. The supplier shall provide final design and coordinate the instrument and control system for proper operation with related equipment and materials furnished by other suppliers under other sections of these Specifications and with related existing plant equipment.

B. Auxiliary and accessory devices necessary for system operation or performance, such as transducers or relays to interface with equipment provided by other suppliers under other Sections of these Specifications, shall be included whether they are shown on the instrument drawings or not.

C. Substitutions on functions or type of equipment specified will not be acceptable. In order to insure the interchangeability of parts, the maintenance of quality, the ease of interfacing between the various subsystems and the establishment of minimums with regard to ranges and accuracy, strict compliance with the above requirements shall be maintained. In order to insure compatibility between all equipment, it shall be the responsibility of the system supplier to coordinate all interface requirements with mechanical and electrical system suppliers and furnish any signal isolation devices that might be required.

D. Equipment shall be fabricated, assembled, installed and placed in proper operating condition in full conformity with detailed drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer as approved by the Owner.

E. To facilitate the Owner's future operation and maintenance, products shall be of the same major instrumentation manufacturer, with panel mounted devices of the same type and model to the greatest extent possible.

F. All equipment shall be listed and labeled as defined in Article 100 of National Electrical Code, and shall satisfy applicable Federal, State and local codes.

G. All installations shall be per National Electrical Code, and shall satisfy applicable Federal, State and local codes.

H. Supplementing this Section, the Drawings and the related Specification sections provide additional details showing panel elevations, instrument device schedules, functional requirements of the system and interaction with other equipment.

I. The integrator shall attend a preliminary design review meeting with the Owner to review the overall system software design with emphasis being placed upon the arrangement and interactive operation of items associated with the operator interface screens and functionality.

J. Where manufacturers are named for a particular item of equipment, it is intended as a guide to acceptable quality and performance and does not exempt such equipment from the requirements of these Specifications or Drawings. All meters, instruments, and other components shall be the most recent field proven models marketed by their manufacturers at the time of submittal of Shop Drawings, unless otherwise specified to match existing equipment. All technical data publications included with submittals shall be the most recent issue.

K. In order to centralize responsibility, it is required that all equipment (including field instrumentation and control system hardware and software) offered under this Division shall be furnished and installed by the instrumentation subcontractor, or under the supervision of the instrumentation subcontractor, who shall assume complete responsibility for proper operation of the instrumentation and control system equipment, including that of coordinating all signals, and furnishing all appurtenant equipment.

L. The Contractor shall retain total responsibility for the proper detailed design, fabrication, inspection, test, delivery, assembly, installation, activation, checkout, adjustment and operation of the entire instrumentation and control system as well as equipment and controls furnished under other Divisions of the Specifications. The Contractor shall be responsible for the delivery of all detailed drawings, manuals and other documentation required for the complete coordination, installation, activation and operation of mechanical equipment, equipment control panels, local control panels, field instrumentation, control systems and related equipment and/or systems and shall provide for the services of a qualified installation Engineer to supervise all activities required to place the completed facility in stable operation under full digital control.

M. The instrumentation and control system shall be capable of simultaneously implementing all real-time control and information system functions, and servicing all operator service requests as specified, without degrading the data handling and processing capability of any system component. It shall also be possible to simultaneously generate displays on all workstations and print out data on all printers without degradation of system performance.

N. The mechanical, process, and electrical drawings indicate the approximate locations of field instruments, control panels, systems and equipment as well as field-mounted equipment provided by others. The instrumentation subcontractor shall examine the mechanical, process and electrical drawings to determine actual size and locations of process connections and wiring requirements for instrumentation and controls furnished under this Contract. The instrumentation subcontractor shall inspect all equipment, panels, instrumentation, controls and appurtenances either existing or furnished under other Divisions of the Specifications to determine all requirements to interface same with the control and information system. The Contractor shall coordinate the completion of any required modifications with the associated supplier of the item furnished.

O. The instrumentation subcontractor shall review and approve the size and routing of all instrumentation and control cable and conduit systems furnished by the Electrical Contractor for suitability for use with the associated cable system.

P. The Contractor shall coordinate the efforts of each supplier to aid in interfacing all systems. This effort shall include, but shall not be limited to, the distribution of approved shop drawings to the Electrical Contractor and to the instrumentation subcontractor furnishing the equipment under this Division.

Q. The Contractor shall be responsible for providing a signal transmission system free from electrical interference that would be detrimental to the proper functioning of the instrumentation and control system equipment.

R. The Owner shall have the right of access to the subcontractor's facility and the facilities of his equipment suppliers to inspect materials and parts; witness inspections, tests and work in progress; and examine applicable design documents, records and certifications during any stage of design, fabrication and tests. The instrumentation subcontractor and his equipment suppliers shall furnish office space, supplies and services required for these surveillance activities.

S. The terms "Instrumentation", "Instrumentation and Control System", and "Instrumentation, Control and Monitoring System" shall hereinafter be defined as all equipment, labor, services and documents necessary to meet the intent of the Specifications.

T. Signal Characteristics:
   1. Signals shall be electrical, as indicated herein, and shall vary in direct linear proportion to the measured variable, except as noted. Electrical signals outside control panel(s) shall be 4 to 20 milliamperes DC, except as noted. Signals within enclosures may be 1-5 volts DC.

U. Matching Style Appearance and Type:
   1. All instruments to be panel mounted at the control panels shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be of one (1) manufacturer.

V. Accuracy and Repeatability:
   1. The overall accuracy of each instrumentation system or loop shall be as prescribed in the Specifications for that system or loop. Each system's accuracy shall be determined as a probable maximum error; this shall be the square-root of the sum of the squares of certified "accuracy s" of certain designated components in each system, expressed as a percentage of the actual span or value of the measured variable. Each individual electronic instrument shall have a minimum accuracy of +/-0.7 percent of full scale and a minimum repeatability of +/-0.4 percent of full scale unless otherwise specified. Instruments which do not conform to or improve upon these criteria are not acceptable.

W. Alternative Equipment or Methods:
   1. Equipment or methods requiring redesign of any project details are not acceptable without prior approval of the Owner. Any changes inherent to a proposal alternative shall be at no additional cost to the Owner. The required approval shall be obtained in writing by the I&C Subcontractor through the Contractor prior to submittal of Shop Drawings and data. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage and maintenance enhancement over the equipment or method specified, or shall include evidence that a specified component is not available. Otherwise, alternative equipment (other than direct, equivalent substitutions) and alternative methods shall not be proposed.

1.03 REFERENCE STANDARDS:

A. American Society for Testing and Materials (ASTM):
   1. ASTM A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.

B. International Society of Automation (ISA):
   1. ISA S5.2 - Binary Logic Diagrams for Process Operations.
   2. ISA S5.3 - Graphic Symbols for Distributed Control/Shared Display Instrumentation Logic and Computer Systems.
   3. ISA S5.4 - Standard Instrument Loop Diagrams.

C. American National Standards Institute (ANSI):
   1. ANSI X3.5 - Flowchart Symbols and Their Usage in Information Processing.

D. National Electrical Manufacturers Association (NEMA).

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 RELATED WORK:

A. The supplier shall furnish all materials, labor and services specified in the following Specification sections as required ensuring a single, coordinated system is supplied:
   1. Section 17303 - Software Programming and Control Strategies.

2. Section 17304 - Instrumentation.

B. The Supplier shall in particular coordinate his work with the work under the following:
   1. Division 0 - Bidding and Contract Requirements.
   2. Division 1 - General Requirements.
   3. Division 11 - Equipment.
   4. Division 15 - Mechanical.
   5. Division 16 - Electrical.

C. Instrument and control systems furnished by the Supplier shall be designed and coordinated for proper operation with related equipment and materials furnished by other suppliers under other sections of these specifications.
   1. Verify following work not by I&C Supplier is provided:
      a. Correct type, size, and number of signal wires with their raceways including grounding systems, special cables and Ethernet cables.
      b. Correct electrical power circuits and raceways.
      c. Correct size, type, and number of I&C related pipes, valves, fittings, and tubes.
      d. Correct size, type, materials, and connection of process mechanical piping for in-line primary elements.
      e. Instrument A.C. power source and disconnect switch for process instrumentation, A.C. grounding systems, A.C. power supplies for all equipment, control panels and accessories furnished under Division 17.
      f. Conduit and raceways for all instrumentation and control system signal wiring,
      g. Installation of (pull in conduit system) copper and fiber optic data communications cables.
      h. Installation of grounding systems for all digital equipment, local control panels, and field instrumentation provided under Division 17. Grounding systems shall be complete to the equipment provided under Division 17, ready for termination by the instrumentation subcontractor.
      i. Termination of all instrumentation and control system grounding, signal and data communications cables, wiring and surge suppression devices at the equipment end of all equipment furnished under other divisions of the Specifications. Wiring systems shall be complete to the equipment provided under Division 17, ready for termination by the instrumentation subcontractor.
   2. For equipment not provided under I&C Supplier, but directly connected to equipment required by I&C Supplier:
      a. Obtain from Contractor, manufacturer's information on installation, interface, function, and adjustment.
      b. Coordinate with Contractor to allow required interface and operation with I&C System.
      c. For operation and control, verify that installations, interfacing signal terminations, and adjustments have been completed with manufacturer's recommendations.
      d. Test to demonstrate required interface and operation with I&C System.
      e. Examples of items in this category, but not limited to the following:
         1) Valve operators, position switches, and controls.
         2) Variable frequency drives.

3) Motor control centers.
4) Package control systems.

1.05 QUALITY ASSURANCE:

A. The Contractor shall provide qualifications, details and a description of the proposed instrumentation supplier and how he/she proposes to fulfill the requirements set forth in this Specification. The supplier shall present the information in sufficient detail so that proper evaluation regarding the experience and capabilities of the supplier can be performed.
   1. The information shall contain evidence that the proposed supplier has sufficient financial resources to meet the obligations incident to the performance of the work including available bonding. (This requirement may be provided in the form of a verifiable or certified financial report for the company's latest fiscal year).
   2. The information shall contain a list of personnel available for assignment to the responsible positions of Project Manager, Project Engineer, Installation Supervisor and Area Service Representative. Also include a concise resume of each individual's education, work experience and accomplishments.
   3. The information shall contain the following specific information:
      a. Maintenance services available, hardware and software: Evaluation will be based on the supplier's capability to provide the required routine and emergency services locally (within 180 miles of job site). The supplier's proposal is to describe the capabilities and location of his/her nearest (to job-site) service organization.
      b. Technical validation examples of recently completed, and similar scope projects: the supplier is to provide information regarding type, size, complexity, and performance of five systems recently completed, along with names, addresses, telephone numbers of persons qualified to verify supplier's statements approximate cost of the instrumentation system supplied, project completion date and description. Evaluation will be based on the similarity of system requirements and supplier's performance.
      c. A description of how the supplier plans to execute the various functions and locations where the various portions of the work will be performed, coordinated and managed (e.g., design, engineering, manufacturing, programming, testing and scheduling). The vendor is required to state in his/her proposal those functions which he/she intends to subcontract to other organizations and include the name, address and capabilities of these organizations.
   4. The supplier shall be required to demonstrate a minimum of five years recent, past experience in the design, manufacture and commissioning of instrumentation and control systems of comparable size, type and complexity to the proposed project. The supplier shall be required to have his/her own in-house capability to handle complete system engineering, fabrication, and testing.
   5. The supplier shall have a UL approved shop and shall build all panels according to UL 508A.
   6. Instrumentation and Controls supplier shall be C.C. Control Corp., Curry Controls, Commerce Controls, Inc., Champion Controls, Revere Controls, L3 communications, CEC Controls, or Owner approved equal.

7. Coordination, drafting, procurement and expediting, scheduling, construction, testing, inspection, installation, training start-up service for calibration and commissioning and warranty compliance for the period specified.
8. The supplier shall coordinate with on-going projects in construction and the instrument Contractor of the on-going projects for interfacing with other devices that are provided as part of the other on-going projects and schedule the connection, modifications, etc. accordingly to avoid any conflicts.

1.06 SUBMITTALS:

The supplier is responsible to comply to all below listed submittals requirements for all the work and material provided in the project scope. Contractor shall disregard the requirements not applicable in the project.

A. Submit shop drawings in accordance with Section 01330. These shop Drawings shall fully demonstrate that the equipment and services to be furnished will comply with the provisions of these specifications and shall provide a true and complete record of the equipment as manufactured and delivered. Submittals shall be bound in separate three-ring binders, with an index and sectional dividers, with all Drawings reduced to a maximum size of 11-in by 17-in for inclusion within the binder. Separate submittals shall be made as follows:
   1. Section 17300 Instrumentation Control and Monitoring System - General Provisions (including project plan, testing related subjects, Owner training plan, spares, expendable and test equipment).
   2. Specification Section 17303 Software Programming and Control Strategies.
   3. Specification section 17304 Instrumentation.

B. Project Plan:

   It shall provide an overview of the proposed system including system architecture diagrams, the approach to work, the proposed work schedule indicating milestones and potential meetings, project personnel and organization, details of factory testing and field testing, details of training programs and a paragraph by paragraph review of the specifications indicating any proposed deviations. The schedule shall illustrate all major project milestones including the following:

   1. Schedule for all subsequent project submittals.
   2. Tentative dates for all project design review meetings.
   3. Schedule of manufacture and staging of all instrumentation and control system equipment.
   4. Schedule for shipment of all instruments and control system equipment all peripheral devices.
   5. Schedule for equipment start up.
   6. Schedule for operational readiness and 30-day acceptance tests.
   7. Schedule for all training.
   8. The project plan must be submitted and approved before any future submittals are made.

C. Testing Related Submittals
   1. Test Procedures: Submit the procedures proposed to be followed during the test. Procedures shall include test descriptions, forms, and checklists to be used to control and document the required tests.
      a. Preliminary test procedure submittals: Prior to the preparation of the detailed test procedures, submit outlines of the specific proposed tests. Submittals shall include examples of the proposed forms, checklists, and layout of testing equipment and wiring diagrams.
      b. Test Procedure Submittals: After the preliminary test procedure submittals have been reviewed by the Owner and returned stamped either "approved" or "approved as noted, confirm" submit the proposed detailed test procedures. Following this, the tests may be started.
   2. Test Documentation: Upon completion of each required test, document the test by submitting a copy of the signed off test procedures.

D. Owner Training Plan – Submittals:
   1. Preliminary training plan submittal:
      a. Within 60 days of contract award to the Contractor, submit an overview of the proposed training plan. This overview shall include, for each course proposed:
         1) An overview of the training plan explaining why specific courses are proposed.
         2) Course title and objectives.
         3) Prerequisite training and experience of attendees.
         4) Recommended types of attendees.
         5) Course Content - A topical outline.
         6) Course Duration.
         7) Course Location - Factory training facility, on site and/or off site classroom.
         8) Course Format - Lecture, laboratory demonstration, etc.
         9) Qualifications and experience of individual(s) providing training.
      b. The Owner will review the preliminary training plan submittal.
   2. Training Plan Submittal: Upon receipt of the Owner's comments on the preliminary training plan, submit the specific proposed training plan. The training plan shall include:
      a. Definitions of each course.
      b. Specific course attendance.
      c. Schedule of training courses including dates, duration and locations of each class.
      d. Resumes of the instructors who will actually implement the plan.
   3. A minimum of 14 days prior to beginning each training course, submit documentation for use by the Owner's personnel during training. The training documentation shall be specific to the particular course, and shall include the following:
      a. A listing of all subjects to be covered.
      b. Course schedule.
      c. Documentation/lesson plans covering all subjects to be covered during the course instruction. Information shall be in a "how to" format, with sufficient background documentation and references to manufacturer literature to provide a thorough and clear understanding of the materials to be covered.

E. Spares, Expendables, and Test Equipment Lists Submittal:
   1. This submittal shall include for each Subsystem:
      a. A list of, and descriptive literature for, spares, expendables and test equipment as specified for each Instrumentation Sections 17300.
      b. A separate list of, and descriptive literature for, additional spares, expendables and test equipment recommended by the System Supplier.
      c. Unit and total costs for the additional spare items recommended for each subsystem.
      d. Provide storage instructions for all spare parts.

F. Instrumentation:
   1. This submittal shall provide complete documentation of all field instruments and other instrument and control equipment not specified to be submitted elsewhere.
      a. Provide data sheets for each component listing all model numbers, optional and ancillary devices that are being provided. The data sheets shall be provided with an index and proper identification and cross-referencing. They shall include but not be limited to the following information:
         1) Project Equipment Number and tag number per the Contract Drawings.
         2) Product (item) name used herein and on the Contract Drawings.
         3) Manufacturer's complete model number.
         4) Location of the device.
         5) Input - output characteristics.
         6) Range, size and graduations.
         7) Physical size with dimensions, enclosure NEMA classification and mounting details.
         8) Materials of construction of all components.
         9) Instrument or control device sizing calculations where applicable.
         10) Certified calibration data on all flow metering devices.
      b. Provide equipment specification sheets which shall fully describe the device, the intended function, how it operates and its physical environmental and performance characteristics. Each data sheet shall have appropriate cross references to equipment identification tags. As a minimum the specification sheets shall include the following:
         1) Dimension, rigid-clearances for maintenance and calibration.
         2) Mounting or installation details.
         3) Connection.
         4) Electrical power or air requirements.
         5) Materials of construction.
         6) Environmental characteristics.
         7) Performance characteristics.

1.07 SEQUENCING AND SCHEDULING

A. Allowance for Interruptions to Contractor’s work due to application software testing:
   1. The Contractor shall anticipate interruption of testing and delays to Work and shall allow for the following:
      a. Investigation of software problems.
      b. Retesting.

B. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and schedules listed below have been completed and satisfied:
   1. Submittal Reviews by Owner:
      a. Prerequisite: Owner acceptance of Instrumentation Control and Monitoring Schedule of Values and Progress Schedule.
      b. Schedule: submit within 90 days after award of contract:
         1) Section 17300 Process Instrumentation and Controls - General Provisions (including project plan, testing related subjects, Owner training plan, spares, expendable and test equipment).
         2) Specification Section 17303 Software Programming and Control Strategies.
         3) Specification section 17304 Instrumentation.
   2. Hardware Purchasing, Fabrication, and Assembly:
      a. Prerequisite: Associated Shop Drawing Submittals completed.
   3. Preliminary design review meeting with the Owner.

1.08 DELIVERY, STORAGE AND HANDLING

A. Shipping Precautions:
   1. After completion of shop assembly, factory test and approval all equipment, cabinets, panels and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weights shall be shown on shipping tags together with instructions for unloading, transporting, storing and handling at job site.
   2. Special instructions for proper field handling, storage and installation required by the manufacturer for proper protection, shall be securely attached to the packaging for each piece of equipment prior to shipment. The instructions shall be stored in re-sealable plastic bags or other acceptable means of protection.
   3. All equipment supplied under Section 17304 shall be shipped to the job site.

B. Identification:
   1. Each component shall be tagged to identify its location, tag number and function in the system. Identification shall be prominently displayed on the outside of the package.
   2. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment supplied under this Section.

C. Storage:
   1. Equipment shall not be stored out-of-doors. Equipment shall be stored in dry permanent shelters including in-line equipment and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor at his/her own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such tests as directed by the Owner. This shall be at the cost and expense of the Contractor, or the apparatus shall be replaced by the Contractor at his/her own expense.

1.09 WARRANTY

A. The instrumentation and control systems integrator shall provide a one (1) year warranty to the Owner for on-site warranty services. The warranty shall include all labor, parts, and emergency calls providing initial phone response within 2 hours and on-site response within 24 hours, to provide complete system maintenance and troubleshooting for a warranty period of one year after the date of final acceptance of the system. The warranty shall apply to all hardware and software components furnished, installed, programmed and calibrated by the instrumentation and control systems integrator.

B. The warranty contract shall also include a minimum of 2 (semi-annual) preventive maintenance visits by a qualified serviceman of the supplier who is familiar with the type of equipment and software provided for this project. Each preventive maintenance visit shall include routine adjustment, calibration, cleaning and lubrication of system equipment and verification of correct software operation.

C. During the one-year warranty period, observation of maintenance operations by Owner's personnel and the instruction of said personnel in the details of the maintenance work being performed, shall be provided. At the end of the warranty contract period, the Supplier shall replenish the spare parts supply to the original status of component parts and physical condition.

D. During the one-year warranty period, the original programmer of the PLC logic and HMI programming, or person who has intimate knowledge of the software and approved by Owner, shall respond within 2 hours by phone and 24 hours onsite to perform requested corrective actions. If programmer fails to respond within given time, Owner will back charge the Contractor for actions taken.

1.10 ENVIRONMENTAL CONDITIONS

A. Instrumentation equipment and enclosures shall be suitable for ambient conditions specified. All system elements shall operate properly in the presence of telephone lines, power lines, and electrical equipment.

B. Inside control rooms and climate-controlled electrical rooms, the temperature will normally be 20 to 25 degrees Celsius; relative humidity 40 to 80 percent without condensation and the air will be essentially free of corrosive contaminants and moisture. Appropriate air filtering shall be provided to meet environmental conditions (i.e., for dust).

C. Other indoor areas may not be air conditioned/heated; temperatures may range between 0 and 40 degrees Celsius with relative humidity between 40 and 95 percent.

D. Field equipment including instrumentation and panels may be subjected to wind, rain, lightning, and corrosives in the environment, with ambient temperatures from -20 to 40 degrees Celsius and relative humidity from 10 to 100 percent. All supports, brackets and interconnecting hardware shall be aluminum or 316 stainless steel as shown on the installation detail drawings.

1.11 FINAL SYSTEM DOCUMENTATION

A. Prior to final acceptance of the system and Owner training, operating and maintenance manuals covering instruction and maintenance on each type of equipment shall be furnished in accordance with the Section 01782.

B. The instructions shall be bound in three-ring binders with Drawings reduced or folded for inclusion and shall provide at least the following as a minimum:
   1. A comprehensive index.
   2. A complete "As Constructed" set of approved shop Drawings.
   3. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.
   4. Full specifications on each item.
   5. System schematic drawings "As Constructed", illustrating all components, piping and electrical connections of the systems supplied under this Section.
   6. Detailed service, maintenance, and operation instructions for each item supplied.
   7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
   8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
   9. Complete parts lists with stock numbers and name, address and telephone number of the local supplier.

C. The supplier's final documentation shall be new documentation written specifically for this project, but may include standard and modified standard documentation. Modifications to existing hardware or software manuals shall be made on the respective pages or inserted adjacent to the modified pages. All standard documentation furnished shall have all portions that apply clearly indicated. All portions that do not apply shall be lined out.

D. The manuals shall contain all illustrations, detailed drawings, wiring diagrams and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.

E. If the supplier transmits any documentation or other technical information which he/she considers proprietary, such information shall be designated. Documentation or technical information which is designated as being proprietary will be used only for the design, construction, operation, or maintenance of the system and, to the extent permitted by law, will not be published or otherwise disclosed.

F. The requirements for the supplier's final documentation are as follows:
   1. As built documentation shall include all previous submittals, as described in this Specification, updated to reflect the as-built system. Any errors in or modifications to the system resulting from the Factory and/or Field Acceptance Tests shall be incorporated in this documentation.
   2. The Hardware Maintenance Documentation shall describe the detailed preventive and corrective procedures required to keep the system in good operating condition. Within the complete Hardware Maintenance Documentation, all hardware maintenance manuals shall make reference to appropriate diagnostics, where applicable, and all necessary timing diagrams shall be included. A maintenance manual or a set of manuals shall be furnished for all delivered hardware, including peripherals. The Hardware Maintenance Documentation shall include, as a minimum, the following information:
      a. Operation Information - This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.
      b. Preventative-Maintenance Instructions - These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines and the adjustments necessary for periodic preventive maintenance of the System.
      c. Corrective-Maintenance Instructions - These instructions shall include guides for locating malfunctions down to the card-replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause and instructions for remedying the malfunction.
      d. Parts Information - This information shall include the identification of each replaceable or field-repairable module. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross-references between system supplier's part number and manufacturer's part numbers shall be provided.
   3. The Software Maintenance documentation shall provide a detailed description of the entire software system. This documentation shall be sufficient for software maintenance and modification of the entire software system. The following items shall be included with the software maintenance documentation.
      a. Computer Manufacturer's User Manuals - All computer manufacturer's manuals applicable to the system being provided.
      b. System Supplier's User Manuals - All applicable software manuals developed by the system supplier for the application software shall be provided.

c. Application/Custom Software Manuals - These manual(s) shall include all software maintenance information not included in the computer manufacturer's and system supplier's standard manuals. Each custom program developed specifically for the system shall include the following information as a minimum:
    1) Table of Contents.
    2) Overview of the program.
    3) Narrative describing exactly how the program works. All calculations, references to process I/O points and operator inputs should be mentioned.
    4) A flowchart shall be provided to clarify the narrative description.
    5) A List of Variables used by the program including the function of each. A cross reference to the Software Functional Design Documentation shall be provided where appropriate.

d. Software Listings - Two sets of well-annotated program listings of all software provided shall be furnished for all software items. These shall include, but not be limited to, the following:
    1) All listings associated with the system generation and software configuration of the specific system (i.e., system parameterization tables, build maps, disk maps, etc.).
    2) Listings of all data bases configured for and associated with the system.
    3) Listing of all custom or modified software developed specifically for the system.
    4) These listings shall reflect any changes made after the factory acceptance test.

e. Machine Readable Documentation - The supplier shall provide two sets of the following as-built documentation in machine readable format:
    1) Disk Pack(s) of the entire as-built software system in object format ready to mount and execute on the system. If the proposed configuration does not include removable disk packs, this requirement shall be fulfilled with transportable storage media compatible with the system furnished such as USB Flash Drive.
    2) Source storage media of the entire software system. The facility to easily locate any source program and obtain the corresponding hardcopy listing shall also be provided.
    3) The machine readable documentation shall be 100 percent compatible with the Software Listings previous defined. As with the Software Listings, any changes made during or after factory acceptance test shall be reflected in both the media.

f. Retrofit Documentation - The Owner recognizes the fact that not all possible problems related to real-time events, software interlocks, flags, active tasks and hardware utilizations can be discovered during the Acceptance Tests. Therefore, the supplier shall investigate, diagnose, repair, update and distribute all pertaining documentation of the deficiencies which become evident during the warranty period. All such documentation shall be submitted to the Owner within 30 days of solving the problem.

4. Provide Operator's Manuals for the system operators. These manuals shall be separately bound and shall contain all information necessary for the operator to operate the system. The manuals shall be written in non-technical terms and shall be organized for quick access to each detailed description of the operator's procedure. Manuals shall contain, but not be limited to, the following information:
    a. A simple overview of the entire system indicating the function and purpose of each piece of equipment.
    b. A detailed description of the operation of the Process Operator Console including all appropriate CRT displays.
    c. A detailed description of the operation and interface of all hardwired panels.
    d. Complete step-by-step procedures for starting up and shutting down the entire system.
    e. Complete step-by-step procedures for starting up or shutting down an individual component.
    f. A complete description for operating all computer system equipment (i.e., CPU, disk drive, etc.).
    g. Procedures for changing paper, tape, etc.
    h. A complete description of the operation of each plant control function. All operator input to these functions shall be described.
    i. A listing of all data base point names with their respective point descriptions.
    j. A complete glossary of terms.

G. Programs and Source Listings:
    1. Provide two copies of all standard, of-the-shelf system and application software (exclusive of firmware resident software) on CD ROM or DVD-ROM. One copy shall be the original from the manufacturer, with one additional copy for backup purposes.
    2. Provide two copies of source listings on CD ROM or DVD-ROM for all custom software written specifically for this plant, all database files configured for this facility, and all control strategies. All source listings shall include a program abstract, program linkage and input/output data. Comments describing the program flow shall be frequently interspersed throughout each listing.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION:

A. Contractor shall refer to the specification section 01110 Summary of Work for detail sequence of construction and schedule and shall coordinate his/her work accordingly.

2.02 SPARE PARTS

A. Spare Parts:
    1. Spare parts shall be as defined in the related specification sections. All spare parts shall be new and unused.

2. All spare parts shall be individually packaged and labeled.
3. The spares listed above shall be packed in a manner suitable for long-term storage and shall be adequately protected against corrosion, humidity and temperature.

2.03 NAMEPLATES

A. All items of equipment listed in the instrument schedule, control panels, and all items of digital hardware shall be identified with nameplates. Each nameplate shall be located so that it is readable from the normal observation position and is clearly associated with the device or devices it identifies. Nameplates shall be positioned so that removal of the device for maintenance and repair shall not disturb the nameplate. Nameplates shall include the equipment identification number and description. Abbreviations of the description shall be subject to the Owner's approval.

B. Nameplates shall be made of 1/16-inch thick machine engraved laminated three-ply phenolic plastic having white numbers and letters not less than 1/4-inch high on a black background. The manufacturer agrees that nameplate wording may be changed without additional cost or time if changes are made prior to commencement of engraving.

C. Nameplates shall be attached to metal equipment by self-tapping 316 stainless steel screws and to other surfaces by an epoxy-based adhesive that is resistant to oil and moisture. In cases where the label cannot be attached by the above methods, it shall be drilled and attached to the associated device by means of stainless steel wire.

D. Nameplates shall identify tag number of instruments inside cabinet and identify all other internal cabinet component. Devices shown on shop drawings shall be labeled with the name and tag that appears on the diagram. Prior to mounting adhesive nameplate, the intended surface shall be cleaned with an alcohol or lacquer thinner. Nameplates shall be attached to panel surfaces, not to instruments.

2.04 SIGNAL COORDINATION REQUIREMENTS

A. The Contractor shall be responsible for coordinating signal types and transmission requirements between the various parties providing equipment under this Contract. This shall include, but not be limited to, distribution of appropriate shop drawings among the equipment suppliers, the electrical subcontractor, the HVAC subcontractor, and the instrumentation and control integrator.

B. Analog signals shall be signals for transmitting process variables, etc. from instruments, and to and from panels, equipment PLC's and Control System PLC's.

C. Discrete signals shall consist of contact closures or powered signals for transmitting status/alarm information and control commands between starters, panels, equipment PLC's, the Control System, etc.

D. Analog Signal Transmission:
   1. Signal transmission between electric or electronic instruments, controllers, and all equipment and control devices shall be individually isolated, linear 4-20 milliamperes and shall operate at 24 volts D.C.
   2. Signal output from all transmitters and controllers shall be current regulated and shall not be affected by changes in load resistance within the unit's rating.
   3. All cable shields shall be grounded at one end only, at the control panel, with terminals bonded to the panel ground bus.
   4. Analog signal isolation and/or conversion shall be provided where necessary to interface with instrumentation, equipment controls, panels, and appurtenances.
   5. Non-standard transmission systems such as pulse duration, pulse rate, and voltage regulated shall not be permitted except where specifically noted in the Contract Documents. Where transmitters with nonstandard outputs do occur, their outputs shall be converted to an isolated, linear, 4-20 milliampere signal.
   6. The Contractor shall provide 24 V power supplies for analog signals and instruments where applicable and as required inside panels, controls, etc.
   7. Where two-wire instruments transmit directly to the Control and Information System, the Instrumentation Supplier shall provide power supplies at the PLC-equipped control panels for those instruments.
   8. Where four-wire instruments with on-board loop power supplies transmit directly to the Instrumentation Control and Monitoring System, the Instrumentation and Control System Integrator shall provide necessary signal isolators or shall otherwise isolate the input from the Control and Information System loop power supply. Similar provisions shall be made when a third element such as a recorder, indicator, or single loop controller with integral loop power supply is included in the loop.

E. Discrete Inputs:
   1. All discrete inputs to equipment and Control and Information System PLC's, from field devices, starters, panels, etc., shall be dry contacts in the field device or equipment, powered from the PLC's, unless specified otherwise.
   2. Sensing power (wetting voltage) supplied by the PLC shall be 24 VDC.

F. Discrete Outputs:
   1. All discrete outputs from local control panels and PLC's to field devices, starters, panels, etc., shall be dry contact closures with isolation relay outputs.
   2. Outputs to solenoid valves shall be fused 120 VAC, powered from the PLC or control panel via output relays. Each output shall be fused using blown fuse indicating fuse holders.

G. Other Discrete Signals:
   1. Discrete signals between starters, panels, etc. may be 120 VAC, as long as such contacts are clearly identified in the starter, panel, etc. as being powered from a different power supply than other starter/panel components.
   2. Where applicable, warning signs shall be affixed inside the starter, panel, etc. stating that the panel is energized from multiple sources.

3. Output contacts in the starter, panel, etc. which are powered from other locations shall be provided with special tags and/or color coding. Disconnecting terminal strips shall be provided for such contacts.
4. The above requirements shall apply to all starters and panels, regardless of supplier.

PART 3 EXECUTION

3.01 CLEANING

A. The Contractor shall thoroughly clean all soiled surfaces of installed equipment and materials.

B. Upon completion of the instrumentation and control work, the Contractor shall remove all surplus materials, rubbish, and debris that have accumulated during the construction work. The entire area shall be left neat, clean, and acceptable to the Owner.

3.02 FINAL ACCEPTANCE

A. Final acceptance of the Instrumentation, Control and Information System will be determined complete by the Owner, and shall be based upon the following:
1. Receipt of acceptable start up completion and availability reports and other documentation as required by the Contract Documents.
2. Completion of the Availability Demonstration of the System as a whole.
3. Completion of all punch-list items.

B. Refer to Section 01770 entitled “Closeout Procedures” for additional requirements.

3.03 GENERAL INSTALLATION

A. Instrumentation and accessory equipment shall be installed in accordance with the manufacturer's instructions. The locations of equipment, transmitters, alarms and similar devices shown on the Drawings are approximate only. Exact locations shall be as approved by the Owner during construction. Obtain in the field all information relevant to the placing of process control work and in case of any interference with other work, proceed as directed by the Owner and furnish all labor and materials necessary to complete the work in an approved manner. All instruments shall be mounted as to allow access for service without the use of portable ladders.

B. The instrumentation loop descriptions indicate the intent of the interconnection between the individual instruments. Any exceptions should be noted. Two complete sets of approved shop drawings shall be kept at the job site during all on-site construction. Both sets shall be identically marked up to reflect any modifications made during field installation or start-up. All markings shall be verified and initialed by the Owner or his/her designated representative.
1. Following completion of installation and the operational readiness test, one set of the marked up drawings shall be provided to the Owner, the other retained by the supplier for incorporation of the mark-ups into final as-built documentation.

C. The instrumentation installation details on the Drawings indicate the designed installation for the instruments specified. Where specific installation details are not specified or shown on the Drawings, the American Petroleum Institute (API) Recommended Practice 550 shall be followed as applicable.

D. All work shall be executed in full accordance with codes and local rulings. Should any work be performed contrary to said rulings, ordinances and regulations, the Contractor shall bear full responsibility for such violations and assume all costs arising there from.

E. All equipment used in areas designated as hazardous shall be designed for the Class, Group and Division as required on the Electrical Drawings for the locations. All work shall be in strict accordance with codes and local rulings, should any work be performed contrary to said rulings, ordinances and regulations, the supplier shall bear full responsibility for such violations and assume all costs arising there from.

F. Unless specifically shown in the Drawings, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands as detailed on the installation detail drawings. All instrumentation connections shall be provided with shutoff and drain valves. For differential pressure transmitters, valve manifolds for calibration, testing and blow down service shall also be provided. For slurries, chemical or corrosive fluids, diaphragm seals with flushing connections shall be provided.

G. All piping to and from field instrumentation shall be provided with necessary unions, test tees, couplings, adaptors and shut-off valves.

H. Field instruments requiring power supplies shall be provided with local electrical shutoffs and fuses as required.

I. Brackets and hangers required for mounting of equipment shall be provided. They shall be installed in a workmanlike manner and not interfere with any other equipment.

J. The system supplier shall investigate each space in the building through which equipment must pass to reach its final location. If necessary, the system supplier shall be required to ship his/her material in sections sized to permit passing through restricted areas in the building. The system supplier shall also investigate, and make any field modifications to the allocated space for each cabinet, enclosure and panel to assure proper space and access (front, rear, side).

K. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded as directed by the manufacturer of the instrumentation equipment but in no case shall more than one ground point be employed for each shield.

L. Lifting rings from cabinets/assemblies shall be removed. Hole plugs shall be provided for the holes of the same color as the cabinet.

M. The system supplier, acting through the Contractor, shall coordinate the installation, the placing and location of system components, their connections to the process equipment panels, cabinets and devices, subject to the Owner's approval. He/She shall be responsible to ensure that all field wiring for power and signal circuits are correctly done in accordance with best industry practice and provide for all necessary system grounding to insure a satisfactory functioning installation. The Contractor hereunder shall schedule and coordinate his/her work under this section with that of the electrical work specified under applicable Sections of Division 16.

3.04 TESTS (GENERAL)

A. The supplier shall test all equipment at the factory prior to shipment. Unless otherwise specified in the individual specification sections, all equipment provided by the supplier shall be tested at the factory as a single fully integrated system.

B. As a minimum, the testing shall include the following:
   1. Calibration and Calibration Test.
   2. Operational Readiness Test (ORT).

C. Tests shall be scheduled and performed to meet overall construction schedule requirements.

D. Each test shall be in the cause and effect format. The person conducting the test shall initiate an input (cause) and upon the system's or subsystem's producing the correct result (effect), the specific test requirement will have been satisfied.

E. All tests shall be conducted in accordance with prior Owner- approved procedures, forms and checklist. Each specific test to be performed shall be described and a space provided after it for signoff by the appropriate party after its satisfactory completion.

F. Copies of these signoff test procedures, forms and checklists will constitute the required test documentation.

G. Provide all special testing materials and equipment. Wherever possible, perform tests using actual process variables, equipment, and data. Where it is not practical to test with real process variables, equipment and data, provide suitable means of simulation. Define these simulations techniques in the test procedures.

H. The Contractor shall require the supplier to coordinate all of his/her testing with him, all affected Subcontractors and the Owner.

I. The Owner reserves the right to test or retest all specified functions whether or not explicitly stated in the prior approved Test Procedures.

J. The Owner's decision shall be final regarding the acceptability and completeness of all testing.

K. The supplier shall furnish the services of servicemen, all special calibration and test equipment and labor to perform the field tests.

3.05 CALIBRATION AND CALIBRATION TESTS

A. All instruments and systems shall be calibrated after installation, and checked in conformance with the component manufacturer's written instructions.

B. This shall provide that those components having adjustable features are set carefully for the specific conditions and applications of this installation, and that the components and/or systems are within the specified limits of accuracy. Defective elements which cannot achieve proper calibration or accuracy, either individually or within a system, shall be replaced. This calibration work and Calibration test shall be accomplished by the technical field representatives of the Single I&C Sub-Contractor who shall certify in writing to the Contractor that for each loop or system all calibrations have been made and that all instruments are ready to operate. Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:
    a. Project name.
    b. Loop number.
    c. Tag number.
    d. Manufacturer.
    e. Model number.
    f. Serial number.
    g. Calibration range.
    h. Calibration data: Input, output, and error at 10 percent, 50 percent and 90 percent of span.
    i. Switch setting, contact action, and deadband for discrete elements.
    j. Space for comments.
    k. Space for sign-off by Single I&C Sub-Contractor and date.
    l. Test equipment used and associated serial numbers.
    m. Calibration Manuals shall be supplied by the Contractor for each instrument in which calibration is necessary. The Contractor shall provide any special instruments required for calibration.

C. Proof of Conformance - The burden of proof of conformance to specified accuracy and performance is on the Contractor using its designated Single I&C Sub-Contractor. The Contractor's designer shall supply necessary test equipment and technical personnel if called upon to prove accuracy and/or performance, at no separate additional cost to the Owner, wherever reasonable doubt or evidence of malfunction or poor performance may appear within the guarantee period.

3.06 OPERATIONAL READINESS TESTS (ORT)

A. All test requirements listed in this section shall be tested by supplier prior the ORT to confirm that system is ready and fully functional. The supplier shall notify the Owner in writing that the system is ready for the ORT and allow the Owner to schedule a test date within 15 days of receipt of the "Ready to Test" letter. At the

time of notification, the system supplier shall submit any revisions to the detailed test procedure previously approved by the Owner in the project system plan. Also, submittal shall include I/O check list signed off by the supplier, instrument calibration sheets, all control strategies test procedure signed off as tested, and all other documentation confirming that system is completely tested and ready for ORT.

B. The purpose of the test shall be to verify the functionality, performance, and stability of the hardware and software. The system must operate continually for 100 hours without failure that causes complete loss of significant system function, such as responding to commands, before the test shall be judged successful. Successful completion of this test, as determined by the Owner, shall be the basis for approval of the system to continue to 30-day acceptance test.

C. The various tests performed during the Owner witnessed ORT shall be designed to demonstrate that hardware and software fulfill all the requirements of the Specifications. Any additional hardware or software that may be required to successfully verify system operation shall be supplied at no cost to the Owner.

D. Some of the test to be performed shall include but not be limited to the following:
   1. Building and loading the System Data Base.
   2. Conduct online modifications to the data base.
   3. Demonstrate operability of the interfaces (hardware and software).
   4. Demonstrate operability of the data communication network.
   5. Demonstrate all system software functions specified.
   6. Verify the displays and interactive capabilities of the operator's console.
   7. Simulate selected operating conditions to verify the performance of the monitoring and control functions.
   8. Generate reports using test data.

E. During the test for a period of time equal to at least 20 percent of the test duration, the Owner's representative shall have unrestricted access to the system.

F. All analog control panels shall be included in these tests.

G. All deficiencies identified during these tests shall be corrected and retested prior to completing of the Factory Demonstration Test as determined by the Owner.

H. The following documentation shall be made available to the Owner at the test site both before and during the Factory Demonstration Tests:
   1. All Drawings and Specifications, addenda and change orders.
   2. Master copy of the test procedure.
   3. List of the equipment to be tested including make, model and serial number.
   4. Design-related hardware submittal applicable to the equipment being tested.
   5. Preliminary software documentation submittal.

I. All test data and procedure followed during testing shall be logged, and certified copies of the logs shall be provided to the Owner.

J. Loop/Component Inspections and Tests: The entire system shall be checked for proper installation, calibrated and adjusted on a loop-by-loop and

component-by-component basis to ensure that it is in conformance with related submittals and these Specifications.

1. The Loop/Component Inspections and Tests shall be implemented using Owner-approved forms and checklists.
    a. Each loop shall have a Loop Status Report to organize and track its inspection, adjustment and calibration. These reports shall include the following information and check off items with spaces for signoff by the system supplier:
        1) Project Name.
        2) Loop Number.
        3) Tag Number for each component.
        4) Check offs/signoffs for each component:
            a) Tag/identification.
            b) Installation.
            c) Termination - wiring.
            d) Termination - tubing.
            e) Calibration/adjustment.
        5) Check offs/signoffs for the loop:
            a) Panel interface terminations.
            b) I/O interface terminations.
            c) I/O signal operation.
            d) Inputs/outputs operational: received/sent, processed, adjusted.
            e) Total loop operation.
        6) Space for comments.
    b. Each active Analog Subsystem element and each I/O module shall have a Component Calibration Sheet. These sheets shall have the following information, spaces for data entry and a space for signoff by the system supplier:
        1) Project Name.
        2) Loop Number.
        3) Component Tag Number of I/O Module Number.
        4) Component Code Number Analog System.
        5) Manufacturer (for Analog system element).
        6) Model Number/Serial Number (for Analog system).
        7) Summary of Functional Requirements. For example:
            a) For Indicators and Recorders: Scale and chart ranges
            b) For Transmitters/Converters: Scale and chart ranges
            c) For Computing Elements: Function
            d) For Controllers: Action (direct/reverse) control modes (PID)
            e) For Switching Elements: Unit range, differential (FIXED/ADJUSTABLE), reset (AUTO/MANUAL)
            f) For I/O Modules: Input or output
        8) Calibrations; for example:
            a) For Analog Devices: Required and actual inputs and outputs at 0, 25, 50, 75 and 100 percent of span, rising and falling.
            b) For Discrete Devices: Required and actual trip points and reset points.
            c) For Controllers: Mode settings (PID).
            d) For I/O Modules: Required and actual inputs or outputs for 0, 25, 50, 75 and 100 percent of span, rising and falling.

9) Space for comments.
10) Space for signoff by the system supplier.

2. The Contractor shall require the system supplier to maintain the Loop Status Reports and Components Calibration sheets at the jobsite and make them available to the Owner at any time.
3. These inspections and tests do not require witnessing. However, the Owner will review and initial all Loop Status Sheets and Component Calibration Sheets and spot-check their entries periodically and upon completion of the Operational Readiness Tests. Any deficiencies found shall be corrected.

3.07 TRAINING

A. The cost of training programs to be conducted with Owner's personnel shall be included in the Contract price. The training and instruction, insofar as practicable, shall be directly related to the systems being supplied.

B. The supplier shall provide detailed manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

C. The supplier shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to Owner.

D. The training program shall represent a comprehensive program covering all aspects of the operation, maintenance and cleaning procedures for the system.

E. All training schedules shall be coordinated with, and at the convenience of the Owner. Shift training may be required to correspond to the Owner's working schedule.

F. The Contractor shall provide training and instruction to thoroughly familiarize the Owner's operations and maintenance personnel with the use, maintenance, calibration, repair and replacement of all components of the control system. The training shall be scheduled concurrent with the calibration, equipment testing, process system testing, and start-up testing phases of the project.

G. Training shall be performed by qualified representatives of the Instrumentation Control and Monitoring System Integrator. Training shall be specifically tailored to this project and reflect the control system installation and configuration. All training shall be conducted at the job site, unless an alternate location is approved by the Owner. The following table summarizes the training hours required, which shall be provided at no additional cost to the Owner:

Onsite Training Class	Administrators, Screen Developers Class	Operators Class	Conducted By
Instrumentation Hardware	8 hrs	8 hrs	I&C Integrator

H. Each training class shall be not more than 8 hours in duration. Separate classes shall be conducted for the Owner's operation and maintenance personnel. Operator classes shall emphasize operational theory and use of the control system. Maintenance classes shall stress troubleshooting, repair, calibration, replacement, and other technical aspects of the control system.

I. Each of the training classes listed above for Operators shall be conducted twice during separate weeks to allow for scheduling of the Owner's personnel.

J. Training classes shall be scheduled a minimum of three (3) weeks in advance. Proposed training material, including a resume for each proposed instructor and a detailed class outline/lesson plan shall be submitted to the Owner at least 60 days in advance of when the training is scheduled to begin. The Owner and the Owner shall review the submitted data for suitability and provide comments and requested changes that shall be incorporated into the training plan.

K. Within 10 days of completion of each training class, the Contractor shall present to the Owner the following:
   1. A list of all Owner personnel attending the class.
   2. A copy of the text utilized during the class with all notes, diagrams, and comments.

3.08 SUPPLEMENTS

A. Supplements listed below, following "END OF SECTION" are parts of this Specification:
   1. Instrumentation Calibration Sheet.
   2. Loop Status Report.
   3. Functional Acceptance Test Sheet.

END OF SECTION

LOOP STATUS REPORT

PROJECT NAME:_____
PROJECT NO.:_____

FUNCTIONAL REQUIREMENTS

			COMPONENT	**STATUS**		
TAG NO.	DELIVERED *	TAG/IDENTIFI-CATION CHECK*	INSTALLATION CHECK	TERMINATION WIRING*	TERMINATION TUBING*	CALIBRATED*
REMARKS				LOOP READY FOR START-UP BY DATE		

* INITIAL AND DATE WHEN COMPLETE

FUNCTIONAL ACCEPTANCE TEST SHEET

PROJECT NAME: _____
PROJECT NO: _____

FUNCTIONAL REQUIREMENTS AND SUMMARY OF COMPONENTS: (ATTACH XEROX OF LOOP SPECIFICATION FROM THE CONTRACT DOCUMENTS)
VERIFICATION OF LOOP STATUS REPORT AND BY:_____ INSTRUMENT AND VALVE CALIBRATION SHEETS DATE:_____
DEMONSTRATION TEST(S): FOR EACH FUNCTIONAL REQUIREMENT OF THE LOOP: REQUIRED PERFORMANCE (a) LIST AND NUMBER THE REQUIREMENT (c) CITE THE RESULTS THAT WILL VERIFY THE (b) BRIEFLY DESCRIBE THE DEMONSTRATION (d) PROVIDE SPACES FOR INITIAL AND DATE OF TEST TEST WITNESS.

PERFORMED BY: WITNESSED BY: COMPLETED DATE:	LOOP ACCEPTED BY (OWNER) BY DATE
CHECK IF REMARKS ON REVERSE SIDE	LOOP NO.

SECTION 17301

CONTROL SYSTEM HARDWARE

PART 1 GENERAL

1.01 REQUIREMENTS

A. The Instrumentation and Control Systems Integrator (Integrator) shall furnish all labor, materials, equipment, services and incidentals required to install and place into operation a digital PLC and computer-based plant control and monitoring system configured as shown on the Contract Drawings, and as described in the specifications.

B. All digital system hardware equipment, materials and appurtenances shall be supplied in accordance with the requirements in this specification.

C. The Integrator shall be responsible for providing accessory devices including furnishing and installation of interposing relays, control switches and signal converters necessary to perform the intent as shown on the drawings and described in the control strategies, and services necessary to achieve a fully integrated and operational system as shown on the Contract Drawings and Specifications.

D. The Integrator shall furnish and install all cabling and cable accessories, including tools necessary for connecting the host computer network and peripherals, Programmable Logic Controller, remote input/output devices.

E. The Integrator shall also furnish the services of an authorized PLC Manufacturer startup/service representative and training representative for startup assistance and system checkout services.

1.02 SCADA SYSTEM GENERAL REQUIREMENTS

A. Modify existing control panels Caustic RIO (HCL Control Panel) , PLC-2_CP Control Panel and PLC-3_CP Control Panel to accommodate all the new signals per P&ID drawings and additional 20 percent spares. Contractor shall provide modification including adding additional I/O cards in the existing racks if needed, configuration, termination, I/O mapping, scaling, etc. for a complete and working PLC system. New I/O cards shall match existing type and number of I/O points.

1.03 RELATED WORK

A. The supplier shall furnish all materials, labor and services specified in the following Specification sections as required ensuring a single, coordinated system is supplied:
   1. Section 17300 - Instrumentation Control and Monitoring System - General Provisions.
   2. Section 17303 - Software Programming and Control Strategies.
   3. Section 17304 - Instrumentation

B. The Supplier shall in particular coordinate his work with the work under the following:
   1. Division 0 - Bidding and Contract Requirements.
   2. Division 1 - General Requirements.
   3. Division 16 - Electrical.

1.04 SUBMITTAL REQUIREMENTS

A. Refer to Section 17300 - Instrumentation Control and Monitoring System - General Provisions.

1.05 DIGITAL HARDWARE CONFIGURATION

A. All discrete and analog data acquisition, pre-processing, storage and process control functions shall be performed at the PLC level. Operator workstations and touch screen HMIs, if any, shall be fully independent devices that individually connect to the Ethernet local area network.

1.06 SPARE PARTS

A. The following expendable products shall be provided:
   1. Items with limited shelf-life shall be provided over the year as needed.
   2. One (1) year supply of items recommended by the Manufacturer of the equipment for each component.

PART 2 PRODUCTS

2.01 GENERAL SYSTEM HARDWARE REQUIREMENTS

A. Large scale integrated (LSI) circuit construction shall be employed unless otherwise specified.

B. Modular construction shall be employed to simplify maintenance and to provide for future hardware expansion. Plug-in, modular PCBs or modules shall be employed for easy removal to permit exposure of circuit wiring, components and test points. Extender boards shall be provided if necessary to permit PCBs to be completely exposed for testing purposes.

C. Keying schemes shall be used to prevent PCB misplacement.

D. Each process control system local area network connected device shall continuously perform on-line diagnostics and failure reporting to the operator workstations.

E. The temperature inside each enclosure containing digital hardware (i.e., cabinet, panel or console) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature.

2.02 DIGITAL SYSTEM FAILURE DETECTION AND FAIL-OVER REQUIREMENTS

A. No degradation in control system performance shall occur when the system is operating in a partial failure or an equipment fail-over mode. Likewise, no degradation of system performance shall occur while a backed up system component is undergoing preventive or corrective maintenance.

B. All devices connected to the local area network shall be self-checking and shall report their operational status to the operator workstations as whether "normal" or "failed".

2.03 SYSTEM ARCHITECTURE

A. The Plant control and SCADA systems specified shall be designed to collect and store accurate, reliable operating information for present and future uses; perform efficient process control; assist Plant operating personnel by noting and announcing off-normal operating conditions and equipment failures; perform calculations based on sensor and manually entered inputs; provide displays and summary reports for use by Plant operating and supervisory personnel.

B. The Plant control and SCADA system shall be capable of supporting 25 percent spare I/O points without the need for additional base hardware or software modification other than configuring the database for the new points.

2.04 COMMUNICATIONS

A. The system shall monitor message transfers for errors and provide counters to show link performance. Counters shall be maintained for block check errors, Longitudinal Redundancy Check (LRC) errors, parity errors, missed bytes, frames received, and security disconnects. Alarms shall be provided to alert Plant personnel of communication link problems.

2.05 PROGRAMMABLE LOGIC CONTROLLER AND I/O MODULES

A. Control and data acquisition associated with the Plant equipment shall be performed by a Programmable Logic Controller (PLC). Each PLC shall consist of a primary central processing unit (CPU), power supply, Ethernet interface module, Input/Output (I/O) chassis with I/O modules, and a bus controller. All components of the PLC system, except for the programming unit, shall be standard products of a single manufacturer. Third-party components shall not be permitted. The programmable controller shall be Allen Bradly CompactLogix series 1769-L36ERM.

B. Process input and output modules:
   1. The control system shall be capable of handling the required number of process inputs and outputs as indicated on the P&I drawings, including an additional 25 percent active spares, plus capacity to accommodate 25 percent future inputs and outputs by the addition of I/O cards. Process interface units shall be provided with screw-type terminal blocks with barriers between adjacent terminals for connection of field inputs. Terminals shall be suitable for accepting up to and including No. 14 AWG wire. All terminals shall be provided with unique identification in accordance with approved shop drawing loop interconnection diagrams. I/O cards (modules) shall be plug in type into a support chassis that also contains a power supply. The requirements for each type of module are:
      a. Switch contact input modules. Switch contact input modules shall be capable of supporting dry contact inputs (minimum duration 100 ms). The PLC shall provide at least 24V D.C. wetting power to the field contacts. The wetting power shall be isolated from the PLC internal power. The module inputs shall be optically isolated from the PLC and designed to withstand transients and surges without damage. Input components shall be individually protected to ensure that failure within one component will not interrupt processing of others. Input circuits shall be protected up to 175 VAC RMS fault. Light emitting diodes, (LEDs), one adjacent to each pair of input terminals, shall be provided to indicate a closed contact condition. Digital Input module shall be Allen Bradley 1769-IA16.
      b. Analog input modules. Analog input modules shall accept 4-20 mA DC inputs from field mounted transmitters. Common mode input protection of 30 VDC minimum shall be provided. Input signal A/D conversion shall be a minimum of 12-bits, with an accuracy of one bit. Isolated DC power for field transmitters shall be provided as required. Analog input modules shall be Allen Bradley 1756-IF4I Differential Mode wiring.
      c. Switch Contact Output Modules. Switch contact output modules shall be capable of providing dry-contacts in either momentary (pulsed), or latched (sustained) mode to control AC or DC powered loads. All DC output circuits shall incorporate current limiting and, for DC powered loads, switching spike suppression diodes. Contact outputs shall be rated to 5 amps at 120 VAC minimum. The output failure mode shall be selectable so that upon station or communication system failure all outputs would be placed in the non-conducting mode, or remain as they were prior to failure. Isolation resistance shall be 1,000 ohms minimum at 300 VDC between any set of field terminals and any other set or earth ground. Isolation voltage shall be 500 VAC RMS minimum between any set of field terminals and any other set or earth ground. Light-emitting diode status indication shall be provided adjacent to each contact output to indicate a closed contact condition. The digital output module shall be Allen Bradley 1769-OW16I.

d. Analog Output Modules. Analog output modules shall provide isolated 4-20 mA dc signals to adjust setpoints of local process control stations, pump speed, valve positions, etc. Output load drive capability shall be 750 ohms minimum for each output. There shall be separate D/A conversion circuits for each output which shall convert 12-bit data words into output signals with an accuracy of +/- 1 bit over the full scale output span. Response to station or communication system failure shall be selectable such that upon failure the output would either remain at the last value, or go to zero (4mA), as required by the process. Analog output modules shall be Allen Bradley 1769-OF4CI.
e. Provide the following chassis mounted communication modules as indicated on Drawings:
f. Ethernet/IP communications interface module Allen Bradley 1769-AENTR.
g. Each I/O chassis shall be properly sized to accommodate enough I/O modules with power supply, and required I/O modules.
h. All I/O shall be wired to terminal blocks.

2.06 SURGE PROTECTIVE DEVICE (SPD) PROTECTION

A. General:
1. SPD protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and be maintenance free and self-restoring.
2. Instruments shall be housed in a suitable case, properly grounded. Ground wires for all SPDs shall be connected to a good earth ground and where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the instrument enclosure or a separate NEMA 4X junction box coupled to the enclosure.

B. Power Supply:
1. Protection of all 120 VAC instrument power supply lines shall be provided. Control panels shall be protected by line noise suppressing isolation transformers and SPDs. Field instruments shall be protected by SPDs. For control panels, the line noise suppressing isolation transformer shall be Topaz Series 30 Ultra isolators or approved equal. The suppressor shall be CITEL DS72RS-120.

C. Analog Signals:
1. Protection of analog signal lines originating and terminating not in the same building shall be provided by SPDs. For analog signal lines the SPDs shall be Critec UTB-30-DP. For field mounted two-wire instruments the SPDs shall be encapsulated in stainless steel pipe nipples, and shall be Edco SS64 series.
2. For field mounted four-wire 120VAC instruments, the SPDs shall be in a NEMA 4X polycarbonate enclosure, Critec UTB-110-DP.

2.07 TUBING AND FITTINGS

A. All instrument air header takeoffs and branch connections less than 2-in shall be 316 stainless steel.

B. All instrument shut-off valves and associated fittings shall be supplied in accordance with the piping specifications and all instrument installation details. Fittings shall be Swagelok 316 stainless steel or equal and valves shall be Whitney 316 stainless steel or equal.

C. All instrument tubing shall be fully annealed ASTM A269 Seamless 316 grade free of OD scratches having the following dimensional characteristics as required to fit the specific installation:
   1. 1/4-in to 1/2-in O.D. by 0.035 wall thickness.
   2. 5/8-in to 1-in O.D. by 0.049 wall thickness.
   3. 1-in O.D. by 0.065 wall thickness.
   4. 1-1/4-in O.D. by 0.065 wall thickness.
   5. 1-1/2-in O.D. by 0.083 wall thickness.
   6. 2-in O.D. by 0.95 wall thickness.

D. All process connections to instruments shall be annealed 1/2-in O.D. stainless steel tubing, Type 316.

E. All tube track shall be supported by stainless steel and installed as per manufacturer's installation instructions.

2.08 CONTROL PANELS, ENCLOSURES AND CABINETS

A. The following Paragraphs describe general fabrication requirements of control panels, enclosures, consoles and cabinets.

B. Wiring:
   1. All interconnecting wiring, except for electronic circuits, shall have 600 volt insulation and rated for not less than 90 degrees C.
   2. Power distribution wiring on the line side of fuses shall be 12 AWG minimum. Control wiring on the secondary side of fuses shall be 14 AWG minimum. Electronic analog circuits shall utilize 16 AWG shielded, twister pair, cable insulated for not less than 300 volts.
   3. Power and low voltage dc wiring systems shall be routed in separate wireways. Crossing of different system wires shall be at right angles. Different system wires routed parallel to each other shall be separated by at least 12-in. Different wiring systems shall terminate on separate terminal blocks. Wiring troughs shall not be filled to more than 60 percent visible fill.
   4. All wiring shall terminate in a master terminal board, rigid type and numbered. The master terminal board shall have a minimum of 25 percent spares. Terminal blocks shall be arranged in vertical rows and separated into groups. (Power, AC control, DC signal, alarm, and graphic). Terminal blocks shall be barrier type with the appropriate voltage rating (600 volts minimum). They shall be the raised channel mounted type. Wire connectors shall be the hook fork type with non-insulated barrel for crimp type compression connection to the wire. Wire and tube markers shall be the sleeve type with heat impressed letters and numbers. Direct interlock wiring between equipment will not be allowed. Only one side of a terminal block row shall be used for internal wiring. The field wiring side of the terminal shall not be within 6-in of the side panel or adjacent terminal.

5. All wiring to hand switches and the like which are live circuits independent of the panel's normal circuit breaker protection shall be clearly identified as such.
6. All wiring shall be clearly tagged and color coded. All tag numbers and color coding shall correspond to the panel wiring diagrams and loop drawings. All power wiring, control wiring, grounding and dc wiring shall utilize different color insulation for each wiring system used.
7. Each control loop or system shall be individually protected by fuses or breakers. All protecting devices shall be clearly labeled and located for ease of maintenance.
8. Provide surge protectors on all incoming power supply lines at each panel.
9. Plug strips with grounding type receptacles shall be provided for 120 V AC power supply connections. Each piece of equipment requiring AC power shall be provided with an NFPA No. 70 Type SJ cord with molded-on grounding type plug for AC power connection. Internal fans, receptacles, or lights shall be wired on separate circuits to control, logic, or instruments.

C. Wire Tagging:
1. General: Wiring shall be tagged at terminations with machine printed plastic sleeves. Wire marker sleeve (tag) materials for all power, control, and signal wires shall be as follows:
2. Signal Wires: The wire marker shall not be heat shrunk until the outer jacket and foil shield are cut back so that the marker shall also serve to insulate the end of the foil shield from ground. An additional identical marker shall be heat shrunk at the ends of the cable to identify the cable between pulling and termination.
3. All Others: Markers for cables and wire 0.450 inch and smaller in diameter shall be white, heat shrinkable, flame retarded sleeves. Markers for cables and wire larger than 0.450 inch in diameter shall be flame retarded wrap around white film with a dual adhesive system which is heat set. The letters and numbers that identify each cable or wire shall be machine printed with 1/8-inch high characters on sleeves with permanent black inch. Sleeves shall be sized to fit the conductor insulation and shrunk to fit the conductor with hot air after installation. The lettering on the wire marker shall face the viewer and be positioned to be read without twisting the wire. The wire markers shall be heat shrunk irradiated polyolefin, conforming to UL 224. The wire marking system shall be Brady Permasleeve and Brady PS-PTR-II Printer, or equal.

D. Wire Colors:
1. Power and Control: Power and control conductors in panels shall have the following insulation colors:

Code	120V AC wire	Panels
L	Power	Black
C	Control	Red
N	Neutral	White
PG	Ground	Green

2. Signal: Signal conductors in panels shall have the following insulation colors:

Code	24V AC wire	Color
SP	Power Supply	Black
S	Signal (pos)	Black
SG	Signal group	White
PG	Equipment ground	Green

E. Terminals and Fuses:

1. Terminal Blocks: Unless otherwise shown or specified, terminal blocks shall be captive screw with pressure plate, DIN EN 50035 rail 600-volt rating. Terminal blocks shall be as specified in the following table:

120V AC Power and Controls		
Description	**Type**	**Application**
Fuse terminal block/blown fuse LED indicator	Phoenix UK6-HESI or equal	Power Supply for Field Panels
Terminal Block	Phoenix UK10, or equal 2.05 E.1.	Neutral & Control Wiring
Grounding Terminal Block	Phoenix USLKG4, or equal	Equip. Grounding Conductor
Disconnect Terminal Block	Phoenix UK4-TP/P, or equal	Foreign Circuit Disconnect
Double Level High Density Terminal Block	Phoenix UKKB3, or equal	Neutral & Control Wiring

24V DC (and other voltage) Signals		
Description	**Type**	**Application**
Disconnect Terminal Block Loop w/Test Sockets	Phoenix UK4-T-P/P, or equal	4-20 mA Current (supply side)
Terminal Block w/Test Sockets	Phoenix UK5 w/PSB 3/10/4 Test Plug Socket, or equal	1-5V DC Analog Signals
Terminal Block	Phoenix UK5, or equal	4-20 mA Current Loop (return side) Shield Drains 24V DC Signal
Terminal Block	Phoenix MBK, or equal	Splicing Cables where space is limited
Double Level High Density Terminal Block	Phoenix UKKB3, or equal	24V DC Signal
Terminal Markers and Terminal Marking Card	Phoenix SBS5, or equal	All Terminal Blocks except MBK

2. Terminal Tags Covers and Markers: Each terminal strip shall have a unique identifying alphanumeric code at one end and a plastic marking strip running the entire length with a unique number for each terminal. Numbers shall be machine printed and 1/8 inch high. Terminal blocks carrying power circuits shall be provided with a transparent, hinged cover for personnel protection and accessibility.
3. Fuses: Fuses shall be 1/4 x 1-1/4-inch. Fuses on 120V AC circuits shall be ceramic tube type with 25,000 amperes interrupting capacity at 125 volts and neon blown fuse indicator lamps. Fuses for 24V DC circuits shall be fast acting glass tube type rated 1/8 or 1/10 amp for 4-20 Ma loops and 3 amps for the power supply to individual instruments. Fuse holders for 120 V AC shall be drawout type and molded from melamine plastic.

F. Equipment Mounting/Arrangement:
1. All components shall be mounted in a manner that shall permit servicing, adjustment, testing and removal without disconnecting, moving or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Components mounting shall be oriented in accordance with the internal components shall be identified with suitable plastic or metal engraved tags attached with drive pins adjacent to (not on) each component identifying the component in accordance with the drawing, specifications and supplier's data.
2. All exterior panel mounted equipment shall be installed with suitable gaskets, faceplates, etc, required to maintain the NEMA rating of the panel.

G. Nameplates: Furnish in accordance with Section 17300 - Instrumentation Control and Monitoring System - General Provisions Article 2.03 Paragraph A.

H. Painting: all sections shall be de-scaled, degreased, filled, ground and finished. The enclosure when fabricated of steel shall be finished with two rust resistant phosphate prime coats and two coats of enamel, polyurethane, or lacquer finish which shall be applied by either the hot air spray or conventional cold spray methods. Brushed anodized aluminum, stainless steel and FRP panels will not require a paint finish. Interior metal surfaces shall be prepared, prime and finish coated in accordance with manufacturer’s recommendations and shall be Fed. Std. Color 27722, white.

I. Freestanding Vertical Panels or Computer Consoles
   1. Freestanding vertical panels and computer consoles in air conditioned environments and shall be of NEMA 12 construction and be labeled by underwriters laboratories. The panels shall be constructed of 11 gauge thick sheet steel, suitably braced internally for structural rigidity and strength. All exposed welds, seams, or edges shall be ground smooth. Front panels or panels containing instruments shall be not less than 7 gauge thick stretcher leveled sheet steel, reinforced to prevent warping or distortion. Where face-mounted instruments are specified, they shall be mounted on an interior hinged sub-panel arranged to swing completely out of the enclosure. Face-mounted instruments that are more than 6 inches deep, weigh more than 10 pounds, or exert more than 4 ft-lbs. pounds moment force on the face of the panel shall be rigidly supported at the rear of the instrument.
   2. All outdoor panels shall be NEMA 4x 316-stainless steel and be provided with sunshields. Outdoor panels shall face north to the greatest extent possible. All outdoor panels that are in direct sunlight shall be stainless steel finished or painted in white.
   3. Panels shall be provided with full length rear doors or front access doors as shown on the panel details. Full length rear access door shall be not greater than 24-in in width. Front access doors with mounted instruments or control devices shall be of sufficient width to permit door opening without interference from flush mounted instruments. All doors shall be mounted with strong, continuous, piano type hinges and be provided with lockable door handles and three point latches.
   4. Approximate size and equipment layout is shown on the panel details.
   5. Provide overhead switched lighting and at least one convenience receptacle in each panel.
   6. The panel shall be suitable for top or bottom conduit entry as required by the Electrical Drawings. For top mounted conduit entry the panel top shall be provided with nominal one foot square removable access plates which may be drilled to accommodate conduit and cable penetrations. All conduit and cable penetrations shall be provided with ground bushings, hubs, gasketed locknuts, or other accessories as required to maintain the NEMA rating of the panel and electrical rating of the conduit system.
   7. All panel enclosures shall be as manufactured by Hoffman, or equal.

J. Wall or Unistrut Mounted Cabinets:
   1. Unless noted otherwise on the Contract Drawings, all indoor wall or unistrut mounted panels in air conditioned areas shall be minimum of NEMA 12 and fabricated of not less than USS 14 gauge steel. All wall or unistrut mounted panels installed outdoors, and indoor panels in rooms below grade, non-air conditioned, damp, wet or corrosive areas shall have a NEMA 4X rating shall be constructed of 316-stainless steel, unless FRP is specifically indicated to be provided. Any FRP panels located in direct sunlight shall be provided with a protective coating to prevent discoloration flaking and cracking.
   2. All panel enclosures shall be as manufactured by Hoffman, or equal.

K. Cabinet Cooling:
   1. Where required by the contract documents, control panels shall have sufficient cooling and/or ventilation not to limit the interior temperature to 80 degrees F in a 120-degree F environment. Outdoor control panels with electronic equipment shall be furnished with sun shields around and on top of the control panels. Furnish panel enclosure with an air-to-air heat exchanger: Noren Compact Cabinet Cooler model CC2500FP, SC, SS, W with corrosion resistant core, stainless steel enclosure, and wash down rated fans, sized appropriately to dissipate expected internal and ambient heat loads. The electronic equipment shall be installed in the panel with sufficient cooling space such that the Control System will work without air conditioning at 95 degrees ambient at 90 percent humidity.

L. Panel Grounding:
   1. Cabinet shall be provided with two copper ground bars. One bar shall be bonded to the panel frame or sheet metal and to the building ground system. The second (signal) ground bar shall be mounted on insulated stand-offs and shall be bonded to the frame ground bar at one point only. Signal circuits, signal cable shields, and low-voltage DC power supply commons shall be bonded to the signal ground bar. UPS, 24V DC power supply, and isolation transformer shall be bonded to the frame ground bar. In cabinets exceeding 30 inches in width, ground bars shall be ¼-by 1-inch copper bars extending the entire length.

M. Panel Coating:
   1. Exterior surfaces shall be prepared, primed and finish coated with manufacturer's standard finish. Panel color shall be paint in White or stainless steel finish. Interior metal surfaces shall be prepared, prime and finish coated in accordance with manufacturer's recommendations and shall be Fed. Std. Color 27722, white.

N. Wiring Duct:
   1. Plastic wiring duct shall be slotted type with dust cover, Panduit Type E or NE, as required.

2.09 HMI TOUCH PANEL

A. As indicated on the drawings the panel shall be a Panel View Plus 1250 2711P-T6C20D, or equal.
   1. The OIT or Panel HMI, an electronic graphical interface, shall provide a display of data I/O points monitored and controlled by the processor in the panel.
   2. A standard flow control facility OIT/HMI panel shall connect by Ethernet to the communication system on a VPN to the control system in the District's operations control center and also to the PLC it monitors via the router.
      a. Include one populated CF port, one USB version 2.0 port, one nine pin RS-232 port, and one 10/100 RJ-45 Ethernet port.

2.10 SYSTEM COMPONENTS

A. Y58 Ethernet Fiber-to-Copper Transceiver:
   1. Function: Convert fiber optic Ethernet signal (100 Base-FX) to copper signal (10/100 Base-TX).
   2. Features:
      a. Fiber Optic Connectors: Coordinate.
      b. Copper Connector: RJ45.
      c. Power: 10 to 30V dc.
      d. Mounting: DIN-rail.
   3. Performance:
      a. IEEE Compliance: Full 802.3.
      b. EMI Emissions and Safety: FCC Part 15A, UL 1604, Class 1, Division 2, Groups B, C, D.
   4. Manufacturer and Product:
      a. N-TRON.
      b. BlackBox.
      c. Or equal.

B. Y81A Network Switch, Ethernet:
   1. Full compliance with IEEE 802.3.
   2. Supports Ethernet (10BASE-TX), Fast Ethernet (100BASE-TX/FX) and Gigabit Ethernet (1000BASE-TX/FX) networking technologies.
   3. Wire-speed switching fabric.
   4. Ports:
      a. 10/100/1000 Base TX: Quantity as shown on block diagram plus 3 spare.
         1) RJ 45 sockets.
         2) Auto crossing.
         3) Auto negotiating.
         4) Auto polarity.
         5) Full duplex capable.
      b. 1000 Base FX: Two, minimum.
         1) SC sockets.
         2) Multimode cable.
            a) Compatible with 50/125 micron and 62.5/125 micron fibers.
         3) Full duplex capable.
         4) 8 dB link budget at 1,300 nm.
   5. Network Topology:
      a. Star.
      b. Ring with HIPER-Ring.
      c. RSTP.
   6. Management: Serial interface, web interface, SNMP v1, v2, v3.
   7. Diagnostics:
      a. LEDs (Power, Link Status, Data, Fault, redundancy manager).
      b. RMON (statistics, history, alarms, events).
      c. Port mirroring.
      d. Topology detection 802.1ab.
   8. Configuration: Terminal software, BootP, DHCP, DHCP Option 82.
   9. Security:
      a. Port security (MAC based and IP based).
      b. SNMP V3.

10. Other Services:
    a. Port prioritization (IEEE 802.1D/p).
    b. VLAN (802.1Q).
    c. Multicast (IGMP Snooping/Queier, GMRP).
    d. Broadcast limiter.
    e. Flow Control (IEEE 802.3x SNTP).
11. Redundancy:
    a. HIPER-Ring (ring structure).
    b. RSTP.
    c. Redundant net/ring coupling.
    d. Dual Homing.
    e. Redundant 24-volt power supply.
12. Power:
    a. Panel mount: 24V dc, 375 ma max.
    b. Rack mount: 120V AC.
13. Operating Temperature: 0 to 60 degrees C.
14. IEC 60068-2-27 Shock: 15g, 11 ms duration, 18 shocks.
15. IEC 60068-2-6 Vibration:
    a. 1 mm, 2 to 13.2-Hz, 90 minutes.
    b. 0.7g, 13.2 to 100-Hz, 90 minutes.
    c. 3.5 mm, 3 to 9-Hz, 10 cycles, 1 octave/minute.
    d. 1g, 9 to 150-Hz, 10 cycles, 1 octave/minute.
16. Approvals: cUL 508 (E175531), cUL 1604 Class I Div 2 (E203960), cUL 60950 (E168643).
17. Spares: Provide a spare switch that is identical to provided one.
18. Manufacturer, model:
    a. Panel mount: Allen Bradley Stratix or N-Tron – Managed or Lightly Managed with CIP/ENIP support. Provide minimum 8 RJ45 ports and Fiber ports as need..
    b. All switches to be same revision

C. Y41 Uninterruptible Power Supply System, Tower:
1. General:
    a. Function: Provides backup power and power regulation for workstations and peripherals.
2. Performance:
    a. Capacity: 1.4 kVa, minimum.
    b. Input Power:
        1) 120V ac single phase, 60-Hz, unless otherwise noted.
        2) Connections: Manufacturer’s standard, unless otherwise noted.
    c. Output Power:
        1) 120 V ac single-phase, 60-Hz, unless otherwise noted.
        2) Connections: Manufacturer’s standard, unless otherwise noted.
    d. Backup Runtime:
        1) Full Load: 10 minutes, minimum.
3. Features:
    a. Topology: Line-Interactive.
    b. Transfer Time: 6 ms, maximum.
    c. Diagnostics: Full system self-test on power up.
    d. Communication Port: USB and serial port, minimum.
    e. UL Listed.

f. Warranty: 2 years.
g. Surge Suppression: Manufacturer Standard.

4. Accessories:
   a. Software: Manufacturer standard software.
   b. Provide power cables as required.
5. Manufacturer and Model:
   a. Panel Mounted: SOLA-HD SDU with A Series COMM Card or equivalent.
   b. All others: Eaton 5P 1500 Tower.

2.11 MISCELLANEOUS PANEL COMPONENTS

A. Pilot Type Indicating Lights:
   1. Type:
      a. Heavy duty oil tight type which utilizes LED style lamps, minimum 22 mm.
   2. Functional/Performance:
      a. Lights supplied with 120V AC power shall have integral reduced voltage transformers if necessary.
      b. Lamps shall be replaceable from the front of the unit.
      c. Lights shall be push to test type.
   3. Physical:
      a. LED color shall be as indicated on the instrument device schedule.
      b. Provide legend faceplates engraved to indicate the required function of each device.
      c. Units shall be rated NEMA 13 for indoor panels. Units located outdoors or indicated to be weatherproof shall be rated NEMA 4X.
   4. Manufacturers:
      a. Microswitch.
      b. Allen Bradley.
      c. General Electric.

B. Rotary Hand Switches and Pushbuttons:
   1. Type:
      a. Control devices shall be heavy duty oil tight type with stackable contact blocks.
   2. Functional/Performance:
      a. Provide contact arrangement and switching action as required for the control system specified.
   3. Physical:
      a. For 120V AC service provide contacts rated 10 amps at 120V AC, for 24V DC service provide silver sliding contacts rated 5 amps at 125V DC, for electronic (millivolt/ milliamp) switching provide contacts rated lamp at 28V DC.
      b. Pushbuttons shall have flush type operators. Selector switches shall have knob or wing lever operators.
      c. Units shall be rated NEMA Type 13 for indoor service. Units located outdoors or indicated to be weatherproof shall be rated NEMA 4X.
      d. Provide legend plates denoting switch/pushbutton position/ function.
   4. Options/Accessories Required:
      a. Provide lock-out-pushbuttons, key-operators, etc., as indicated on the instrument device schedule.
      b. Provide make-before-break bridging contacts where required.

5. Manufacturers:
    a. Square D.
    b. Allen Bradley.
    c. General Electric.

C. Square Type Selector Switches and Multi-light Indicators
    1. Type:
        a. Selector switches and indicators shall be of the illuminated, multiple lamp, oiltight type with square shape display windows and removable contact blocks.
    2. Functional/Performance:
        a. Provide contact arrangement as required for the control system specified.
    3. Physical:
        a. For 120V AC service provide contacts rated 10 amps at 120V AC, for 24V DC circuits provide silver sliding contacts rated 5 amps at 125V DC, for electronic (Millivolt/ Milliamp) switching duty provide gold plated sliding contacts rated lamp at 28V DC.
        b. Units shall be approximately 2-1/2-in square and shall be divided into as many as four separate lightable quadrants.
        c. Indicating lights used with 120 volt control power shall be provided with an integral transformer to reduce the voltage.
        d. Provide legend plates, color inserts and cover plates to indicate the required function.
    4. Manufacturers:
        a. Microswitch type CMC.

D. Potentiometers:
    1. Type:
        a. Potentiometers shall be of the heavy duty type.
    2. Functional/Performance:
        a. Potentiometers shall be of the three wire type with a total resistance of 1000 ohms. Units shall be rated 2 watts. Linearity shall be plus or minus 5 percent.
    3. Physical:
        a. Units shall be rated NEMA 13 or NEMA 4 for indoor panels. Units used on outdoor panels or indicated as weatherproof shall be rated NEMA 4X.
        b. Provide a legend plate with resolution of one percent of entire span of potentiometer.
    4. Manufacturers:
        a. Allen Bradley.
        b. Micro Switch.
        c. General Electric.

E. Industrial Relays and Time Delays:
    1. Type:
        a. Industrial heavy duty relays.
    2. Functional/Performance:
        a. Contact arrangement/function shall be as required to meet the specified control function specified.
        b. Contacts shall be rated 10 amps continuous at 600 volts.

c. Relays shall be provided with convertible contact blocks.
d. Solid-state time delay relays shall be used for all time delays and shall be adjustable.

3. Options/Accessories Required:
   a. Provide all mounting rails, etc, that are required.
4. Manufacturers:
   a. Square D.
   b. Allen Bradley.

F. General Purpose Relays and Time Delays:
1. Type:
   a. Units shall be of the general purpose plug-in type.
2. Functional/Performance:
   a. Coil voltage shall match supply voltage.
   b. Contact arrangement/function shall be as required to meet the specified control function.
   c. Mechanical life expectancy shall be in excess of 10 million.
   d. Duty cycle shall be rated for continuous operation.
   e. Units shall be provided with integral indicating light to indicate if relay is energized.
   f. Solid state time delays shall be provided with polarity protection (DC units) and transient protection.
   g. Time delay units shall be adjustable and available in ranges from .1 second to 4.5 hours.
3. Physical:
   a. For 120V AC service provide contacts rated 10 amps at 120V AC, for 24V DC service provide contacts rated 5 amps at 28V DC, for electronic (milliamp/millivolt) switching applicator provide gold plated contacts rated for electronic service.
   b. Relays shall be provided with dust and moisture resistant covers.
4. Options/Accessories Required:
   a. Provide mounting sockets with pressure type terminal blocks rated 300 volt and 10 amps.
   b. Provide relays with manual test push button and indicating light when energized.
   c. Provide mounting rails/holders as required.
5. Manufacturers:
   a. Eagle signal controls.
   b. Allen Bradley.
   c. Potter & Brumfield.

G. Signal Relay Switches (Current Trips):
1. Type:
   a. Solid state electronic type.
2. Functional/Performance:
   a. Input - 4-20 mA
   b. Output - Isolated contact output, double pole double throw, rated 5 amps at 120V AC.
   c. Accuracy - 0.1 percent.
   d. Protection - Provide RFI protection.
   e. Deadband - Adjustable between 0.1 and 5.0 percent of span.

f. Setpoint Adjustment - Provide graduated dial for each alarm setpoint from 0 to full scale. Alarms shall be adjustable to trip on rising or falling input signal.
g. Repeatability - Trip point repeatability shall be at least 0.1 percent of span.

3. Physical:
   a. Mounting - Suitable for mounting in an enclosure or high density instrument rack.
4. Options/Accessories Required:
   a. Mounting rack or general purpose enclosure as required.
5. Manufacturers:
   a. Rochester Instrument Systems.
   b. Acromag Inc.
   c. Moore Industries.

H. Signal Isolators/Boosters/Converters:
1. Type:
   a. Solid state electronic type.
2. Functional/Performance:
   a. Accuracy - 0.15 percent.
   b. Inputs - Current, voltage, frequency, temperature, or resistance as required.
   c. Outputs - Current or voltage as required.
   d. Isolation - There shall be complete isolation between input Circuitry, output circuitry, and the power supply.
   e. Adjustments - Zero and span adjustment shall be provided.
   f. Protection - Provide RFI protection.
3. Physical:
   a. Mounting - Suitable for mounting in an enclosure or instrument rack.
4. Options/Accessories Required:
   a. Mounting rack or general purpose enclosure as required.
5. Manufacturers:
   a. Rochester Instrument Systems.
   b. Acromag Inc.
   c. Moore Industries.

I. Signal Selectors, Computation, and Conditioning Relays:
1. Type:
   a. Solid state electronic type.
2. Functional/Performance:
   a. Inputs - 4-20 mA.
   b. Outputs - 4-20 mA.
   c. Protection - Provide RFI protection.
   d. Operation - The relay shall multiply, add, subtract, select, extract the square root, or perform the specified conditioning/computation function required. All inputs shall be able to be individually rescaled and biased as required.
   e. Isolation - All inputs, outputs, and power supplies shall be completely isolated.
   f. Accuracy - 0.35 percent of span.
   g. Adjustments - Multiturn potentiometer for zero, span, scaling, and biasing.

3. Physical:
    a. Mounting - Suitable for mounting in an enclosure or instrument rack.
4. Options/Accessories Required:
    a. Mounting rack or general purpose enclosure as required.
5. Manufacturers:
    a. Rochester Instrument Systems.
    b. Acromag Inc.
    c. Moore Industries.

J. Intrinsically Safe Relays:
1. Type:
    a. Relays shall be of the solid state electronic type in which the energy level of the sensing or actuation circuit is low enough to allow safe usage in hazardous areas.
2. Options/Accessories Required:
    a. Relays shall match power supply provided.
    b. Relays shall be located in non-hazardous areas.
3. Manufacturers:
    a. Consolidated Electric.
    b. Gems Safe-Pak.
    c. Warrick Controls.
    d. R. Stahl, Inc.

K. Digital Panel Meter:
1. Type:
    a. Digital process meter.
2. Functional/Performance:
    a. Accuracy - 99.9 percent.
    b. Power requirements - 120V AC or 24V DC as required.
    c. Operating temperature - 0 to 60 degrees Celsius
    d. Display - LED display, 3-1/2 digit minimum resolution. The indicator shall indicate the value of the analog input signal in engineering units with scale range as noted. Decimal point shall be field selectable. Unit shall provide overrange indication.
    e. Operating Temperature: 32 to 122 degrees F (0 to 50 degrees C) (reduced to 40 degrees C if maximum display brightness is selected).
    f. Storage Temperature: -4 to 185 degrees F (-20 to 85 degrees C).
    g. Humidity: 85 percent RH non-condensing.
3. Physical:
    a. Housing - High impact plastic, or extruded aluminum, with splashproof lens cover and gasketing to meet NEMA 4 requirements.
    b. Legend - Provide a permanent service legend to display the engineering units of the process variable.
4. Manufacturers:
    a. Newport Electronics.
    b. Precision Digital.
    c. Approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. The Supplier shall furnish all labor, materials, equipment, and incidentals required to install the system in accordance with Section 17300 - Instrumentation Control and Monitoring System - General Provisions and as specified herein.

B. The Supplier shall be responsible for ensuring that all field wiring for power and signal circuits is correct and wired in accordance with best industry practice. Also, the Supplier shall be responsible for providing all necessary system grounding to insure a satisfactory functioning installation.

C. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded as directed by the Manufacturer of the instrumentation equipment but in no case shall more than one ground point be employed for each shield.

D. Analog, discrete, and power wiring shall be physically separated to the maximum extent possible. In no case shall any wire bundle contain signals of mixed types.

E. One (1) full day meeting with the System Supplier, Owner shall be arranged to discuss the overall system design, implementation, HMI screens, trends and reports.

3.02 TESTS AND ACCEPTANCE

A. System testing and acceptance shall be performed in accordance with the requirements defined in Section 17300 - Instrumentation Control and Monitoring System - General Provisions and as specified herein.

B. A complete set of preventive maintenance procedures shall be performed on all equipment no more than thirty days prior to final factory tests on the full integrated system. This shall include such items as calibration of A/D converters, adjustment of power supplies, adjustment of all CRTs for convergence and color, etc.

3.03 TRAINING

A. A complete training program for site courses shall be provided in accordance with the requirements of Section 17300 - Instrumentation Control and Monitoring System - General Provisions and as specified herein.

3.04 WARRANTY/PREVENTIVE MAINTENANCE

A. Warranty and Preventive Maintenance shall be included in the Contract Price and provided as defined in Section 17300 - Instrumentation Control and Monitoring System - General Provisions.

END OF SECTION

SECTION 17303

SOFTWARE PROGRAMMING AND FUNCTIONAL CONTROL DESCRIPTIONS

PART 1 GENERAL

1.01 REQUIREMENTS

A. The Contractor shall furnish, test, install and place in satisfactory operation all control and monitoring system software with all required programming and software appurtenances as herein specified and shown on the Drawings complete in place.

B. The Instrumentation and Control System Integrator (integrator) shall provide the services of a software Engineer that shall perform all required programming work necessary to achieve a fully integrated and operational system.

C. Additional services and programming necessary for overall system operation or performance shall be included whether they are described in detail or not. A list of required screens is provided in this specification.

D. The PLC program and local HMI system configurations shall be created and installed in full conformity with the drawings, specifications, engineering data, instructions of the contract documents and recommendations of equipment manufacturers (where applicable), and the Owner.

E. Programming, copying, configuring of the new PLC systems and associated HMI screens shall be provided as follows:
   1. Applications Software:
      a. PLC Applications Software: Provide one license for Rockwell Automation Studio 5000 v. 30.02.00 or latest, perpetual.
      b. Owner existing SCADA Software is VTScada version 12.1.23.
   2. The Contractor shall include the following activities in his contract:
      a. Preliminary design review meeting with Owner and Engineer.
      b. Input to project plan submittal defined in Section 17300 - Instrumentation Control and Monitoring System - General Provisions.
      c. Software and control strategy submittals defined in Section 17300 - Instrumentation Control and Monitoring System - General Provisions.
      d. Testing, training, software and control strategy submittals defined in Section 17300 - Instrumentation Control and Monitoring System - General Provisions.
      e. Operational readiness tests, calibration test and 30-day acceptance tests as defined in Section 17300 - Instrumentation Control and Monitoring System - General Provisions.
      f. Graphic display meetings with the Owner defined in Section 17300 - Instrumentation Control and Monitoring System - General Provisions.
      g. Onsite checkout of applications software.
      h. Onsite assistance to Instrumentation Contractor.
      i. As specified in Section 01110 - Summary of Work.

j. Training as described in Section 17300 - Instrumentation Control and Monitoring System - General Provisions.
k. O&M Manuals.

1.02 RELATED WORK

A. The Contractor shall provide all programming related labor and services as required to support the requirements of the following sections to ensure a single, coordinated control and monitoring system is furnished:
   1. Section 17300 - Instrumentation Control and Monitoring System - General Provisions.
   2. Section 17304 - Instrumentation.

B. The Contractor shall in particular coordinate his work with the work under the following:
   1. Division 0 - Bidding and Contract Requirements.
   2. Division 1 - General Requirements.
   3. Division 11 - Equipment.
   4. Division 15 - Mechanical.
   5. Division 16 - Electrical.

1.03 DESIGN REVIEWS AND PROGRESS REPORTS

A. A preliminary and critical design review meeting shall be conducted by the Instrumentation and Control Integrator, Engineer and Owner-designated representatives, to ensure design compliance with all specification hardware and software requirements. Other supplemental design review meetings may be held as required by the Owner to resolve specific problems to provide positive assurance to the Owner that the design conforms to contractual requirements or to allow for concurrent planning activities by the Owner that are dependent upon the as-built system configuration/operation. Design reviews shall, at the discretion of the Owner, be conducted either at the Owner's facility, the Instrumentation and Control Integrator's facility, or at a location suggested by the Owner.

B. The preliminary design review shall be a formal meeting to review the overall system design with emphasis being placed upon the arrangement and interactive operation of all items of digital equipment. The preliminary design review shall be conducted no later than 90 days after notice to proceed. To the greatest extent possible, all data to be presented at the preliminary design review meeting shall be furnished to the Owner two (2) weeks prior to the meeting date. Data made available by the Contractor shall include, but not be limited to the following:
   1. Overview of software design and organization, including control system and operating personnel interactions.
   2. Schedules.
   3. Intended plan for implementing system development assembly, check-out, hardware/software performance verification, installation, activation, and factory test activities.
   4. Identification of critical engineering activities and long lead-time procurement items.
   5. Preliminary compilation of control strategy design approach.

6. A block diagram(s) of the proposed digital system configuration shall be provided. A functional description of the block diagram(s) shall also be provided. The functional description shall describe the overall system operation, interaction between system elements, system response time estimate, fail-over procedures and system/operator interactions.
7. Software information including:
    a. Overall description of software.
    b. List and description of all system software.
    c. List and description of all process control system software.
    d. A detailed description of how data base points, control strategies, text and schematic displays and textural reports are implemented and modified.

1.04 ON SITE SERVICES

A. On-site Software Consultant: following Final Acceptance, provide on-site software consulting support on a demand basis for 1 year. Provide a minimum of 15 man-days of on-site support through a minimum of two visits to the station. This support shall be provided by a programmer that is thoroughly familiar with the control system designed and furnished, and that has a minimum of 2 years of experience with the Instrumentation and Control Integrator's firm. Support shall include overall optimization of the control and monitoring system operation, and any additional training that is in addition to that specified under Section 17300 - Instrumentation Control and Monitoring System - General Provisions, Article TRAINING.

1.05 GUARANTEE

A. The Contractor shall guarantee all equipment and installation, as specified herein, for a period of 1 year following the date of Owner acceptance of the work. To fulfill this obligation, the Contractor shall utilize technical service personnel designated by the Instrumentation and Control Integrator to which the Contractor originally assigned project responsibility for instrumentation. Services shall be performed within 2 calendar days after notification by the Owner.

PART 2 PRODUCTS

2.01 GENERAL INFORMATION AND DESCRIPTION

A. These Specifications are intended to give a general description of what is required, but do not cover all details which will vary in accordance with the requirements of the equipment furnished. They are, however, intended to cover the furnishing, the delivery and complete installation and field testing, of all software and programming for complete systems herein specified, whether specifically mentioned in the Specification or not.

B. The graphics element shall provide a means of creating and displaying color graphic displays that will be used by the operator to monitor and control the process. Real-time values being read from field devices (I/O devices, programmable logic controllers, remote telemetry units, etc.) shall be displayed on demand in a

variety of user-configurable formats. Systems which require replication of databases on each LAN connected device are not acceptable.

2.02 SYSTEM DATABASE

A. The Contractor shall develop and assign identification tag names to all new I/O points in the PLC database, and local HMI SCADA system. All Tag names shall conform to the Owner's standards and preferences for the identification of discrete and analog I/O. The software programmer shall meet with the Owner prior any programming activities to coordinate tag naming conventions for each individual tag. As a minimum, each database shall have the following:
   1. Tag identification number.
   2. Tag description.
   3. Rack/Slot/Point assignment.
   4. Internal PLC I/O address.
   5. Analog low and high scale values and engineering units.
   6. Analog low-low, low, high, high-high alarm limits.
   7. Digital on/off descriptions.
   8. Digital alarm state.
   9. Additional interface address (if necessary)

2.03 LOCAL HMI SYSTEM

A. The Owner will provide guidelines for HMI display screens, trend display screens, alarm system configurations, alarm set-points, alarm system displays, and user security levels. The Contractor shall use these templates and guidelines in developing graphical displays and interfaces to provide a fully functional working system in place.

B. Program and configure new PLC and HMI system as shown on drawings, specified here and as required. All features and controls from package system provided on Local HMI screens shall be provided to the plant SCADA per P&ID drawings. All equipment connected to the main control panel and controlled by the package system PLC shall be coordinated with package system supplier for proper operation and control.

2.04 FUNCTIONAL CONTROL DESCRIPTIONS

A. The control strategies are written descriptions of the programming required to implement regulatory and sequential control of the unit processes. Control strategies shall fully reside in the memory of the designated PLC. Coefficients pertaining to control strategies shall be modifiable through the operator interface in the monitoring / control mode.

B. The control system programmer shall include an additional 8 hours on-site to fine tune control systems and make minor software modifications in order to resolve any logic discrepancies encountered during start-up, and supply the Owner with a complete functional system. This shall be part of the bid package with no additional cost to the Owner. Only main control strategy will be listed in this specification. Contractor shall also provide other control strategies not listed below but stated in the drawings or in other specifications.

C. General Programing Requirements:
   1. The control system shall be designed to allow online calibration and repair of instruments used in the plant control scheme without disruption of the plant process or production rate. This shall be accomplished using operator selectable process hold values in conjunction with operator selectable hold timers and alarms to remind operators to reset the system to active inputs.
   2. 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 all PLC algorithms and calculations.
      b. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
   3. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from SCADA. Update and display the current value at all locations, regardless of where the last change was made.
   4. Program slew rates for all setpoints to limit the effect of updated setpoints on the process:
      a. Provide for control setpoints and manual speed and position selections.
      b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
      c. Provide operator access to change slew rates from SCADA.
   5. Saved setpoints:
      a. Provide an operator selection to save all setpoint values.
      b. Furnish 1 or more screens at SCADA that display the initial values for all setpoints defined during start-up and the value for each setpoint the last time they were saved.
      c. Provide an operator selection to restore all setpoints to the initial start-up value.
      d. Provide an operator selection to restore all setpoints to the last saved value.
   6. Store a copy of all adjustable parameters and accumulated and integrated totals in SCADA:
      a. Upon re-loading of the PLC program, re-load these values to the PLC from SCADA.
   7. 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 100,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 5 or more zeros).
      d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years.
   8. Timers:
      a. Provide programmable settling and proving timers in all control sequences for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions:
         1) The settling timers may be overridden by setting the timer to 0 seconds.

b. Embed the timers in the PLC logic, tune in the field, and list separately as part of the software submittal and O&M manual.

D. 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 SCADA and enable acknowledgement at SCADA. All alarms indicated at SCADA shall be integrated in the Client existing alarm dial-out system.
      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. Flash all alarm and fail conditions and their respective indicators on the SCADA screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present. 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) Flash with a cycle rate of 1/2 second on and 1/2 second off.
      e. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the SCADA graphic alarm indicator off.
      f. For all alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from zero seconds to 100 minutes. The initial setting of proving timers shall be zero seconds:
         1) The PLC shall start the timer when it first detects an alarm condition and shall only activate the alarm after the timer has expired.
         2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.
      g. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
      h. All alarms that are generated by the PLC and have active role in PLC logic, shall be latched, and shall be resettable from the HMI screens, except the alarms that need to be reset on the field.
      i. All alarms that are generated by the PLC and have only monitoring purposes, shall be present only while the conditions that caused the alarm are present, and be automatically reset when the conditions are no longer present.
   3. Where a reset is shown for counts, totals and times maintained in the PLC:
      a. Provide a reset button on the SCADA screen that displays the value.
      b. Provide a preset function in SCADA to allow an operator-entered value to become the current accumulated total.
      c. Limit access to the reset and preset functions to operators with suitable security level.

d. Log the value before reset, operator, time, and date of reset in SCADA archive.
e. Log the value before preset, preset value, operator, time, and date of preset in the SCADA archive.

4. Where start counts are indicated on the Drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:
   a. Display total starts on SCADA screens, and provide a reset function.
   b. Where indicated, calculate number of starts for each day:
      1) Display current day and previous day starts on SCADA displays.
      2) Do not reset daily start count when overall count is reset.
      3) Archive starts for each day through SCADA.
5. Where run time accumulation is indicated on the Drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:
   a. Display total run time in hours on SCADA screens.
   b. Where indicated, calculate total run time for each day:
      1) Display current day and previous day run time in SCADA to the nearest 0.1 hour.
      2) Do not reset daily run time when overall time is reset.
      3) Archive run time for each day through SCADA.
6. For all monitored analog values:
   a. Convert all values to engineering units in floating-point format within the PLC.
   b. Maintain trends in SCADA.
   c. Totalize flows in the PLC logic:
      1) Where flow volume is provided as a discrete input pulse, flow total is calculated by adding the "volume per pulse" value to the flow total on each off-to-on transition of the discrete input.
      2) Where no totalizer input is shown, integrate the analog input over time.
      3) Display totals in SCADA.
      4) Archive totals to the historical database through SCADA.
   d. Calculate hourly, daily, and monthly averages:
      1) Calculations shall be performed by the PLC.
      2) Display averages on SCADA screen, and archive through SCADA.
   e. Calculate minimum and maximum values for each hour, day, and month:
      1) Calculations shall be performed by the PLC.
      2) Display minimum and maximum on the SCADA screen, and archive through SCADA.
   f. Generate an alarm whenever an override value is in use.
7. Analog data processing:
   a. Engineering units conversion:
      1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
   b. Analog magnitude checking:
      1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.

c. Analog value quality:
    1) Monitor analog values received at each PLC from analog inputs or communications from another PLC or RIO, and generate alarms for the following conditions:
        a) Rate of change in excess of acceptable limit:
            (1) Provide a separate rate limit for each value.
        b) Stale value:
            (1) For analog signals that come from analog inputs or calculations using analog inputs, which are expected to have some variation each time the input is read, alarm when there is no change in the value for 10 times the normal expected scan or communication update.

8. Analog device override (SCADA):
    a. Provide the following functions from SCADA for all analog inputs:
        1) An override value to be used in place of the analog input:
            a) Enter in engineering units:
                (1) Display the calibrated range in engineering units.
                (2) Only allow entries within the calibrated range of the instrument.
            b) When the analog input is enabled, provide value tracking so that the override value matches the analog input value when the input is initially disabled.
            c) Maintain override status and value in the PLC.
            d) Only allow access to override selections and settings to operators with sufficient security.
        2) An enable/disable selection:
            a) When enabled, the value used by the PCIS system is equal to the analog input value.
            b) When disabled, the analog input is ignored, and the override value is used for all control and display functions.
            c) Generate an alarm whenever an analog input is disabled.
            d) Enter a value for the analog input from SCADA to the PLC.
            e) When disabled is active, use the override value for all display and control functions instead of the actual analog input value.
9. Tank and vessel levels:
    a. Display all tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
        1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during screen meetings.
    b. Monitor rate of change of volume on all tanks and vessels:
        1) Establish the maximum and minimum rate of change. Generate an alarm whenever the volume reach either. Make this alarm set points operator adjustable.
10. I/O filtering and processing:
    a. Analog input filtering:
        1) For each analog input provide an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering effect.

2) Monitor analog input signal quality:
    a) Over range: The input value is above the normal range (typically over 21 mA).
    b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
    c) Generate alarms for over or under range inputs.
    d) Do not use over or under range values for control or calculation purposes:
        (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
        (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.
3) Digital input filtering (proving timer):
    a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
    b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.

11. Instrument scaling (in SCADA):
    a. Provide 1 or more maintenance SCADA screens to display ranges and trigger points for all field instruments:
        1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
        2) For discrete instruments, display calibrated pick-up and drop-out values.
12. SCADA HAND-OFF-AUTO:
    a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in SCADA, accessed from a SCADA screen for operators with sufficient security, to provide the following operating modes:
        1) SCADA AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
        2) SCADA HAND: Enables SCADA Manual control where control decisions are made by an operator through the SCADA START-STOP, OPEN/CLOSE, or other selections as indicated.
        3) SCADA OFF: Automated SCADA control is disabled, and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.
        4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.
13. Display the current status of all operator selections (SCADA HAND/AUTO, SCADA START/STOP, etc.) on SCADA screens.

14. Permissives:
    a. Implement software permissives where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software permissives when equipment is operating in SCADA AUTO or SCADA HAND.
    b. Use hard-wired permissives for equipment protection where indicated.
15. Process control algorithms:
    a. PID algorithms: Use where indicated, or where necessary to provide fast response:
        1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
            a) Display Output, CV.
            b) Display Setpoint, SP.
            c) Display Process Variable, PV.
            d) Allow for operator selection of Automatic or Manual control of the output.
            e) Under Manual control of output allow the operator to enter the desired output value.
            f) Allow for input of the 3 Proportional, Integral, and Derivative tuning parameters.
            g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or SCADA), or when the equipment has reached a physical limit.
            h) When controlled equipment is being operated in remote SCADA HAND, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.
16. Equipment alternating and sequencing:
    a. Distribute number of starts and run time equally between identical equipment.
    b. Provide operator selection to disable run time matching functions.
17. Motor control:
    a. Monitor the device's LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
        1) Display current REMOTE status on the SCADA screens.
    b. Monitor the device's running status from the starter auxiliary or run status input:
        1) Display the current status (running or stopped) on the SCADA screens.
        2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
        3) Provide time stamp for each start.
        4) For motors 200 hp and greater, provide software to prevent exceeding the manufacturer's recommended maximum starts per hour.
    c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of SCADA AUTO or SCADA HAND control modes based upon operator selection using the SCADA screens.

d. Starting, stopping, and running when the device LOR is in LOCAL:
    1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
    2) With the LOR switch in the OFF position, the motor is prohibited from running.
    3) With the LOR switch in the REMOTE position, the motor is controlled remotely.
e. Starting, stopping, and running when the device LOR is in REMOTE:
    1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable "Control Activation" timer:
        a) Provide "Control Activation" timers for each piece of controlled equipment:
            (1) If the LOR and required running status do not change, and the PLC does not receive running status within the "Control Activation" time period:
                (a) De-activate the output.
                (b) Place the device in a "Failed" state.
                (c) Generate a "Failed to Respond" alarm.
    2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the "Control Activation" timer:
        a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the "Control Activation" time period:
            (1) Keep the RUN output off or the STOP output on.
            (2) Place the device in a "Failed" state.
            (3) Generate a "Failed to Respond" alarm.
    3) Reset device "Failed" condition using one of the following:
        a) An operator turns the device’s LOR switch out of REMOTE, and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
        b) An operator acknowledges the fault from SCADA.
f. Where motor winding high temperature switches or RTD temperature elements are shown, generate an alarm when high temperature is sensed (contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.
g. Control two-speed motors similar to other motors, except as listed below:
    1) Motor states are RUN-FAST, RUN-SLOW, and STOP.
    2) Start all two-speed motors in the RUN-SLOW state. If or when the high speed is required (RUN-FAST operator selection or process conditions), transition to RUN-FAST after a designated time.
    3) When transitioning from RUN-FAST to RUN-SLOW, remove the RUN-FAST output or issue a STOP, then wait for a "Fast to Slow" time delay before energizing the RUN-SLOW or START-SLOW output.

h. Simultaneous starts:
    1) Prevent more than one motor-driven load 25 hp or larger in the same facility from starting concurrently:
        a) When starting one load, inhibit start logic for all other such equipment until the load being started is up to speed (RVSS or VFD), or after a setpoint time delay (full-voltage starters and miscellaneous equipment).
    2) Use the same logic to prevent multiple large devices from starting concurrently on restoration of power after a power outage, whether operating on generator or utility power.

i. Speed control:
    1) Modulate speed on VFD-driven motors using PID control algorithms to maintain process conditions as described in the specific loop descriptions.
    2) Operate speed control within a pre-defined range:
        a) Minimum speed as determined by equipment manufacturer. The minimum speed shall be set at VFD as motor protection and PLC minimum speed value shall match settings in VFD.
        b) Maximum speed 100 percent (60 hertz) or as identified by equipment manufacturer.
    3) Where multiple equipment may operate together to maintain the same process condition:
        a) Provide an operator selection for starting sequence.
        b) Start the first equipment at a preset starting speed.
        c) When one or more equipment is running and the speed control algorithm reaches a preset "Start Next" speed value (initially 95 percent of speed range) through a preset time delay:
            (1) Start the next available equipment at the preset starting speed.
            (2) Ramp up the started equipment at operator configurable ramp up rate. The PID controller should automatically begin to reduce other equipment speed. Once both equipment reach are within 5% of each other, resume the speed control algorithm for those equipment.
            (3) Operate all equipment at the same speed following the output of the speed control algorithm.
        d) When two or more pieces of equipment are running, monitor for a "Stop Next" condition:
            (1) Where flow rate is monitored, use a preset "Stop Next" flow rate for each possible number and combination of equipment:
                (a) Determine "Stop Next" ramp down rate based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the "Start Next" speed.

(2) When the "Stop Next" condition exists through a preset time delay:
(a) Ramp down the stopped equipment at operator configurable ramp rate. The PID controller should automatically begin to increase other equipment speed. Stop the load once it reaches minimum speed.
(b) Operate all remaining equipment at the same speed following the output of the speed control algorithm.

18. Gate and valve control:
a. Monitor the device's LOCAL-STOP-REMOTE (LSR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):
1) Display current REMOTE status on SCADA screens.
b. Start an "Open Activation" timer whenever the device is expected to be open (PLC has issued an OPEN command in SCADA AUTO, or OPEN was selected in SCADA HAND):
1) Initially set "Open Activation" time to twice the normal opening time.
2) If the LSR position and open command do not change, and the PLC does not receive fully open status feedback within the "Open Activation" time period:
a) De-activate the open output.
b) Place the device in a "Failed" state.
c) Generate a "Failed to Open" alarm.
c. Start a "Close Activation" timer whenever the device is expected to be closed (PLC has issued a CLOSE command in SCADA AUTO, or CLOSE was selected in SCADA HAND):
1) Initially set "Close Activation" time to twice the normal closing time.
2) If the LSR position and close command do not change, and the PLC does not receive fully closed status feedback within the "Close Activation" time period:
a) De-activate the close output.
b) Place the device in a "Failed" state.
c) Generate a "Failed to Close" alarm.
d. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a "Position Error" timer whenever the position feedback differs from the required position command by more than a setpoint error when the LSR is in REMOTE:
1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
3) Initially set the "Position Error" time to 60 seconds.
4) If the LSR position does not change, and position error stays outside of the setpoint error through the "Position Error" time period:
a) Hold position output.
b) Place the device in a "Failed" state.
c) Generate a "Position Fail" alarm.

e. Provide separate time delay settings for each function and for each device.
f. If the valve position inputs indicate an impossible state (i.e., valve open and closed at the same time), place the device in a "Failed" state and generate an "Illegal State" alarm.
g. Reset device "Failed" condition using one of the following:
    1) An operator turns the device's LSR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
    2) An operator acknowledges the fault from SCADA.
h. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
i. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) in the PLC:
    1) Display count on the SCADA screen.
    2) Provide a reset function for the count.

19. Chemical systems (SCADA):
    a. Provide the following chemical system screens:
        1) Where a single SCADA system manages more than one chemical system, a main menu screen that will allow the operator to access the individual chemical system screens using software keys.
        2) One or more SCADA screens for each individual chemical system controlled at that location, containing:
            a) All status displays (running, failed, etc.).
            b) Selections (lead/lag, which process flow to pace to, etc.).
            c) Setpoint entry and display.
            d) Calculated feed requirement (result of flow pacing calculation) in engineering units (typically milligrams of chemical per minute).
            e) Output signal to feeder in percent of full span.
            f) Actual chemical flow rate from flowmeter (where shown).
            g) Process flow rate(s) used to pace each chemical on the individual chemical screens (PROC FLOW):
                (1) Where different process flows can be selected for flow pacing, display and identify the selected source.
        3) Chemical system calculations: Perform calculations as indicated on the Drawings and in the individual loop descriptions. Use the following assumptions, unless otherwise noted.
        4) Where chemical flow feedback is not used, assume feeder output is linear in response to control signal.
        5) Zero signal (typically 4 milliamperes) produces zero flow.
        6) Perform flow-pacing calculations using as indicated on the Drawings or described in the individual loop descriptions.
    b. Provide the setpoints and selections indicated on the Drawings and in the individual loop descriptions. Typical setpoints include:
        1) QMAX: Maximum calibration value:
            a) Chemical flow rate measured from calibration column at maximum feeder output (typically in gallons of solution per hour or milliliters of solution per minute).

2) CONC: Chemical concentration:
   a) The concentration of the chemical in the solution to be fed, in engineering units (typically milligrams of chemical per liter of chemical solution).
3) DENSITY:
   a) Density of the chemical solution to be fed in engineering units or as a specific gravity.
   b) Used to calculate the concentration of the chemical in the solution.
4) DOSE: Desired dosage:
   a) Desired chemical concentration in the process stream in engineering units (typically milligrams of chemical per liter of process fluid).
5) FLOW SEL: Selection of process stream(s) for flow pacing.
6) OPEN/CLOSED LOOP:
   a) Selection of method of controlling chemical flow-paced feed rate.
   b) OPEN LOOP: Signal to feeder is based on feeder calibration (QMAX) to deliver calculated chemical solution feed rate. Chemical solution flowmeter is not used for control.
   c) CLOSED LOOP: Chemical feed rate is directly controlled using the calculated chemical solution feed rate as the setpoint, and the flow rate from the chemical solution flowmeter as the process variable.

c. Chemical control algorithms:
   1) Flow pacing algorithm: Operator selects a desired dose and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, and feeder calibration. The calculation is as follows (units may vary from those shown in the calculation below):

$$FEEDER\ FLOW\ (\frac{ml}{min}) = \frac{21.948 * DOSE\left(\frac{mg}{L}\right) * PROCESS\ FLOW\,(MGD)}{CONC\left(\frac{lb}{gal}\right)}$$

$$FEEDER\ FLOW\ (\%) = \frac{FEEDER\ FLOW(\frac{ml}{\min})}{QMAX(\frac{ml}{\min})}$$

   2) Flow pacing with closed loop algorithm: Operator selects a desired dose and the control system adjusts the speed of the chemical feeder through a speed control signal to match the measured chemical feed rate to a flow rate setpoint. This flow rate setpoint shall be derived from the process flow and operator setpoints for dosage and concentration. The calculation is as follows (units may vary from those shown in the calculation below):

$$\boldsymbol{FEEDER\ FLOW}\ (\frac{\boldsymbol{ml}}{\boldsymbol{min}}) = \frac{\boldsymbol{21.948 * DOSE}\left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right) * \boldsymbol{PROCESS\ FLOW(MGD)}}{\boldsymbol{CONC}\left(\frac{\boldsymbol{lb}}{\boldsymbol{gal}}\right)}$$

a) Adjust the speed of the chemical feeder using a PID control algorithm to maintain the calculated FEEDER FLOW:
   (1) SP = Calculated FEEDER FLOW.
   (2) PV = Chemical Flow.
   (3) CV = Speed of the Chemical Feeder.

3) Flow pacing with analyzer trim algorithm: Operator selects a desired dose and desired analyzer setpoint band and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, process analyzer output, and feeder calibration. The calculation is as follows (units may vary from those shown in the calculation below):

$$\boldsymbol{PRE\ TRIM\ FLOW}\ \left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right) = \frac{\boldsymbol{21.948 * DOSE}\left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right) * \boldsymbol{PROCESS\ FLOW(MGD)}}{\boldsymbol{CONC}\left(\frac{\boldsymbol{lb}}{\boldsymbol{gal}}\right)}$$

$$\boldsymbol{TRIM\ MULTIPLIER} = \frac{\boldsymbol{AI} - \frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH + QAL)}}{-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH - QAL)}}$$

CLIP THE TRIM MULTIPLIER OUTPUT TO A MAXIMUM OF 1 AND MINIMUM OF -1.

$$\boldsymbol{TRIM\ ADDER}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right) = \boldsymbol{0.10 * TRIM\ MULTIPLIER * PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)$$

$$\boldsymbol{FEEDER\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right) = \boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right) + \boldsymbol{TRIM\ ADDER}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)$$

$$FEEDER\ FLOW\ (\%) = \frac{FEEDER\ FLOW(\frac{ml}{\min})}{QMAX(\frac{ml}{\min})}$$

4) Flow pacing with closed loop and analyzer trim algorithm: Operator selects a desired dose and desired analyzer setpoint band and the control system adjusts the speed of the chemical feeder through a speed control signal to match the measured chemical feed rate to a flow rate setpoint. An additional control algorithm is used in the calculation to fine-tune the feed based on an analytical measurement as measured by the process analyzer.

$$\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\frac{\boldsymbol{21.948}*\boldsymbol{DOSE}\left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right)*\boldsymbol{PROCESS\ FLOW(MGD)}}{\boldsymbol{CONC}\left(\frac{\boldsymbol{lb}}{\boldsymbol{gal}}\right)}$$

$$\boldsymbol{TRIM\ MULTIPLIER}=\frac{\boldsymbol{AI}-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH+QAL)}}{-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH-QAL)}}$$

CLIP THE TRIM MULTIPLIER OUTPUT TO A MAXIMUM OF 1 AND MINIMUM OF -1.

$$\boldsymbol{TRIM\ ADDER}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\boldsymbol{0.10}*\frac{\boldsymbol{AI}-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH+QAL)}}{-\frac{\boldsymbol{1}}{\boldsymbol{2}}\boldsymbol{(QAH-QAL)}}*\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)$$

$$\boldsymbol{FEEDER\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)=\boldsymbol{PRE\ TRIM\ FLOW}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)+\boldsymbol{TRIM\ ADDER}\left(\frac{\boldsymbol{ml}}{\boldsymbol{min}}\right)$$

a) Adjust the speed of the chemical feeder using a PID control algorithm to maintain the calculated FEEDER FLOW:
   (1) SP = Calculated FEEDER FLOW.
   (2) PV = Chemical Flow.
   (3) CV = Speed of the Chemical Feeder.

20. Breaker status:
    a. Display the following data to the extent it is available from the specified device:
       1) Open.
       2) Closed.
       3) Tripped.
       4) Ground fault.
21. Power and starter information:
    a. Retrieve data via power quality meters, motor protection relays, digital bus networks, or metering instruments, as indicated.

b. Display the following data to the extent it is available from the specified device:
    1) Current:
        a) A-Phase.
        b) B-Phase.
        c) C-Phase.
    2) Volts:
        a) A-Phase.
        b) B-Phase.
        c) C-Phase.
    3) Reactive power (kVAR).
    4) Real power (kW).
    5) Apparent power (kVA).
    6) Power factor.
c. For engine/generator system monitoring, also display percent of rated output.

22. Power failure: Retain all operating setpoints, ranges, and alarm settings during power failure.

2.05 PROJECT SPECIFIC CONTROL NARRATIVES

A. Refer to Section 17101A – Specific Control Strategies.

PART 3 EXECUTION

3.01 GENERAL

A. Contractor shall refer to Section 01110 - Summary of Work for detail sequence of construction and schedule and coordinate his/her works accordingly.

3.02 TESTS (GENERAL)

A. Refer to Section 17300 - Instrumentation Control and Monitoring System - General Provisions for required tests.

END OF SECTION

SECTION 17304

INSTRUMENTATION

PART 1 GENERAL

1.01 GENERAL INFORMATION AND DESCRIPTION

A. This specification is intended to give a general description of what is required, but does not cover all details which will vary in accordance with the requirements of the equipment furnished. It is, however, intended to cover the furnishing, the shop testing, the delivery and complete installation and field testing, of all powered and unpowered instruments and appurtenances whether specifically mentioned in the specification or not.

B. Instruments shall be furnished and installed with all necessary accessory equipment and auxiliaries whether specifically mentioned in these Specifications or not. Installations shall incorporate the highest standards for the type of service shown on the Drawings including loop testing of the entire installation and instruction of operating personnel in the care, operation, calibration and maintenance of all instrumentation.

C. All instrumentation shall be of first class workmanship and shall be entirely designed and suitable for the intended services. All materials used in fabricating the equipment shall be new and undamaged.

1.02 UNPOWERED INSTRUMENTS

A. The Instrumentation and Control System Integrator shall furnish, install, test and place in operation process instrumentation as scheduled herein together with all signal converters, transmitters, isolators, amplifiers, etc. to interface all instrumentation, panels, controls and process equipment control panels with the process controls as shown on the Drawings and as specified. The Contractor may elect to install primary elements on process lines provided that the Instrumentation and Control System Integrator provides full on-site supervision during installation. Mounting of associated transmitters, indicators, power supplies, brackets and appurtenances shall be provided as specified herein and shown on the Drawings.

B. It is the intent of this Specification and the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The Instrumentation and Control Integrator shall supervise installation of equipment provided under this Division where installation is provided by others.

C. Tappings and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. It is the Contractor's responsibility to ensure that the location, supports, orientation and dimensions of the connections and tappings for instrumentation furnished under this Division are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

D. Unless otherwise specified, instruments shall be provided with enclosures to suit specified environmental conditions. Field-mounted devices shall be rugged and mounted on walls or pipe stanchions.

1.03 POWERED INSTRUMENTS

A. The Instrumentation and Control System Integrator shall furnish, install, test and place in operation powered process instrumentation (level transmitters, etc.) as scheduled herein together with all signal converters, transmitters, isolators, amplifiers, etc. to interface all instrumentation, panels, controls and process equipment control panels with the process control system as shown on the Drawings and as specified. Powered instruments are those instruments which require power (120 VAC or 24 VDC loop power) to operate. The Contractor may elect to install primary elements on process lines provided that the Instrumentation and Control Integrator provides full on-site supervision during installation. Mounting of associated transmitters, indicators, power supplies, brackets and appurtenances shall be provided as specified herein and shown on the Drawings.

B. It is the intent of this Specification and the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The Instrumentation and Control Integrator shall supervise installation of equipment provided under this Division where installation is provided by others.

C. Tappings and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. It is the Contractor's responsibility to ensure that the location, supports, orientation and dimensions of the connections and tappings for instrumentation furnished under this Division are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage, and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

PART 2 PRODUCTS

2.01 INSTRUMENTATION GENERAL

A. Type

1. All instrumentation supplied shall be of the manufacturer's latest design and shall produce or be activated by signals which are established standards for the water industry. Microprocessor-based equipment shall be supplied unless otherwise specified. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings, or as required
2. All electronic instrumentation shall be of the solid-state type and shall utilize linear transmission signals of 4 to 20 mA dc (milliampere direct current), however, signals between instruments within the same panel or cabinet may be 1-5V dc (volts direct current), or the like.
3. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero based signals will be allowed.
4. Equipment installed in a hazardous area shall meet Class, Group, and Division as shown on the Electrical Drawings, to comply with the National Electrical Code.
5. All indicators and recorder readouts shall be linear in process units, unless otherwise noted.
6. All transmitters shall be provided with integral indicators as shown on drawings.
7. Electronic equipment shall be of the manufacturer's latest design, utilizing printed circuitry and suitably coated to prevent contamination by dust, moisture and fungus. Solid state components shall be conservatively rated for their purpose, to assure optimum long term performance and dependability over ambient atmosphere fluctuations and 0 to 100 percent relative humidity. The field mounted equipment and system components shall be designed for installation in dusty, humid and slightly corrosive service conditions.
8. All equipment, cabinets and devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, as much as reasonably possible, and shall consist of equipment models which are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.
9. Unless otherwise specified, field instrument and power supply enclosures shall be 316- stainless steel, fiberglass or PVC coated copper free cast aluminum NEMA 4X construction.
10. Where separate elements and transmitters are required, they shall be fully matched, and unless otherwise noted, installed adjacent to the sensor. Special cables or equipment shall be supplied by the associated equipment manufacturer.
11. All cables provided under this section shall be rated for environment. Wet locations shall include conduits systems below grade rated.

B. Electrical:
   1. All non-loop powered equipment shall be designed to operate on a 60 Hertz alternating current power source at a nominal 117 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplied required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.
   2. Materials and equipment used shall be U.L. approved wherever such approved equipment and materials are available.
   3. All equipment shall be designed and constructed so that in the event of a power interruption, the equipment specified hereunder shall resume normal operation without manual resetting when power is restored.

2.02 INSTRUMENTS

A. D1 Diaphragm Seal - Threaded
   1. Type:
      a. Thread Attached.
      b. Welded Metal Diaphragm.
      c. Exposed Surfaces - 316 stainless steel.
   2. Operation:
      a. Purpose - To protect instruments or gauges from the process medium.
      b. Operating Principal - A flexible diaphragm separates process medium and instrument element. Space on instrument side of diaphragm to be completely filled with a suitable silicone or instrument oil. The process pressure is transmitted by the liquid filled system to the instrument element.
   3. Functional:
      a. Filling Screw - Include on all units.
      b. Pressure Limits - 1,000 psi.
      c. Flushing Connection - Include on all units.
      d. Capillary tubing as required.
   4. Physical:
      a. Top Housing - 316 Stainless Steel, Cadmium plated.
      b. Bottom Housing - Compatible with the process.
      c. Diaphragm - 316 ELC Stainless Steel.
      d. Exposed Surfaces - 316 Stainless Steel.
      e. Bolts, Nuts and Plugs - 18-8 stainless steel or 316 stain steel.
      f. Capillary - 1/4-in stainless steel armor shielded.
   5. Manufacturers:
      a. Mansfield-Green.
      b. Ashcroft.
      c. Or approved equal.

B. P4 Pressure Gauge:
   1. General:
      a. Function: Local pressure indication.
      b. Type: Bourdon tube element.
   2. Performance:
      a. Scale Range: As noted.

b. Accuracy: Plus or minus 0.50 percent of full scale.

3. Features:
   a. Dial: 4-1/2-inch diameter.
   b. Pointer Vibration Reduction: Required, unless otherwise noted. Use the following method.
      1) Liquid filled gauge front, unless otherwise noted.
         a) Glycerine fill, unless otherwise noted.
   c. Case Material: Black thermoplastic, unless otherwise noted. Stainless in direct sun or in possible contact with chemicals / vapor.
   d. Materials of Wetted Parts (including element, socket/process connection, throttling device (if specified) and secondary components):
      1) Stainless steel, unless otherwise noted.
   e. Pointer: Adjustable by removing ring and window.
   f. Window: Glass or acrylic, unless otherwise noted.
   g. Threaded reinforced polypropylene front ring.
   h. Case Type: Solid front with blow-out back.
4. Process Connection:
   a. Mounting: Lower stem, unless otherwise noted.
   b. Size: 1/2-inch MNPT, unless otherwise noted.
5. Accessories:
   a. Throttling Device: Required, unless otherwise noted.
      1) Type suitable for the intended service.
      2) Install in gauge socket bore.
6. Manufacturers and Products:
   a. Ashcroft;
      1) Black Thermoplastic: Duragauge Model 1259/Model, 1279/Model, 1279 PLUS!
      2) Stainless Steel: T5500 or T6500.
   b. Ametek U.S. Gauge;
      1) Black Thermoplastic Solfrunt Model 19XX/1981Advantatge.
      2) Stainless Steel: 1931.
   c. WIKA,
      1) Black Thermoplastic: Type 2XX.34.
      2) Stainless Steel: Type 2XX.50.

C. P7 Pressure Switch, Adjustable Dead Band:
1. General:
   a. Function: Monitor pressure, activate switch at set point, and deactivate switch at reset point.
   b. Type:
      1) Piston-actuated.
      2) Both set point and dead band (the differential between set point and reset point) adjustable.
2. Performance:
   a. Set Point:
      1) As noted.
      2) Repeatability: Plus or minus 1 percent of range.
   b. Reset Point: As noted.
   c. Range: The noted set point shall fall between 20 percent and 80 percent of the range.

d. Deadband: Adjustable within nominally 25 percent and 85 percent of range.
e. Overpressure Proof Pressure:
1) Pressure psi Ranges: At least 400 percent of rated maximum static pressure.
2) Pressure Inches of Water Ranges: 20 psig.
3) Compound Range: 250 psig.
4) Vacuum Range: 250 psig.
f. Operating Temperature Range:
1) Dependent on actuator seal materials.
2) For Buna-N seal, 0 degrees F to 150 degrees F.

3. Features:
a. Actuator Seal: Buna-N, unless otherwise noted.
b. Adjustable dead band.
c. Mounting: Surface, unless otherwise noted.

4. Process Connection:
a. 1/4-inch NPT female connections, unless otherwise noted.
b. Materials:
1) Pressure psi Ranges: Type 316 stainless steel, unless otherwise noted.
2) Pressure Inches of Water Ranges: Epoxy coated carbon steel, unless otherwise noted.

5. Enclosure: NEMA 4X, unless otherwise noted.

6. Signal Interface:
a. Contact Type:
1) SPDT.
2) Rated for 10 amps minimum at 120V ac.
b. Hermetically Sealed Switch: If noted.

7. Manufacturers and Products:
a. Ashcroft; L or P Series.
b. United Electric; J6 Series.
c. If NEMA 7, explosion-proof enclosure specified; Ashcroft; P Series only.

D. P3 Pressure Differential Transmitter:
1. General:
a. Function:
1) Measure differential pressure.
2) Transmit signal proportional to either differential pressure or square root of differential pressure, as applicable.
b. Type:
1) Electronic variable capacitance or silicon strain gauge.
2) Two-wire transmitter; "smart electronics."
c. Parts: Transmitter and accessories.

2. Performance:
a. Range: As noted.
1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
b. Accuracy: Plus or minus 0.10 percent of span, unless otherwise noted.
c. Ambient Operating Temperature: Minus 40 degrees Fahrenheit to plus 175 degrees Fahrenheit, with integral meter.

d. Process Operating Temperature: Minus 40 degrees Fahrenheit to plus 250 degrees Fahrenheit.
e. Humidity: 0 to 100 percent relative humidity.
f. Hazardous Location Certifications: If and as noted.

3. Features:
   a. Linear or square-root output, user-configurable.
   b. Factory preconfigure for square root output if transmitter tagged as "FT" or "FIT."
   c. Adjustable damping.
   d. LCD indicator, unless otherwise noted.
      1) Display in either percent or engineering units, field configurable.
   e. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
      1) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
   f. Wetted O-Rings: Glass-filled TFE, graphite-filled PTFE, or Viton, unless otherwise noted.
   g. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
   h. Fill Fluid: Silicone, unless otherwise noted.
4. Process Connections:
   a. Line Size: 1/2 inch.
   b. Connection Type: FNPT.
   c. Diaphragm Seal: Pressure Differential Sensor shall be provided with factory assembled Diaphragm Seal.
5. Signal Interface:
   a. 4-20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.
      1) Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.
   b. FOUNDATION Fieldbus Protocol: If noted.
   c. Profibus: If noted.
6. Enclosure:
   a. Type: NEMA 4X.
   b. Materials: Coated aluminum, unless otherwise noted.
   c. Mounting bracket, unless otherwise noted.
      1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
7. Accessories:
   a. Three-valve manifold, unless otherwise noted.
      1) Includes one equalization and two isolation valves.
      2) Type 316 stainless steel.
8. Manufacturers and Products:
   a. Rosemount; Model 3051 CD, with Hart and Bluetooth configuration and maintenance.
   b. Vega Instruments.
   c. Approved equal.

E. P9 Pressure Transmitter:
1. General:
   a. Function: Measure pressure and transmit signal proportional to pressure.

b. Type:
    1) Electronic variable capacitance or silicon strain gauge.
    2) Two-wire transmitter; "smart electronics".
c. Parts: Transmitter and accessories.

2. Performance:
    a. Range: As noted.
        1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
    b. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
    c. Ambient Operating Temperature: Minus 40 degrees Fahrenheit to plus 175 degrees Fahrenheit, with integral meter.
    d. Process Operating Temperature: Minus 40 degrees Fahrenheit to plus 250 degrees Fahrenheit.
    e. Humidity: 0 to 100 percent relative humidity.
    f. Hazardous Location Certifications: If and as noted.
3. Features:
    a. Type: Gauge pressure, unless otherwise noted.
    b. Adjustable damping.
    c. LCD indicator, unless otherwise noted.
        1) Display in either percent or engineering units, field configurable.
    d. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
        1) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
    e. Wetted O-Rings: Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise noted.
    f. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
    g. Fill Fluid: Silicone, unless otherwise noted.
4. Process Connections:
    a. Line Size: 1/2 inch.
    b. Connection Type: FNPT.
    c. Diaphragm Seal: Pressure Sensor shall be provided with factory assembled Diaphragm Seal.
5. Signal Interface:
    a. 4-20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.
        1) Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.
    b. FOUNDATION fieldbus protocol: If noted.
    c. Profibus: If noted.
6. Enclosure:
    a. Type: NEMA 4X.
    b. Materials: Coated aluminum, unless otherwise noted.
    c. Mounting bracket, unless otherwise noted.
        1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
7. Accessories:
    a. Two-valve (isolate and vent) Stainless Steel Manifold: If noted.

8. Manufacturers and Products:
    a. Gauge Pressure Units:
        1) Rosemount; Model 3051 TG, with Hart and Bluetooth configuration and maintenance.
        2) Vega Instruments.
        3) Approved Equal.
    b. Absolute Pressure Units:
        1) Rosemount; Model 3051 TA, with Hart and Bluetooth configuration and maintenance.
        2) Vega Instruments.
        3) Approved Equal.

F. P15 Pressure Seal, Annular:
1. General:
    a. Function:
        1) Sense pressure in a process line and transfer to pressure monitoring device.
        2) Protect attached pressure monitoring device from sludge or slurry.
    b. Type: Annular fluid-filled device that senses pressure through flexible sleeve around full pipe circumference.
2. Performance:
    a. Operating Conditions: Suitable for line pressures up to pipe flange rating.
3. Features:
    a. Construction:
        1) In-line, 8 Inches and Smaller: Full-faced thru-bolted with outside diameter same as mating flanges, unless otherwise noted.
        2) In-line, 10 Inches and Larger: Wafer style.
        3) Offline: Threaded, unless otherwise noted.
    b. Materials:
        1) Body: Carbon steel, unless otherwise noted.
        2) Flanges (where applicable): Carbon steel, unless otherwise noted.
        3) Flexible Sleeve: Buna-N, unless otherwise noted.
        4) Fill Fluid: Ethylene glycol/water or propylene glycol, unless otherwise noted.
    c. Factory Filled System:
        1) Filled and assembled with pressure monitoring device(s).
        2) Coordinate attached pressure monitoring device(s) with system integrator. Seal vendor's standard pressure monitoring device(s) only acceptable if it meets specification of the related pressure monitoring device.
4. Process Connections:
    a. Mounting: In-line or offline, as noted or shown.
    b. Pipe Size:
        1) In-line: As noted or shown.
        2) Offline: 2 inches, unless otherwise noted.
    c. Connections:
        1) In-line, Full-faced through-bolted: ASME B16.5, 150-pound flanges.
        2) In-line, Wafer style: Compatible with Classes 150/300 flange drilling.
        3) Offline: Female NPT Threaded, unless otherwise noted.
5. Manufacturers and Products:
    a. Red Valve Company; Series 40, Series 42/742, Series 48.

b. Dover/OPW Engineered Systems; Iso-Ring.

G. L6 Radar Type Level Transmitter:
1. Type:
a. Radar sensor type where short microwave impulses are emitted by the antenna system in the direction of the measured product, reflected by the product surface and received back again by the antenna system. The time from emission to reception of the signals is proportional to the level.
2. Performance:
a. Measuring Range: 49.2ft.
b. Deviation: ±0.08-inch.
c. Process Fitting: Thread G 1 1/2 , mounting strap, compression flanges from 3-inch.
d. Process pressure: -14 to 29 psig.
e. Process temperature: -40 to 176 degrees Fahrenheit.
f. Operating voltage: 9.6 to 35VDC.
g. Output: two wire 4-20mA.
3. Physical:
a. Wetted parts material: Valox PBT or PP.
b. Process seal material: FPM.
c. Housing: Valox PBT.
d. Protection: IP68 at 2 bar.
4. Transmitter:
a. Primary Configuration: Microprocessor based with keyboard operator interface.
b. Enclosure: NEMA 4X polycarbonate, unless otherwise noted.
c. Power Supply: 115-volt, 50/60-Hz, unless otherwise noted.
d. Isolated Analog Output:
1) One, minimum, Milliamp current loop for load impedance of 0 to 750 ohms.
2) Milliamp current loop programmable as 4-20, 0-20, 20-4, or 20-0 mA.
e. Digital Communication: As noted.
f. Other Features: As noted.
g. Discrete Outputs: Minimum, four relays (combination of SPST and SPDT) rated for 5 amps continuous at 120V ac.
h. Display:
1) Multifield LCD.
2) High contrast 40 mm (1.5 inches).
3) In standard engineering units (feet, inches, or centimeters); volumetric conversion.
4) Alarm Messages: Loss of echo and cable circuit open or shorted.
i. Filters, Electronic:
1) For agitator blade echoes.
2) To remove small variations from surface waves.
3) Narrow echo and spike filters to remove spurious readings from noise sources such as variable frequency drives.
4) Various pump control features.
5. Interconnecting Cable: Weatherproof, UV protected, length as required, and type as recommended by manufacturer.

6. Manufacturers:
    a. Endress & Hauser; Model FMR 10 and RIA46-12E7/0 or other Transmitter that has at least one Analog Output (4-20mA) and two Relay Outputs.
    b. Ohmart Vega, VEGAPULS C11 and VEGAMET 861.

H. F20 Flow Element and Switch, Thermal:
1. General:
    a. Function: Monitor process fluid flow and provide contact closure when flow exceeds set point.
    b. Type: Thermal dispersion flow switch using a heated active and a reference RTD temperature sensors to detect rate of flow as a function of the temperature difference between the two sensors.
2. Service:
    a. Fluid: Chemical. Refer to instrument list for process fluid.
    b. Operating Pressure: As noted.
    c. Operating Temperature: As noted.
3. Performance:
    a. Set Point:
        1) Adjustable throughout full range.
        2) Set as noted.
    b. Range: Choose range so that the noted set point is between 30 and 70 percent of the range.
    c. Repeatability: Plus or minus 1 percent of full range.
    d. Temperature, Operating:
        1) Sensor Element: Minus 100 to plus 350 degrees Fahrenheit.
        2) Electronics: Minus 40 to plus 140 degrees Fahrenheit.
    e. Proof Pressure: To 4,000 psig.
    f. Response Time: Field adjustable from 10 to 150 seconds.
4. Features:
    a. Wetted Surfaces Materials: 316 stainless steel with nickel-base braze, unless otherwise noted. The material shall be compatible with process fluid that is sensing. Refer to drawings for exact process fluid identification.
    b. Dry Pipe Protection: When applied to liquid process, furnish protection against the event of the liquid line going dry, unless otherwise noted.
    c. Process Temperature Compensation: Furnish.
5. Process Connections:
    a. Type: 1-inch NPT(M), unless otherwise noted.
    b. Pipe Size: As noted.
    c. Connection Type: Insertion.
    d. Connection Material: 316 stainless steel, unless otherwise noted. The material shall be compatible with process fluid that is sensing. Refer to drawings for exact process fluid identification.
6. Conduit Connection: 1-1/4-inch NPT(F) reduced to 3/4 inch with bushing.
7. Element: Insertion/Body Length (From Tip of Probe to Process Connection): Determined by the Supplier based upon pipe size and sensor mounting requirements, unless otherwise noted. The insertion length shall be noted on an application specific installation detail prepared and submitted for each unit.
8. Electronics:
    a. Location: Integral with element, unless otherwise noted.
    b. Hermetically sealed with SPDT relay.

9. Signal Interface:
    a. Contact: Single-pole, double-throw (SPDT), rated 120V ac, 2 amps.
    b. Connection: Screw terminal block.
10. Enclosure:
    a. Type: NEMA 7BCD with watertight O-ring seal.
    b. Material: Cast aluminum, unless otherwise noted.
    c. Approval: Factory Mutual for hazardous area, unless otherwise noted.
11. Power: 120V ac, 60-Hz, unless otherwise noted.
12. Cable (Furnished Only When Remote Electronics is Specified):
    a. Type: As required.
    b. Length: As required.
13. Manufacturer:
    a. Fluid Components, Inc.; Model FLT93S or Model FR.
    b. Sierra Innova-Switch 615-FS42.

I. M26 Hand Switch and Light, Corrosion, Round:
1. General:
    a. Function: Select, initiate, and display discrete control functions.
    b. Type: Heavy-duty, corrosion-resistant, industrial.
2. General Features:
    a. Mounting: 30.5 mm single round hole. Panel thickness 1/16 inch to 1/4 inch.
    b. Legend Plate: Standard size, square style laminate with white field and black markings, unless otherwise noted. Markings as shown, or as implied by P&IDs.
    c. Configuration: Light, pushbutton, or switch as noted or shown.
3. Light Features:
    a. Lights: 6V ac lamps and integral transformer for operation for operation from 120V ac, unless otherwise noted.
    b. Lens Color: Color as specified, noted, or shown.
    c. Push-to-test, unless otherwise noted.
    d. Additional: As noted.
4. Pushbutton Features:
    a. Operator: Single pushbutton, flush, unless otherwise noted.
    b. Color: Black, unless otherwise noted.
    c. Boot: None, unless otherwise noted.
    d. Contact Arrangement: As required or shown.
    e. Additional: As noted.
5. Selector Switch Features:
    a. Operator: Knob, unless otherwise noted.
    b. Color: Black, unless otherwise noted.
    c. Boot: None, unless otherwise noted.
    d. Positions: As required or shown.
    e. Return: Manual, unless otherwise noted.
    f. Contact Arrangement: As required or shown.
    g. Additional: As noted.
6. Signal Interface:
    a. Contact Block:
        1) Type: Standard, unless otherwise noted.
        2) Materials: Silver amalgam, unless otherwise noted.
        3) Rating: 10 amps continuous at 120V ac, unless otherwise noted.

4) Sequence: Break-before-make, unless otherwise noted or shown.
5) Arrangement: Normally open or normally closed as shown, or to perform the functions noted.

7. NEMA Rating: NEMA 4, watertight, dust-tight, and NEMA 4X, corrosion-resistant.
8. Manufacturers and Products:
   a. Allen-Bradley; Bulletin 800H.
   b. Square D Co.; Class 9001, Type SK.
   c. Eaton Corp.; Cutler-Hammer, Type E34.

J. M30 Horn, Indoor/Outdoor:
1. General:
   a. Function: Audible alarm. Produces sound by electro-mechanical vibration of a diaphragm.
2. Performance:
   a. Temperature, Operating: Minus 65 degrees Fahrenheit to 150 degrees Fahrenheit.
   b. Sound Output Level: 100 dB nominal at 10 feet (110 dB at 1 meter).
3. Features:
   a. Dimensions: 4-3/8 inches in height and width, and 2.5 inches in depth, for horn and enclosure.
   b. Body: Die-cast zinc.
   c. Diaphragm: Stainless steel.
   d. Projector: None, unless otherwise noted.
   e. Listings: UL, cUL listed, FM, CSA approved.
4. Enclosure:
   a. Type: Cast aluminum with neoprene-gasketed NEMA 4X housing.
   b. Mounting: Surface mount.
5. Power: 120V ac, 50/60-Hz, unless otherwise noted.
6. Manufacturer: Federal Signal Corp.; Model 350WB.

K. M31 Warning Light, Indoor/Outdoor:
1. General:
   a. Function: Visual alarm.
   b. Type: Rotating reflector or flashing bulb.
   c. Parts: Light and spare bulbs.
2. Performance:
   a. Temperature, Operating: Minus 35 degrees Fahrenheit to 190 degrees Fahrenheit.
   b. Flash Rate: Nominally 90 per minute.
3. Features:
   a. Dome: Polycarbonate.
   b. Dome Color: Amber, unless otherwise noted.
   c. Lamp Life: 200 hours.
   d. Lamp: Incandescent/25 watts.
4. Enclosure:
   a. Type: IP65 (NEMA 4X).
   b. Mounting: 1/2-inch pipe, unless otherwise noted.
   c. Listing: UL listed, CSA certified.
5. Power: 120V ac, 50/60-Hz.
6. Spare Bulbs: Provide two for each light.

7. Manufacturers: Federal Signal; Model 225.

L. S12 Indicator, Field Mount:
   1. General:
      a. Function: Digital indication of analog signal.
      b. Type:
         1) Integral enclosure suitable for field mounting.
         2) Loop-powered.
   2. Performance:
      a. Accuracy: Plus or minus 0.1 percent of full scale plus or minus one count.
      b. Display Update Rate: 2.5 second minimum.
      c. Operating Temperature Range: Minus 40 degrees Celsius to 80 degrees Celsius.
   3. Features:
      a. Display:
         1) LCD.
         2) 3.5-digits.
         3) 0.35 inch minimum.
      b. Input Impedance: 75 ohms maximum.
   4. Enclosure:
      a. NEMA 4X, unless otherwise noted.
      b. Mounting: Surface, unless otherwise noted.
   5. Loop-powered.
   6. Signal Interface: 4 to 20 mA dc at 24V dc maximum.
   7. Accessories: As required to support the noted options.
   8. Manufacturers and Products:
      a. Newport Electronics, Santa Ana, CA; Model 508B.
      b. Precision Digital, Natick, MA; Model Trident Model PD660/661.

M. S24 Isolator, Current:
   1. General:
      a. Function: Isolate an analog current signal.
      b. Type:
         1) Solid state with external power supply.
         2) Three-way isolation of the input signal, output signal, and external power supply.
      c. Parts: Isolator plus DIN rail strip.
   2. Performance:
      a. Isolation:
         1) Three-way isolation between input, output, and power circuits for common mode voltages up to 250V ac, or 354V dc of ground, on a continuous basis.
         2) Able to withstand 1500Vac dielectric strength test for 60 seconds without breakdown.
      b. Output Ripple: Less than plus or minus 0.1 percent of maximum output span.
      c. Accuracy: Plus or minus 0.1 percent of output span.
      d. RFI Resistance: Less than plus or minus 0.5 percent of output span with RFI field strengths of up to 10V/meter at frequencies of 27, 151, and 467 MHz.

e. EMI resistance: Less than plus or minus 0.25 percent of output span effect with switching solenoids or commutator motors.
f. Ambient Temperature, Operating: Minus 13 degrees Fahrenheit to plus 185 degrees Fahrenheit.

3. Features:
4. a. Zero and span trim adjustments using 15-turn potentiometers.
   b. Calibration independent of load.
5. Signal Interface:
   a. Input:
      1) 4 to 20mA dc.
      2) Impedance: 75 ohms.
   b. Output :
      1) 4 to 20 mA dc.
      2) Drives output load impedance up to 1050 ohms independent of supply voltage to isolator.
6. Enclosure:
   a. NEMA 1, unless otherwise noted.
   b. Mounting: DIN Rail, unless otherwise noted.
7. Power: 115Vac, unless otherwise noted.
8. Accessories: 3-inch Type T DIN rail strip.
9. Manufacturer:
   a. Acromag Model Flat Pack 330I/430I Isolators.
   b. Rochester Model SC-1302 Voltage/Current Transmitter.
   c. AGM Model PTA 4000.

N. Y81A Network Switch, Ethernet:
1. Full compliance with IEEE 802.3.
2. Supports Ethernet (10BASE-TX), Fast Ethernet (100BASE-TX/FX) and Gigabit Ethernet (1000BASE-TX/FX) networking technologies.
3. Wire-speed switching fabric.
4. Ports:
   a. 10/100/1000 Base TX: Quantity as shown on block diagram plus 3 spare.
      1) RJ 45 sockets.
      2) Auto crossing.
      3) Auto negotiating.
      4) Auto polarity.
      5) Full duplex capable.
   b. 1000 Base FX: Two, minimum.
      1) SC sockets.
      2) Multimode cable.
         a) Compatible with 50/125 micron and 62.5/125 micron fibers.
      3) Full duplex capable.
      4) 8 dB link budget at 1,300 nm.
5. Network Topology:
   a. Star.
   b. Ring with HIPER-Ring.
   c. RSTP.
6. Management: Serial interface, web interface, SNMP v1, v2, v3.
7. Diagnostics:
   a. LEDs (Power, Link Status, Data, Fault, redundancy manager).
   b. RMON (statistics, history, alarms, events).

c. Port mirroring.
d. Topology detection 802.1ab.

8. Configuration: Terminal software, BootP, DHCP, DHCP Option 82.
9. Security:
   a. Port security (MAC based and IP based).
   b. SNMP V3.
10. Other Services:
   a. Port prioritization (IEEE 802.1D/p).
   b. VLAN (802.1Q).
   c. Multicast (IGMP Snooping/Queier, GMRP).
   d. Broadcast limiter.
   e. Flow Control (IEEE 802.3x SNTP).
11. Redundancy:
   a. HIPER-Ring (ring structure).
   b. RSTP.
   c. Redundant net/ring coupling.
   d. Dual Homing.
   e. Redundant 24-volt power supply.
12. Power:
   a. Panel mount: 24V dc, 375 ma max.
   b. Rack mount: 120V AC.
13. Operating Temperature: 0 to 60 degrees C.
14. IEC 60068-2-27 Shock: 15g, 11 ms duration, 18 shocks.
15. IEC 60068-2-6 Vibration:
   a. 1 mm, 2 to 13.2-Hz, 90 minutes.
   b. 0.7g, 13.2 to 100-Hz, 90 minutes.
   c. 3.5 mm, 3 to 9-Hz, 10 cycles, 1 octave/minute.
   d. 1g, 9 to 150-Hz, 10 cycles, 1 octave/minute.
16. Approvals: cUL 508 (E175531), cUL 1604 Class I Div 2 (E203960), cUL 60950 (E168643).
17. Spares: Provide a spare switch that is identical to provided one.
18. Manufacturer, model:
   a. Panel mount:
      1) Hirschman, RS20-XX00M2M2SDAEHH. XX=08 or 16 depending on quantity of ports.
      2) Allen Bradley Stratix 5700 or 5400 series.
   b. All switches to be same revision.

2.03 INSTRUMENT LIST

TAG NO.	COMPONENT CODE	COMPONENT TITLE	RANGE	P&I DWG	REMARKS
66-LE/LIT 01	L6	ALUM BULK STORAGE TANK NO. 1 LEVEL	0 – 12 FT	N01	
66-LE/LIT 02	L6	ALUM BULK STORAGE TANK NO. 2 LEVEL	0 – 12 FT	N01	
66-LE/LIT 11	L6	ALUM DAY TANK LEVEL	0 – 11 FT	N01	

TAG NO.	COMPONENT CODE	COMPONENT TITLE	RANGE	P&I DWG	REMARKS
66-PI-11	P4	ALUM INJECTION LINE TO AERATION BASIN PRESSURE	0 – 100 PSI	N01	
66-FSL-01	F20	ALUM TRANSFER PUMPS SUCTION LOW FLOW	Trip: 5 GPM	N-01	
67-LE/LIT 01	L6	AMMONIA BULK STORAGE TANK NO. 1 LEVEL	0 – 14 FT	N02	
67-LE/LIT 02	L6	AMMONIA BULK STORAGE TANK NO. 2 LEVEL	0 – 14 FT	N02	
67-LE/LIT 11	L6	AMMONIA DAY TANK LEVEL	0 – 6 FT	N02	
67-PI-11	P4	AMMONIA SKID NO.1 INJECTION LINE TO 36” PIPE PRESSURE	0 – 100 PSI	N02	
67-PI-11	P4	AMMONIA SKID NO.1 INJECTION LINE TO PIECE RIVER INFLUENT PRESSURE	0 – 100 PSI	N02	
67-PI-11	P4	EXSITING SODIUM HYPOCHLORITE TO PIECE RIVER INFLUENT PRESSURE	0 – 100 PSI	N02	
67-PI-11	P4	AMMONIA SKID NO.2 INJECTION LINE TO RO PERMEATE CLEARWELL PRESSURE	0 – 100 PSI	N02	
67-FSL-01	F20	AMMONIA TRANSFER PUMPS SUCTION LOW FLOW	Trip: 1 GPM	N02	

PART 3 EXECUTION

3.01 INSTALLATION – UNPOWERED INSTRUMENTS

A. Equipment shall be located so that it is accessible for operation and maintenance. The Instrumentation and Control Integrator shall examine the Drawings and Shop Drawings for various items of equipment in order to determine the best arrangement for the work as a whole, and shall supervise the installation of process instrumentation supplied under this Division.

B. Field equipment shall be wall mounted or mounted on two-inch diameter aluminum pipe stands welded to a 10-inch square 1/2-inch thick aluminum base plate unless shown adjacent to a wall or otherwise noted. Instruments attached directly to concrete shall be spaced out from the mounting surface not less than 1/2-inch by use of phenolic spacers. Expansion anchors in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60 inches above the floor or work platform.

C. Embedded pipe supports and sleeves shall be Schedule 40, Type 316 stainless steel pipe, ASA B-36.19, with stainless steel blind flange for equipment mounting as shown on the Drawings.

D. Materials for miscellaneous mounting brackets and supports shall be 316 stainless steel constructions.

E. Pipe stands, miscellaneous mounting brackets and supports shall comply with the requirements of Division 5 of the specifications.

3.02 INSTALLATION – POWERED INSTRUMENTS

A. General:
   1. Equipment shall be located so that it is accessible for operation and maintenance. The Instrumentation and Control Integrator shall examine the Drawings and Shop Drawings for various items of equipment in order to determine the best arrangement for the work as a whole, and shall supervise the installation of process instrumentation supplied under this Division.
   2. Electrical work shall be performed in compliance with all applicable local codes and practices. Where these specifications and the Drawings do not delineate precise installation procedures, API RP550 shall be used as a guide to installation procedures.

B. Equipment Mounting and Support:
   1. Field equipment shall be wall mounted or mounted on two-inch diameter aluminum pipe stands welded to a 10-inch square 1/2-inch thick aluminum base plate unless shown adjacent to a wall or otherwise noted. Instruments attached directly to concrete shall be spaced out from the mounting surface not less than 1/2-inch by use of phenolic spacers. Expansion anchors in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60 inches above the floor or work platform.

2. Embedded pipe supports and sleeves shall be schedule 40, 316 stainless steel pipe, ASA B-36.19, with stainless steel blind flange for equipment mounting as shown on the Drawings.
3. Materials for miscellaneous mounting brackets and supports shall be 316 stainless steel constructions.
4. Pipe stands, miscellaneous mounting brackets and supports shall comply with the requirements of Division 5 of the specifications.
5. Transmitters shall be oriented such that output indicators are readily visible.

C. Control and Signal Wiring: Electrical, control and signal wiring connections to transmitters and elements mounted on process piping or equipment shall be made through liquid-tight flexible conduit. Conduit seals shall be provided where conduits enter all field instrument enclosures and all cabinetry housing electrical or electronic equipment.

3.03 ADJUSTMENT AND CLEANING

A. The Instrumentation and Control Integrator shall comply with the requirements of Division 1 of these Specifications and all instrumentation and control system tests, inspection, and calibration requirements for all instrumentation and controls provided under this Contract and specified herein. The Owner, or his designated representative(s), reserves the right to witness any test, inspection, calibration or start-up activity. Acceptance by the Owner of any plan, report or documentation relating to any testing or commissioning activity specified herein shall not relieve the Contractor of his responsibility for meeting all specified requirements.

B. The Instrumentation and Control Integrator shall provide the services of factory trained technicians, tools and equipment to field calibrate, test, inspect and adjust each instrument to its specified performance requirement in accordance with manufacturer's specifications and instructions. Any instrument which fails to meet any contract requirements, or any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Owner, at no cost to the Owner. The Contractor shall bear all costs and provide all personnel, equipment and materials necessary to implement all installation tests and inspection activities for equipment specified herein.

C. At least 60 days before the anticipated initiation of installation testing, the Contractor shall submit to the Owner a detailed description, in duplicate, of the installation tests to be conducted to demonstrate the correct operation of the instrumentation supplied hereunder.

3.04 FIELD INSTRUMENT CALIBRATION REQUIREMENTS

A. Field Instrument Calibration Requirements:
1. The Instrumentation and Control Integrator shall provide the services of factory trained instrumentation technicians, tools and equipment to field calibrate each instrument supplied under this Contract to its specified accuracy in accordance with the manufacturer's specification and instructions for calibration.

2. Each instrument shall be calibrated at 0, 25, 50, 75 and 100 percent of span using test instruments to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five (5) times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracies as set forth by the National Institute for Standards and Technology (NIST).
3. The Instrumentation and Control Integrator shall provide a written calibration sheet to the Owner for each instrument, certifying that it has been calibrated to its published specified accuracy. The Contractor shall submit proposed calibration sheets for various types of instruments for Owner approval prior to the start of calibration. This sheet shall include but be limited to date, instrument tag numbers, calibration data for the various procedures described herein, name of person performing the calibration, a listing of the published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required and corrections made.
4. If doubt exists as to the correct method for calibrating or checking the calibration of an instrument, the manufacturer's printed recommendations shall be used as an acceptable standard, subject to the approval of the Owner.
5. Upon completion of calibration, devices calibrated hereunder shall not be subjected to sudden movements, accelerations, or shocks, and shall be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices from being subjected to overvoltages, incorrect voltages, overpressure or incorrect air. Damaged equipment shall be replaced and recalibrated at no cost to the Owner.
6. After completion of instrumentation installation, the Instrumentation and Control Integrator shall perform a loop check. The Contractor shall submit final loop test results with all instruments listed in the loop. Loop test results shall be signed by all representatives involved for each loop test.

END OF SECTION

SECTION 17320

PACKAGE CONTROL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this Section:
   1. Instrumentation, Systems, Automation Society (ISA): S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
      c. ICS 2, Industrial Control Devices, Controllers and Assemblies.
   3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   4. Underwriters Laboratories Inc. (UL): 508A, Standards for Safety, Industrial Control Panels.

1.02 SYSTEM DESCRIPTION

A. Assemble panels and install instruments, plumbing, and wiring in equipment manufacturer's factories.

B. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer's factory.

1.03 SUBMITTALS

A. Action Submittals:
   1. Bill of material, catalog information, descriptive literature, wiring diagrams, and Shop Drawings for components of control system.
   2. Catalog information on electrical devices furnished with system.
   3. Shop Drawings, catalog material, and dimensional layout drawings for control panels and enclosures.
   4. Panel elementary diagrams of prewired panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters.
   5. Plumbing diagrams of preplumbed panels and interconnecting plumbing diagrams.
   6. Interconnection wiring diagrams that include numbered terminal designations showing external interfaces.
   7. Panel Power Requirements and Heat Dissipation:
      a. For control panels tabulate and summarize:
         1) Required voltages, currents, and phases(s).
         2) Maximum heat dissipations Btu per hour.

3) Calculations.
4) Steady State Temperature Calculations: For panels, provide heat load calculations showing the panel estimated internal steady state temperature.

B. Informational Submittals:
1. Programmable Controller Submittals:
a. Complete set of user manuals.
b. Fully documented ladder logic listings.
c. Function listing for function blocks not fully documented by ladder logic listings.
d. Cross-reference listing.
2. Manufacturer's list of proposed spares, expendables, and test equipment.
3. Manufacturer's Certificate of Proper Installation

1.04 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

PART 2 PRODUCTS

2.01 SIGNAL CHARACTERISTICS

A. As defined in Section 17300 - Instrumentation Control and Monitoring System – General Provisions.

2.02 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:
1. Northern Instruments; Model Zerust VC.
2. Hoffmann Engineering; Model A-HCI.

2.03 CONTROL PANEL

A. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), UL 508, state and local codes, and applicable sections of NEMA, ANSI, and ICECA.

B. Conform to NEMA ratings as specified in individual equipment sections.

C. Minimum Metal Thickness: 14 gauge.

D. NEMA 250, Type 4X Panels: Type 316 stainless steel construction unless otherwise specified.

E. Doors:
1. Three-point latching mechanisms in accordance with NEMA 250 Type 1 and 12 panels with doors higher than 18 inches.
2. For other doors, stainless steel quick release clamps.

F. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.

G. Access: Front, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

H. Temperature Control:
   1. Nonventilated Panels: Design to adequately dissipate heat from equipment mounted inside panel and on panel. Provide adequate heat exchanger unit.
   2. Ventilated Panels:
      a. Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel and on panel.
      b. For panels with backs against wall, furnish louvers on top and bottom of panel sides.
      c. For panels without backs against wall, furnish louvers on top and bottom of panel back.
      d. Louver Construction: Stamped sheet metal.
      e. Ventilation Fans:
         1) Furnish where required to provide adequate cooling.
         2) Create positive internal pressure within panel.
         3) Fan Motor Power: 120 V ac, 60-Hz, thermostatically controlled.
      f. Air Filters: Washable aluminum, Hoffman Series A-FLT.
   3. Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation.
   4. Space Heaters:
      a. Controlled by humidistat to maintain relative humidity below 70 percent and by thermostat to maintain temperature above 40 degrees Fahrenheit.

I. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.

J. Lighting: Minimum of one hand switch controlled internal 100-watt light for panels 12 cubic feet and larger.

K. Minimum of one 120-volt GFCI duplex receptacle for panels 12 cubic feet and larger.

L. Finish:
   1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer's standard gray unless otherwise specified.
   2. Internal Surfaces: White enamel.

M. Panel Manufacturers:
   1. Hoffman.
   2. H.F. Cox.
   3. Rittal Modular Enclosures

N. Breather and Drains: On all outdoor enclosures furnish with NEMA 250, Type 4 and 4X panels.
   1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.

O. Sunshade:
   1. For all control panels mounted outside not under a canopy provide a sun shade as shown in Typical Detail NM107 in Volume 8 of the Construction Documents.

2.04 CONTROL PANEL ELECTRICAL

A. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" per UL 508A.

B. Control Panels without Motor Starters:
   1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
   2. Locate to provide clear view of and access to breakers when door is open. Group on single subpanel. Provide typed directory.
   3. Circuit Breakers:
      a. Coordinate for fault in branch circuit trips, branch breaker, and not main breaker.
      b. Branch Circuit Breakers: 15 amps at 250 V ac.
      c. Breaker Manufacturers and Products:
         1) Heineman Electric Co.; Series AM.
         2) Airpax/North American Philips Controls Corp.; Series 205.

C. Control Panels with Three-Phase Power Supplies and Motor Starters:
   1. Interlock main circuit breaker with panel door.
      a. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.
      b. Mount operator controls and indications on front access door.
   2. Circuit Breakers:
      a. In accordance with NEMA AB 1.
      b. 35K AIC RMS symmetrical rating, minimum at 480 volts, unless otherwise specified.
      c. Breakers, except Motor Branch Breakers: Molded case thermal magnetic.
      d. 14,000-ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified in package system equipment specification sections.
      e. Tripping: Indicate with operator handle position.
   3. Magnetic Motor Starters:
      a. Full voltage, NEMA ICS 2, Class A, Size O minimum.
      b. Include three-pole bimetallic or eutectic alloy thermal overload relays sized for each motor.
      c. Manual reset type with reset button mounted on panel door.
   4. Motor Control: 120 V ac (except intrinsically safe circuits where applicable).
      a. Power Control Transformer:
         1) Sufficient capacity to serve connected load, including 200 VA for duplex outlet plus 100 VA (minimum).
         2) Limit voltage variation to 15 percent during contact pickup.
         3) Fuse one side of secondary winding and ground the other.
         4) Furnish primary winding fuses in ungrounded conductors.
   5. Power Monitoring Relay:
      a. Protect three-phase equipment from single phasing, phase imbalance, or phase reversal.

b. Separate, isolated contact outputs to stop motors and activate alarm light during abnormal conditions.
c. Transient Voltage Protection: 10,000 volts.
d. Manufacturer and Product: Furnas; Class 47.

6. Power Distribution Blocks: Furnish to parallel feed tap on branch circuit protective devices. Do not "leap frog" power conductors.
7. Terminations for Power Conductors: Suitable for use with 75 degrees Celsius wire at full NFPA 70, 75 degrees Celsius ampacity.

D. Wiring:
1. ac Circuits:
a. Type: 600-volt, Type MTW stranded copper.
b. Size: For current to be carried, but not less than 14 AWG.
2. Analog Signal Circuits:
a. Type: 300-volt, Type 2 stranded copper, twisted shielded pairs.
b. Size: 18 AWG, minimum.
3. Other dc Circuits.
a. Type: 600-volt, Type MTW stranded copper.
b. Size: 18 AWG, minimum.
4. Separate analog and other dc circuits at least 6 inches from any ac power and control wiring.
5. Enclose wiring in sheet metal raceways or plastic wiring ducts.
6. Wire Identification: Numbered and tagged at each termination.
a. Wire Tags: Machine printed, heat shrink.
b. Manufacturers:
1) Brady PermaSleeve.
2) Tyco Electronics.

E. Wiring Interface:
1. For analog and discrete signal, terminate at numbered terminal blocks.
2. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.
3. For panel, terminate at equipment on/with which it is mounted.

F. Terminal Blocks:
1. Quantity:
a. For external connections.
b. Wire spare or unused panel mounted elements to their panels' terminal blocks.
c. Spare Terminals: 20 percent of connected terminals, but not less than 10.
2. General: Group to keep 120 V ac circuits separate from 24 V dc circuits.
a. Connection Type: Screw connection clamp.
b. Compression Clamp:
1) Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection.
2) Guides strands of wire into terminal.
c. Screws: Hardened steel, captive, and self-locking.
d. Current Bar: Copper or treated brass.
e. Insulation:
1) Thermoplastic rated for minus 55 to plus 110 degrees Celsius.
2) Two funnel shaped inputs to facilitate wire entry.

f. Mounting:
    1) Rail.
    2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
    3) End Stops: One at each end of rail, minimum.
g. Wire Preparation: Stripping only.
h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
i. Marking System:
    1) Terminal number shown on both sides of terminal block.
    2) Allow use of preprinted and field marked tags.
    3) Terminal strip numbers shown on end stops.
    4) Mark terminal block and terminal strip numbers as shown.

3. Terminal Block, 120-Volt Power:
    a. Rated Voltage: 600 V ac.
    b. Rated Current: 30 amps.
    c. Wire Size: 22 through 10AWG.
    d. Rated Wire Size: 10 AWG.
    e. Color: Gray body.
    f. Spacing: 0.25 inch, maximum.
    g. Manufacturer and Product: Entrelec; Type M4/6.
4. Terminal Block, Ground:
    a. Wire Size: 22 through 12 AWG.
    b. Rated Wire Size: 12 AWG.
    c. Color: Green and yellow body.
    d. Spacing: 0.25 inch, maximum.
    e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
    f. Manufacturer and Product: Entrelec; Type M4/6.P.
5. Terminal Block, Blade Disconnect Switch:
    a. Use: Provide one for each discrete input and output field interface wire.
    b. Rated Voltage: 600 V ac.
    c. Rated Current: 10 amp.
    d. Wire Size: 22 through 12 AWG.
    e. Rated Wire Size: 12 AWG.
    f. Color: Gray body, orange switch.
    g. Spacing: 0.25 inch, maximum.
    h. Manufacturer and Product: Entrelec; Type M4/6.SN.
6. Terminal Block, Fused, 24 V dc:
    a. Rated Voltage: 600 V dc.
    b. Rated Current: 6.3 amp.
    c. Wire Size: 22 through 12 AWG.
    d. Rated Wire Size: 12 AWG.
    e. Color: Gray body.
    f. Fuse: 5 by 20 GMA fuses.
    g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
    h. Indication: LED diode 24 V dc.
    i. Leakage Current: 5.2 mA, maximum.
    j. Spacing: 0.32 inch, maximum.
    k. Manufacturer and Product: Entrelec; Type M4/6.SFD.
7. Terminal Block, Fused, 120 V ac:
    a. Rated Voltage: 600 V ac.

b. Rated Current: 6.3 amp.
c. Wire Size: 22 through 12 AWG.
d. Rated Wire Size: 12 AWG.
e. Color: Gray body.
f. Fuse: 5 by 20 GMA fuses.
g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
h. Indication: Neon lamp 110 V ac.
i. Leakage Current: 1.8 mA, maximum.
j. Spacing: 0.32 inch, maximum.
k. Manufacturer and Product: Entrelec; Type M4/6.SFL.

G. Grounding: Internal copper grounding bus for ground connections on panels, consoles, racks, and cabinets.

H. Relays:
1. General:
a. Relay Mounting: Plug-in type socket.
b. Relay Enclosure: Provide dust cover.
c. Socket Type: Screw terminal interface with wiring.
d. Socket Mounting: Rail.
e. Furnish holddown clips.
2. Control Circuit Switching Relay, Nonlatching:
a. Type: Compact general purpose plug-in.
b. Contact Arrangement: 3 Form C contacts.
c. Contact Rating: 10 A at 28 V dc or 240 V ac.
d. Contact Material: Silver cadmium oxide alloy.
e. Coil Voltage: As noted or shown.
f. Coil Power: 1.8 watts (dc), 2.7 VA (ac).
g. Expected Mechanical Life: 10,000,000 operations.
h. Expected Electrical Life at Rated Load: 100,000 operations.
i. Indication Type: Neon or LED indicator lamp.
j. Push-to-test button.
k. Manufacturer and Product: Potter and Brumfield; Series KUP.
3. Control Circuit Switching Relay, Latching:
a. Type: Dual coil mechanical latching relay.
b. Contact Arrangement: 2 Form C contacts.
c. Contact Rating: 10 A at 28 V dc or 120 V ac.
d. Contact Material: Silver cadmium oxide alloy.
e. Coil Voltage: As noted or shown.
f. Coil Power: 2.7 watts (dc), 5.3 VA (ac).
g. Expected Mechanical Life: 500,000 operations.
h. Expected Electrical Life at Rated Load: 50,000 operations.
i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.
4. Control Circuit Switching Relay, Time Delay:
a. Type: Adjustable time delay relay.
b. Contact Arrangement: 2 Form C contacts.
c. Contact Rating: 10 A at 240 V ac.
d. Contact Material: Silver cadmium oxide alloy.
e. Coil Voltage: As specified or shown.
f. Operating Temperature: Minus 10 to 55 degrees Celsius.
g. Repeatability: Plus or minus 2 percent.

h. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent or range.
i. Time Delay Setpoint: As specified or shown.
j. Mode of Operation: As specified or shown.
k. Adjustment Type: Integral potentiometer with knob external to dust cover.
l. Manufacturer and Products: Potter and Brumfield.
1) Series CB for 0.1-second to 100-minute delay time ranges.
2) Series CK for 0.1- to 120-second delay time ranges.

I. Intrinsic Safety Barriers:
1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.
2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.

J. Programmable Controllers:
1. Solid state units capable of performing same function as conventional relays, timers, counters, drum sequencers, arithmetic, and other special functions necessary to perform required control functions.
2. Minimum of 64 internal control relays, 16 timer/counters, and four, 16 stop drum sequencers. Furnish minimum of 256 words of nonvolatile memory.
3. Minimum of 12 discrete inputs and 8 discrete outputs, optical isolations rated at 2,500-volt rms. Discrete inputs shall be 120 V ac. Discrete outputs shall be rated for 2 amps at 120 V ac. Each input and output shall have an LED ON/OFF status indicator.
4. Minimum of 25 percent excess capacity for inputs, outputs, internal coils, registers, and other necessary functions.
5. Capable of operating in a hostile industrial environment (for example, heat, electrical transients, RFI, and vibration) without fans, air conditioning, or electrical filtering. Units operate from 0 to 60 degrees Celsius and up to 95 percent humidity, noncondensing.
6. Manufacturer: Allen Bradley.

K. HMI Touch Panel:
1. Operator interface device where operators interact with the control system by using touch screen.
2. Capable of operating in a hostile industrial environment (for example, heat, electrical transients, RFI, and vibration) without fans, air conditioning, or electrical filtering. Units operate from 0 to 60 degrees Celsius and up to 95 percent humidity, noncondensing.
3. Mounted on front of the Control Panel.
4. Manufacturer: Allen Bradley.

L. Fiber Optic/Ethernet Media Converter Switch:
1. Provide FO/Ethernet Media Converter Switch for panels mounted outside, as specified on Block Diagram.
2. Provide FO Patch Panel mounted inside the panel.

M. Front-of-Panel Devices in Conjunction with NEMA 250, Type 1 and 12 Panels:
   1. Potentiometer Units:
      a. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
      b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
      c. Include legend plates with service markings.
      d. Manufacturers and Products:
         1) Allen-Bradley; Model 800T.
         2) Eaton/Cutler-Hammer; Model 10250T.
   2. Indicating Lights:
      a. Heavy-duty, push-to-test type, oiltight, industrial type with integral transformer for 120 V ac applications.
      b. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.
      c. Manufacturers and Products:
         1) Eaton/Cutler-Hammer; Type 10250T.
         2) General Electric; CR2940U.
   3. Pushbutton, Momentary:
      a. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120 V ac.
      b. Standard size legend plates with black field and white markings for service legend.
      c. Manufacturers and Products:
         1) Square D; Class 9001, Type K.
         2) Eaton/Cutler-Hammer; Type T.
         3) General Electric; Type CR-2940.
   4. Selector Switch:
      a. Heavy-duty, oiltight, industrial type with contacts rated for 120 V ac service at 10 amperes continuous.
      b. Standard size, black field, legend plates with white markings, for service legend.
      c. Operators: Black knob type.
      d. Single-hole mounting, accommodating panel thicknesses from 1/16 inch to 1/4 inch.
      e. Manufacturers and Products for Units with up to Four Selection Positions:
         1) Eaton/Cutler-Hammer; Type T.
         2) Square D; Type K.
      f. Manufacturers and Products for Units with up to 12 Selection Positions:
         1) Rundel-Idec; Standard Cam Switch.
         2) Electroswitch; 31.

N. Front-of-Panel Devices Used in Conjunction with NEMA 250, Type 4X Panels:
   1. Potentiometer, Watertight:
      a. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
      b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
      c. Include engraved legend plates with service markings.
      d. Manufacturer and Product: Allen-Bradley; Bulletin 800H.

2. Indicating Lights, Watertight:
   a. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial type with integral transformer for 120 V ac applications and corrosion-resistant service.
   b. Screwed on prismatic lenses and factory engraved legend plates for service legend.
   c. Manufacturers and Products:
      1) Square D; Type SK.
      2) Allen-Bradley; Type 800H.
3. Pushbutton, Momentary, Watertight:
   a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120 V ac service at 10 amperes continuous and corrosion-resistant service.
   b. Standard size, black field, legend plates with white markings for service legend.
   c. Manufacturers and Products:
      1) Square D; Type SK.
      2) Allen-Bradley; Type 800H.
4. Selector Switch, Watertight:
   a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120 V ac service at 10 amperes continuous and corrosion-resistant service.
   b. Standard size, black field, legend plates with white markings, for service legend.
   c. Operators: Black knob type.
   d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
   e. Manufacturer and Products:
      1) Square D; Class 9001, Type SK.
      2) Allen-Bradley; Type 800H.

2.05 INSTRUMENT TAG NUMBERS

A. A shorthand tag number notation is used. For example:

1-AI-12(2)(3)[pH]

Notation	Explanation
1	Unit process number
AI	ISA designator for Analysis Indicator
12	Loop number
(2)	First unit number; number of same component types in a given loop; -1 and 1-2 in this example
(3)	Second unit number; number of same component types with same first unit number in a given loop; -1, -2, and -3 in this example
[pH]	Same notation shown at 2 o'clock position on ISA circle symbol on Process and Instrument Diagram

B. In this example, 1-AI-12(2)(3)[pH] is shorthand for:

1-AI-12-1-1[pH], 1-AI-12-1-2[pH], 1-AI-12-1-3[pH]

1-AI-12-2-1[pH], 1-AI-12-2-2[pH], 1-AI-12-2-3[pH]

2.06 NAMEPLATES, NAMETAGS, AND SERVICE LEGENDS

A. Nametags: Permanently mounted bearing entire ISA tag number.
   1. Panel Mounted: Plastic, mounted to instrument behind panel face.
   2. Field Mounted: Engraved Type 316 stainless steel, 22 gauge minimum thickness, attached with stainless steel.

B. Service Legends (Integrally Mounted with Instrument) and Nameplates:
   1. Engraved, rigid, laminated plastic type with adhesive back. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.
   2. Color: White with black letters.
   3. Letter Height: 3/16 inch.
   4. For each panel, face mounted laminated nameplate inscribed with the panel name and tag number. Color shall be white with black letters 1/2 inch high.

C. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions:

Tag	Inscription(s)	Color
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red
CLOSED	CLOSED	Green
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

1. Standard Pushbutton Colors and Inscriptions:
   a. Use following unless otherwise noted:

Tag Function	Inscription(s)	Color
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black
OCA	OPEN CLOSE AUTO	Black Black Black
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Black Black
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

   b. Lettering Color:
      1) Black on white and yellow buttons.
      2) White on black, red, and green buttons.

2.07 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. General: Equip control panels with surge-arresting devices to protect equipment from damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

B. Suppressor Locations:
   1. At point of connection between each equipment item, including ac powered transmitters and its power supply conductors (direct-wired equipment).
   2. On analog pairs at each end when the pair travels outside of building.
   3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

C. Power Supply Suppressor Assemblies:
   1. Suitable for connection to 120-volt, single-phase power supplies EDCO "HSP SERIES."
   2. Suitable for connection to 480-volt, three-phase power supplies; Square D J9200-9A.

D. Analog Signal Cable Suppressor Assemblies:
   1. Epoxy encapsulated within a phenolic enclosure.
   2. Flame retardant.

3. Four lead devices; include a threaded mounting/grounding stud.
4. Manufacturers and Products:
    a. EDCO; SRA-64 Series.
    b. Joslyn; Series 1800 and 1669.

E. Grounding: Coordinate surge suppressor grounding in field panels and field instrumentation as specified in Section 16450 - Grounding, and suppressor manufacturer's requirements. Furnish control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

PART 3 EXECUTION

3.01 ELECTRICAL POWER AND SIGNAL WIRING

A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.

B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

C. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.

D. Do not splice or tap wiring except at device terminals or terminal blocks.

3.02 PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. During Work, periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules at Substantial Completion.

C. Panels mounted outside shall have space heater mounted inside the panel.

END OF SECTION